SCALE UP
community-driven
bioeconomy development

Sustainability Screening – Strumica, MK

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EXECUTIVE SUMMARY

The sustainability screening conducted in the Strumica region of North Macedonia systematically evaluates the ecological implications associated with various bioeconomic activities. Primarily centered around agriculture, which spans nearly 25,000 hectares, including pastures, meadows, and crops like tomatoes and peppers, the screening encompasses diverse elements contributing to the bioeconomy. Noteworthy it includes fruit production, along with forest residues, afforestation efforts, and municipal biowaste, particularly organic waste, indicating the potential for compost production.

The second chapter introduces the methodology for the SCALE-UP sustainability screening in the Strumica Region, emphasizing water resources, soil analysis, and biodiversity. It discusses the use of indicators to assess ecological and chemical status in surface and groundwater bodies, addressing potential issues like nutrient pollution. The analysis incorporates the RUSLE2015 model for soil erosion indicators and employs the IUCN Red List to evaluate the conservation status of individual species. The chapter recognizes data uncertainties, underlining the need for cautious methodology use and encourages future iterations with enhanced data for more precise assessments.

The comprehensive evaluation meticulously dissects the potential burdens imposed by these bioeconomic activities on crucial environmental facets such as water resources, soil, and biodiversity. In the context of water, the assessment scrutinizes potential risks, including eutrophication, acidification, and pollution stemming from agricultural residues and composting practices. The soil analysis delves into aspects like soil quality, erosion, and organic matter enrichment, primarily associated with the removal of agricultural residues and the composting process. The examination of biodiversity, while acknowledged as understudied in North Macedonia, draws inferences from prevalent practices like leaving residues on farmland and incorporating compost.

The screening results are carefully summarized, offering insights into the potential advantages and disadvantages concerning water bodies, soil resources, and biodiversity. Currently the water condition is considered low for the surface waters and there is no data on the situation with the groundwater bodies. On the soil screening the baseline rating is good, with low erosion on the arable land. Regarding the biodiversity, Strumica region has only 2 endangered species, and no critically endangered. Subsequently, a set of recommendations is presented to address the identified concerns and foster more sustainable practices. For water resources, the Regional Basin Management Plan unfolds as a pivotal guide, laying out regulatory actions, waste management strategies, and erosion control plans. The soil quality predicaments can be alleviated through strategic urban planning, advocating sustainable agricultural practices, afforestation initiatives, and the application of biochar. Biodiversity preservation recommendations span from comprehensive monitoring to revitalization efforts and public awareness campaigns. Crucially, feedback from regional stakeholders significantly contributes to refining the proposed recommendations. This feedback provides insights based on the experience and knowledge of four regional stakeholders actively involved in advancing and developing the Strumica region.

The sustainable agriculture recommendations advocate for a multifaceted approach. This encompasses erosion control, discouragement of burning crop residues, promotion of plowing practices, and the endorsement of crop rotation and diversification for enhanced soil health. Citizen involvement is underscored, urging them to engage in composting practices and adopt beneficial practices gleaned from both the region and European countries. Preservation of biodiversity necessitates proactive measures and initiatives. A fundamental step involves declaring the ecologically significant Monospitovo Swamp as a protected area, recognizing its crucial role in maintaining biodiversity. Similar initiatives are recommended for safeguarding Belasica, acknowledging the importance of preserving this natural habitat.

In conclusion, the sustainability screening serves as a pragmatic tool for comprehending and addressing the ecological impacts associated with bioeconomic activities in the Strumica region. The recommendations, spanning water, soil, and biodiversity aspects, reflect a commitment to fostering sustainability and resilience in the face of the evolving dynamics of the environment.

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Abbreviations

EQS	**Environmental Quality Standards**
EEA	**European Environment Agency**
EU	**European Union**
EUNIS	**European Nature Information System**
RBD	**River Basin District**
RBMP	**River Basin Management Plan**
LSGU	**Local self-government units**
SOC	**Soil Organic Carbon**
SOM	**Soil Organic Matter**
WME	**Water Management Enterprises**
WEI+	**Water Exploitation Index plus**
WFD	**Water Framework Directive**
WISE	**Water Information System for Europe**
MoEPP	**Ministry of Environment & Physical Planning of the Republic of North Macedonia**
JRC	**Joint Research Center**
LUC	**Land Use Cover**
IUCN	**International Union for Conservation of Nature**
CR	**Critically Endangered**
EN	**Endangered**

VU	**Vulnerable**
NT	**Near Threatened**
LC	**Least Concern**
DD	**Data Deficient**
NE	**Not Evaluated**
NGO	**Non-Governmental Organization**

1 Resource management profiles

1.1 Water resources management profile

The water quality in Strumica region is a critical aspect that encompasses water supply, its use for various purposes (population, industry, agriculture), and the management of waste- and stormwater. Management efforts are guided by the National Water Strategy, the Water Management Foundation, and ongoing plans for catchment area management, all governed by a comprehensive legal framework that encompasses the Law on Waters, Environmental Law, Health Care Law, Law on drinking water supply and urban wastewater disposal, and a multitude of specific regulations like the Rulebook on water safety, Water Classification Ordinance, and others. The Law on Waters which is operational since 2010, is in compliance to the EU Directives in the Water Quality Sector (Water Framework Directive (2000/60/EC) as the framework legislation; Urban Wastewater Treatment Directive (91/271/EEC), Nitrates Directive (91/676/EEC), Dangerous Substances to Water Discharges Directive (76/464/EEC) as emission control oriented legislation; water quality oriented directives; pollution prevention and control directives and monitoring and reporting directives (Hidroinzinering, 2010).

Management of water, coastal land and waterways residences is under the jurisdiction of the state administration bodies, with with the exception of those matters which, according to this law, are under the jurisdiction of the bodies of the municipalities (Munistry of environmetal and physical planning, 2015). The buildings and installations, which make up the water supply system in the territory of Strumica region, are managed by the public utility company "Komunalec"-Strumica.

The institutional arrangements for transposition and implementation of flood risk assesment are identical with the Water Framework Directive (WFD). Local self-government units (LSGU) and water management enterprises (WME) are responsible for assessment and management of flood risks at their respective areas. Areas not falling within the jurisdiction of LSGUs or WME areas are responsibility of the Ministry of Environment & Physical Planning of the Republic of Macedonia (MoEPP). MoEPP is competent authority to coordinate the activities for planning and management of floods. Flood risk assessment shall be prepared by WME for the territory they are responsible for or by municipalities for the territories that do not fall under competencies of the WME.

The Strumica region, with around 49,955 inhabitants, has nearly 99% coverage by the water supply system, serving about 8,600 households. The Turia reservoir has been the primary water source since 1978, delivering 5.5 – 6 million m^3 of raw water annually. The Turia reservoir also serves as a reserve, storing 10 million m^3 yearly. The Turia reservoir supplies 3-18 million m^3 annually for irrigation of 10.000 ha arable land, generating hydroelectric power (Municipality of Strumica, 2023). Vodocha reservoir built in 1966 on the river Vodochica is located 7 km west of Strumica. Its purpose is for water supply of Strumica city and irrigation of roughly 3,100 ha of farmland in the Strumica valley (PointPro Consulting, 2015). The Markova Reka reservoir provides water supply to around 5,000 inhabitants and irrigation for 300 ha.

Region's water demand is covered with water resources abstracted from built dams and reservoirs, drainage channels and river discharge

As part of the Water Supply Resources in Strumica region are few bigger rivers:

- **Strumica River** serves as the main recipient for the acceptance of surface waters for the Strumica field in the district of Strumica
- **Turia River** regulation involved digging a new river bed to divert it to Azmak, facilitating unloading of the Strumica River. Also serves as a recipient for HMS Turia's wastewater, covering a gross area of 11015 ha.
- **Trkajna River** serves as regulatory works from the Monospitovo channel mouth at km 0+000 to km 4+980, covering about 5.0 km, a base partition to calm torrential waters.
- **Vodocha River**

The basin of the Strumica River encompasses the southeasternmost region of Macedonia, extending in a northwest-southeast direction as shown on **Error! Reference source not found.**.

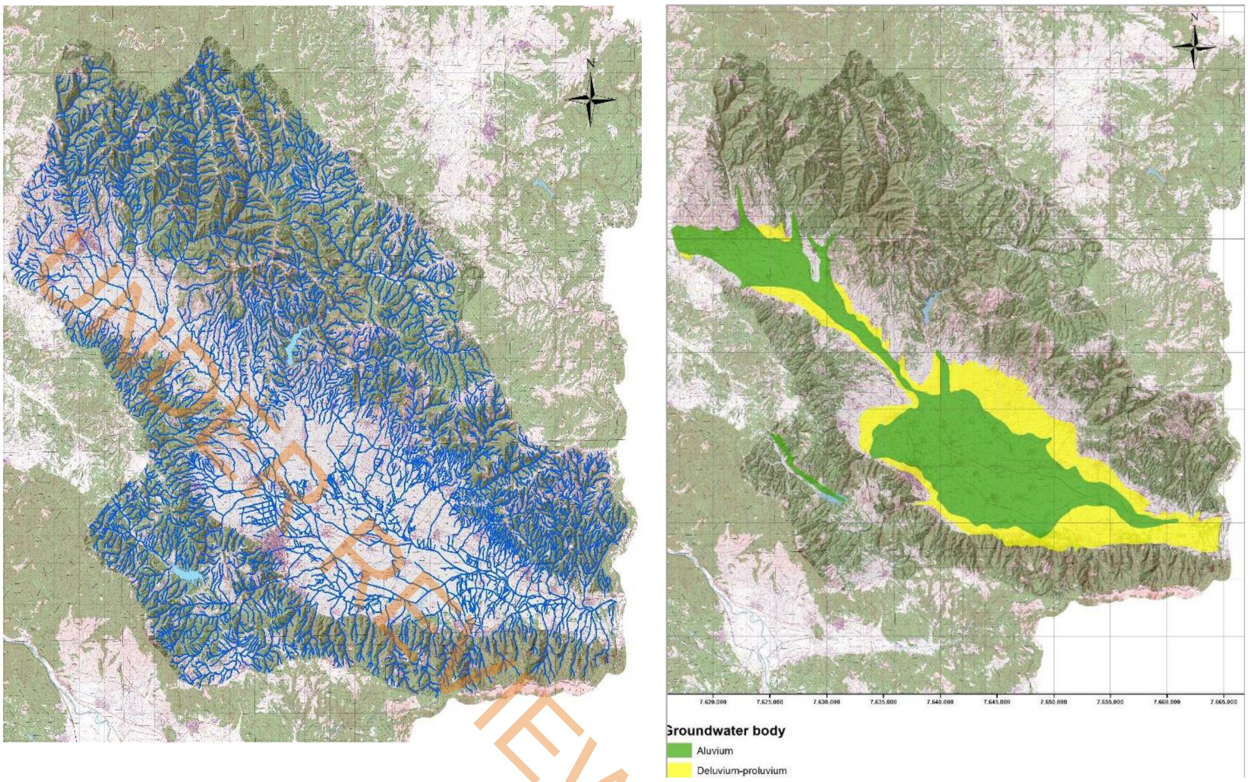

Figure 1 - Strumica River Basin Hydrography Network and Groundwater bodies. Source: PointPro Consulting, 2015

Effective drainage and regulation of riverbeds, including the Strumica River, Turia River, Trkajna River, and Vodocha River, have played a crucial role in flood prevention and overall water management. The region faces the ongoing risk of floods, attributed to factors such as heavy rainfall, snow melting, overflowing of the waters from the riverbeds, specifaily in March and April, non-absorption of stormwater in the sewage system, and potential damage to protective structures. The upper part of the watershed, lacking significant flood protection, poses challenges during intense weather conditions, leading to rapid water concentration and flood waves downstream. While protective structures exist, continuous improvement is essential to enhance the capacity of riverbeds and canal networks for effective flood prevention.

Water management practices in Strumica involve a holistic approach, incorporating a robust legal and regulatory framework, reservoirs for water supply, hydropower generation, irrigation systems, and measures for flood protection. The medium risk of flooding (yellow), as assessed by the Center for Crisis Management, underscores the importance of ongoing revitalization management measures within established legal procedures. The overall conclusion emphasizes the need for sustained efforts to manage water resources effectively, address vulnerabilities, and enhance the overall resilience of the Strumica region to potential water-related crises. As the region navigates the complexities of water management, a continued commitment to comprehensive planning and strategic interventions remains crucial for the sustainable and resilient future of Strumica's water resources.

1.2 Soil resources management profile

Among the most important laws related to agriculture and land use are Law on Agricultural Land, Law on Organic Production, Law on Agriculture and Rural Development, and others. (Ministry of Agriculture, Forestry and Water Management, n.d.) Key documents aimed at enhancing soil quality and advancing agricultural land in the Republic of Macedonia include the “National Development Program of Agriculture and Rural Development” spanning the period 2021-2027 and the National Plan for Organic Production 2013 – 2020“. The strategic documents provide several key directions for the organic agriculture sector. These include expanding areas for collecting wild plants and fruits, producing diverse organic products in ample quantities, integrating advanced technologies into production processes, enhancing market transparency, raising public awareness and visibility of Macedonian organic products, promoting eco-tourism through organic food experiences, incorporating organic agriculture into mainstream education, and initiating research to explore the potential of natural resources for organic production in the Strumica municipality. The competent authority for the implementation of these laws is the Ministry of Agriculture, Forestry, and Water Economy. In specific cases requiring control, oversight is conducted through the Agency for Financial Support in Agriculture and Rural Development.

The regulation of forests and forest land in the Strumica region is governed by the Law on Forest. The implementation of these laws is carried out by legal entities responsible for managing these forests, as well as by state institutions overseeing their enforcement. In the territory of the municipality of Strumica, forest management falls under the responsibility of legal entities such as the Public Enterprise "National Forests" - Branch Forestry Belasica, Strumica Watershed, and the City Public Utility Company "Komunalec.".

The soil in the municipality of Strumica is rich and well-suited for growing crops. The catchment area in Strumica region is relatively low, with an average altitude of 350 m and consist of the following soil types:

- Deluvial formations, made up of sand and clay particles with low porosity and an average depth of 0.5 to 2 m.
- Proluvium formations, consisting of soft particles from metamorphic and magmatic rock masses, along with gravel and clay sand, displaying relatively high porosity.
- Alluvial formations or river sediment, mainly composed of sand and gravel with some clay.
- Upper and lower river terraces, characterized by dust, clay, sand, and gravel, with medium to high density, high porosity, and depths ranging from 10 to 25 meters.
- Pliocene deposits, which go as deep as 1,200 meters and include gravel, clay, marl, and limestone particles.

The total arable land in the Strumica river catchment area is 33,430 ha. Of this, 24,332 ha (72.8%) are used for growing agricultural crops, while the remaining 9,000 ha are dedicated to perennial crops and greenhouses. A notable feature is the widespread distribution of arable lands among individual farmers.

The majority of the municipality's territory is covered with high-quality soils, primarily alluvial, alluvial-carbonate, and deluvial-carbonate soils. The productive land in the Strumica region (including several villages) totals 9,035 ha, out of which, 7,298 ha (80.7%) are used for agriculture, while 1,737 ha (19.3%) are designated as forest land.

Several issues pertaining to soil conditions in the Strumica region include soil contamination from the use of agricultural chemicals, a decrease in the extent of fertile agricultural land, insufficient urban planning leading to the occupation of land for residential and industrial zones, unauthorized constructions, the transformation of agricultural land for economic purposes, and pollution arising from inadequate collection and treatment of municipal wastewater (NIRAS, 2022).

Due to various factors such as environmental conditions, geographical position, climatic features, relief characteristics, historical development, anthropogenic influences, and others, the municipality of Strumica is distinguished by a substantial forest cover, encompassing approximately 38.8% of the municipality's territory (18,860 ha). Quality forests are prevalent at altitudes ranging from 1,000 to 1,500 meters above sea level. Areas below 500 meters primarily consist of degraded forests and thickets.

The total area of these tall forest communities is 2,320 hectares, with the following distribution: Beech: 1,373 ha; Gorun: 243 ha; Black pine: 570 ha; Conifers: 122 ha and Plantations and crops: 12 ha. The varieties and extents of low-stemmed forest communities in the Municipality with the following distribution: Flatterer - 6,491 ha; Gorun - 4,539 ha; Blagun - 2,198 ha; Leaf trees - 1,199 ha; Gaber - 1,161 ha; Shikari - 568 ha; Beech - 353 ha and Conifers - 30 ha, adding up to total of 16,539 ha.

According to the National Spatial Plan, the forests in Strumica are expected to cover an area of 50,900 hectares, with a wood mass of 112 m^3 per hectare. In *Figure 2* the Land Cover from 2022 on national scale is presented, including water areas, forest and crops, built area and rangeland.

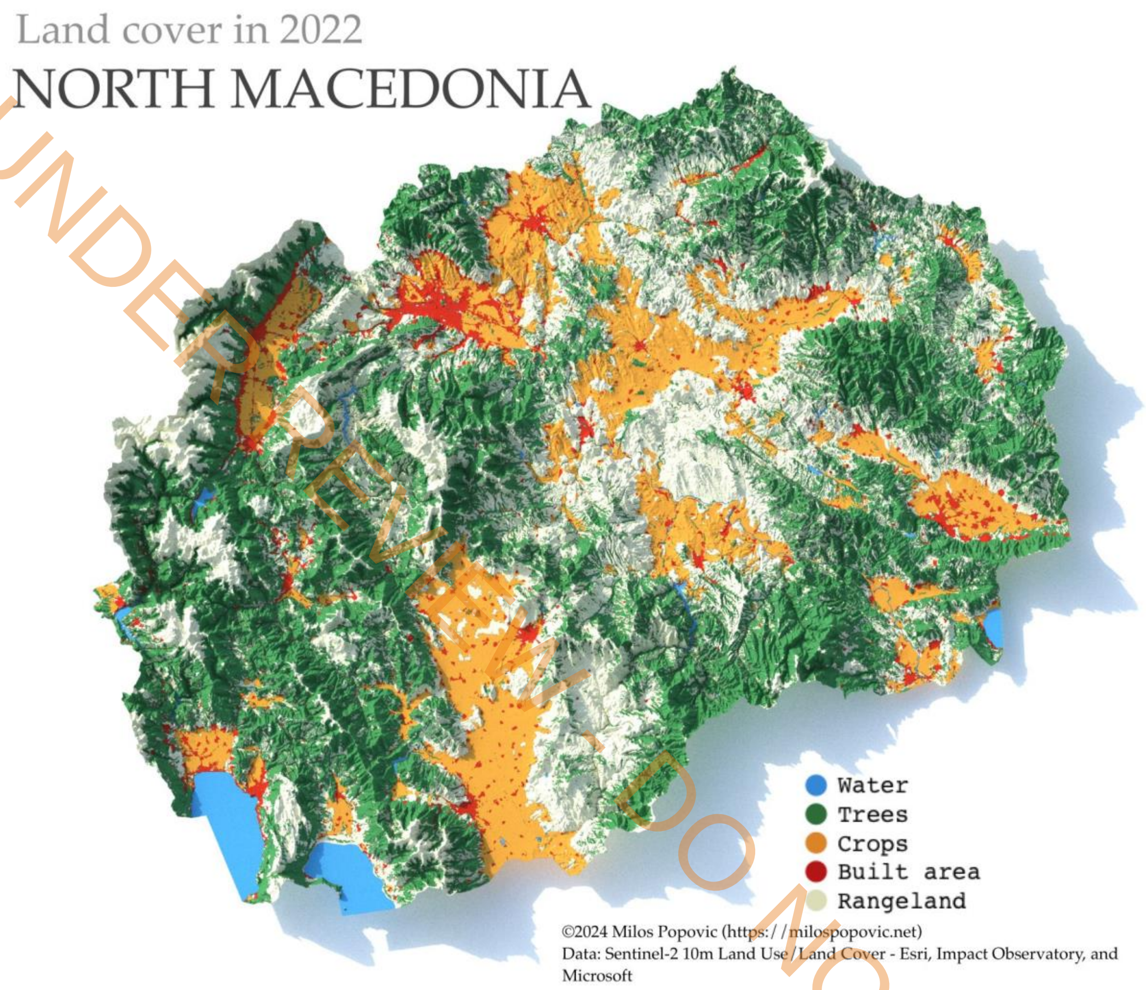

Figure 2 - Land cover of North Macedonia in 2022. Source: Milos Popovic, 2024.

1.3 Biodiversity management profile

North Macedonia is prioritizing forest use and management in line with Europe Union (EU) integration, emphasizing nature protection and biodiversity in its forestry policies. While aligning with EU directives is progress, there's a need for further measures, especially in bio-security under the Convention on Biological Diversity. The challenge lies in synergizing the National Strategy for Biological Diversity, the second national action plan for the environment, and the National Strategy for Sustainable Development. The country is aligning with EU regulations and the Pan-European strategy, having ratified the Birds and Habitats Directive, with NATURA 2000 initiation underway (GIZ and Working group for regional rural development in SEE, 2018).

In 2024, the promotion of national Habitat Map marked a significant milestone (Figure 3). This map is a crucial element in the ongoing effort to identify and assess the ecological status of various regions in the country. It serves as a valuable tool to support planning processes and enhance the environmental evaluation of potential impacts from development projects. The identification and mapping of habitats were conducted using the European Nature Information System (EUNIS) classification, identifying 126 habitats up to level 3. Covering a total area of 25,463 km^2, forest and scrub habitats predominate

(59.61% of the mapped area), followed by grassland habitats (13.80%), water and wet habitats (3.22%), and agricultural and artificial habitats (23.35%).[1]

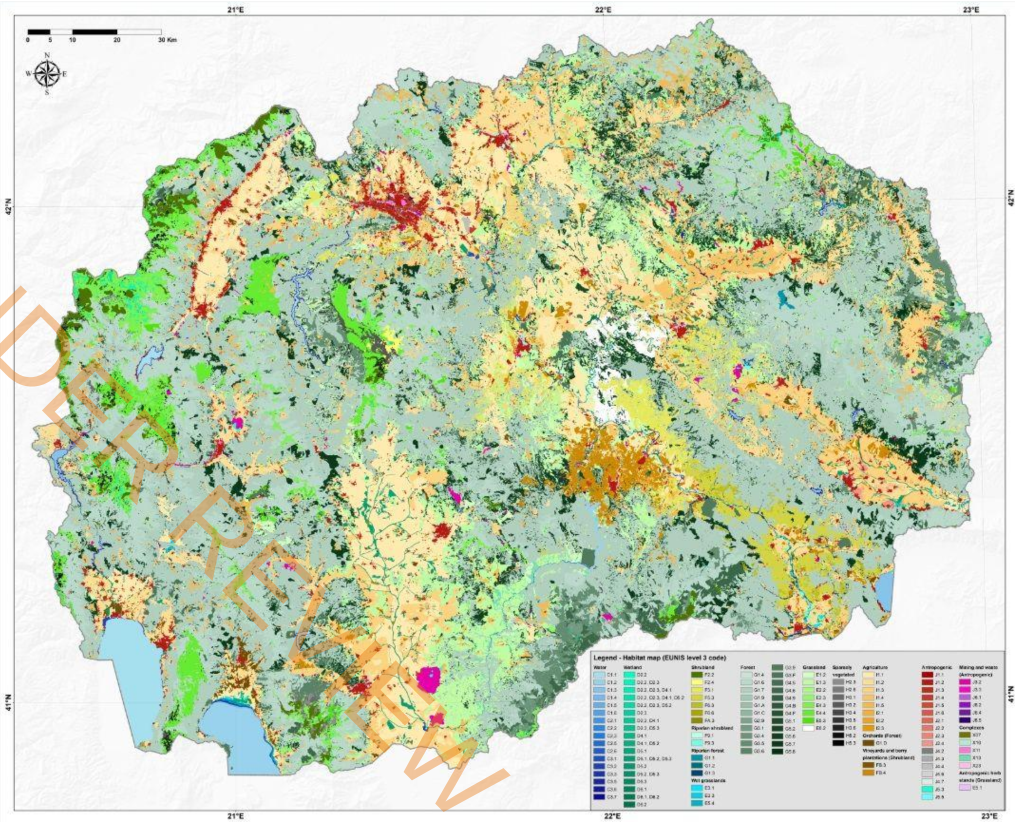

Figure 3 - Habitat map of North Macedonia. Source: MANEKO Solutions, 2024.

The Strumica region is rich with flora, fungi, and fauna, with numerous endemic species attributed to its unique geographical position and climate. The Belasica and Ograzden mountains host thriving forest ecosystems, characterized by deciduous forests dominating the landscape, while evergreen forests are scarce and mainly found in higher elevations. The region's fauna is diverse and includes indigenous and endemic species such as bears, wolves, deer, chamois, wild boars, martens, wild cats, as well as various bird species like eagles, falcons, hawks, and grouse. Additionally, the region is home to a variety of fungi, including boletus, chanterelle, and morel, as well as lizards, snakes, and many insect species.

The region's aquatic flora and fauna are equally diverse, featuring various reeds, marsh vegetation, and algae that support a diverse range of fish species. The area also attracts many migratory bird species, including herons, ducks, and swans.

However, the region faces challenges, particularly in its riverbeds, which often receive wastewater, negatively impacting the existing ecosystems and leading to a reduction in flora, fungi, and fauna populations.

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1 https://www.moepp.gov.mk/en/nastani/%D0%BF%D1%80%D0%B5%D0%B7%D0%B5%D0%BD%D1%82%D0%B8%D1%80%D0%B0%D0%BD%D0%B0-%D0%BF%D1%80%D0%B2%D0%B0%D1%82%D0%B0-%D0%B2%D0%B5%D1%80%D0%B7%D0%B8%D1%98%D0%B0-%D0%BD%D0%B0-%D0%BD%D0%B0%D1%86%D0%B8%D0%BE/

The Law on Nature Protection governs the conservation of nature, including the protection of biological and regional diversity, natural heritage within and outside protected areas, and rare natural features. Conservation efforts are guided by the principle of a high level of protection, requiring all individuals and entities to prioritize the conservation of biological and regional diversity, natural heritage, and the public role of nature in their activities.

According to the sectoral "Study for the Protection of Natural Heritage" (1999) commissioned for the Spatial Plan of the Republic of North Macedonia, the following localities and species in the municipality of Strumica are either protected or proposed for protection:

1. **Monospitov swamp**

The 250-hectare swamp lies at the base of Belasica in Strumicko Pole at an altitude of 240 meters. Thsi monument of nature under III category of protection is home to Glyceria fluitans, Sparganium neglectum, Scirpus maritimus, and Typha angustifolia. Along its fluctuating waterline, forest vegetation thrives, featuring Alnus glutinosa, Periploca graeca, Acer tataricum, Osmunda regalis, Pteridium aquilinum, and Nephrodium thelipteris. This area hosts the Periploco-Alnetum glutinosae association (**Error! Reference source not found.**). It is worth mentioning that Monospitovo swamp is part of the Emerald network in Europe, which preceded the establishment of the Natura 2000 .

Figure 4 – Monospitovo swamp in Strumica region. Source: Doma, 2023.

The protection of Monospitovo swamp is a priority, mandated not only by national laws but also by international conventions and agreements ratified by the Republic of North Macedonia. Additionally, Monospitovo swamp is part of several international initiatives, such as European Green Belt, cross-border protected areas, etc.

2. **Cham Chiflik**

Cham Chiflik is a hill situated between the gorges of the Vodochnica and Trkajna rivers, above Strumica, covering an area of 428 hectares.This site is under IV category of protectio The Coccifero-Carpinetum orientalis pinetosum pallasiana association is present in this area.

The slopes are steep and covered with pine forest (Pinus nigra - Pinus pallasiana) and Scotch oak (Quercus coccifera). Moreover, other Mediterranean species like Clematis flammula, Osyris alba, Cistus villosus, and Carex dystachya are also found here.

3. **River Vodenishnica**

This special natue reserve reserve was surveyed in 1993 and found to hold significant value, thus being under a propoasal for protection of IV category. It is home to protected species in the country, such as yew (Taxus baccata) and wild fir (Ilex aquifolium). The reserve spans 12 hectares and is situated 4 kilometers upstream from the Bansko spa, along the Vodenishnica river.

4. **Shenkoi Orei**

This scientific-research nature reserve is a small stream located east of R'nedova Cheshma, covering an area of 0.3 hectares. Curretly is under proposal for IV category protection. The Platano-Castanerum sativae association is present in this area. In its lower reaches, the stream's water spills over fluvial sediments, creating a wet terrain sheltered from regional climatic influences. This unique habitat supports a diverse floral composition, including Platanus orientalis, Castanea sativa, Juglans regia, Fagus moesiaca, Osmunda regalis, Ruscus aculeatus, and Salix cinerea.

2 Methodology for appraisal of the available capacity of the regional ecosystem

The text in this chapter is strongly based on the description of the methodology for the BE-Rural Sustainability Screening presented in Anzaldúa et al. (2022), with only minor adaptations that resulted from the implementation of the approach in SCALE-UP.

2.1 Water data and indicators

To run the sustainability screening of surface and groundwater bodies potentially relevant to the Strumica Region in North Macedonia, the authors of this report have reviewed the data reported in the River Basin Management Plan (RBMP) for Strumica River Basin District (RBD) for the period 2016-2027. The benefits of tapping on this reporting process is that it includes well-defined indicators like the status of water bodies in each RBD as well as data on significant pressures and impacts on them. Further, these data are official, largely available, accessible, and updated periodically. On national level, there is no Bioeconomy Strategy in place, therefore having regional bioeconomy strategies is a step that is desirable in the future, yet very much needed. Currently, the RBMP is compiled by third support parties, however that does not minimize the importance of the data and information provided for Strumica RBD.

2.1.1 Description of the data / definition of the indicators employed

Data reviewed for this part of the screening included the reported ecological and chemical status of rivers and lakes as well as the quantitative and chemical status of groundwater bodies in the Strumica RBD that is slightly territorially wider than the Strumica Region. The data give indications on water quality of the river basin according to the five status classes defined in the WFD (Table 1). These are: high (generally understood as undisturbed), good (with slight disturbance), moderate (with moderate disturbance), poor (with major alterations), and bad (with severe alterations) (EC, 2003). Further, data on significant pressures and significant impacts on the water bodies in the RBD are used to indicate the burden of specific pressure and impact types on water ecosystems in the regions based on the number and percentage of water bodies subject to them. Significant pressures are defined as the pressures that underpin an impact which in turn may be causing the water body to fail to reach at least the good status class (EEA, 2018).

As non-EU country, North Macedonia is not part of the WISE WFD Data. All data described above were extracted from the River Basin Management Plan for Strumica River Basin District for the period 2016-2027 which comply with the WISE WFD categorization, except for data on significant impacts which are not being analysed in the RBMP and therefore not reported in the sustainability screening for Strumica region.

Table 1 - Indicators used for the water component of the sustainability screening

Category	Indicator Family	Indicator	Spatial level	Unit of measure	Comments/Reference
Water	Water quality	Status of water bodies according to the EU Water Framework Directive	River Basin District	Number of water bodies in high, good, moderate, poor, bad or unknown status	River Basin Management Plan for Strumica River Basin District for the period 2016-2027[2]
	Burden on water bodies	Significant pressures on water bodies	River Basin District	No. and % of water bodies under significant pressures per pressure type	
	Burden on water bodies	Significant impacts on water bodies	River Basin District	No. and % of water bodies under significant impacts per impact type	No data available

Source: Adapted from Anzaldúa et al., 2022.

To determine which status class a certain water body falls into, WFD assessments evaluate the *ecological* and *chemical* status of surface waters (i.e. rivers and lakes) and the *quantitative* and *chemical* status of groundwater bodies. Ecological status refers to *"an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters".* It covers assessments of biological (e.g. presence and diversity of flora and fauna), physico-chemical (e.g. temperature and oxygen content) and hydromorphological criteria (e.g. river continuity) (EC, 2003; BMUB/UBA, 2016). The chemical status of a surface water body is determined by comparing its level of concentration of pollutants against pre-determined Environmental Quality Standards (EQS) established in the WFD (concretely in Annex IX and Article 16(7)) and in other relevant Community legislation. These standards are set for specific water pollutants and their acceptable concentration levels.

In the case of groundwater bodies, chemical status is determined on the basis of a set of conditions laid out in Annex V of the WFD which cover pollutant concentrations and saline discharges. Additionally, the water body's quantitative status is included in the WFD assessments, defined as "*an expression of the degree to which a body of groundwater is affected by direct and indirect abstractions"*. This gives indication on groundwater volume, a relevant parameter to evaluate hydrological regime (BMUB/UBA, 2016).

In the case of surface water bodies, the WFD objective is not only that they reach good status, but that quality does not deteriorate in the future (EC, 2003), which is relevant in the context of the development of bioeconomy value chains.

2.1.2 Methodology applied

The authors of this report have followed the approach described in Anzaldúa et al. (2022) to valorise the data from the River Basin Management Plan For Strumica River Basin District for the period 2016-2027 which to larger extend comply with WFD reporting described in the previous sub-section that

[2] https://www.moepp.gov.mk/wp-content/uploads/2015/01/RBMP-Strumica-2016-2027_MK.pdf

allows for an appraisal that is non-resource intensive (based on reliable, publicly available and accessible data) yet capable of providing a rough overview of the state of the waters in Strumica region. This is in line with the rationale of this sustainability screening, which aims to enable stakeholders with limited financial resources and/or expertise in the field to consider ecological limits in a structured manner when exploring bioeconomy activities. As non-EU country that has not yet adopted the WFD, the reported data from the RBMP is still following the WFD process that has been employed exclusively within the following methodology.

The overall apportionment of rivers, lakes and groundwater bodies in the Strumica Region according to their RBMP (complement to the WFD) status classification can be used to set the baseline for the sustainability screening. It provides initial insight on the situation in the demarcation as regards "ensuring access to good quality water in sufficient quantity", "ensuring the good status of all water bodies", "promoting the sustainable use of water based on the long-term protection of available water resources" and "ensuring a balance between abstraction and recharge of groundwater, with the aim of achieving good status of groundwater bodies", all explicit aims of the WFD that are aligned with the consideration of ecological limits. Further, the data on significant impacts and pressures affecting the water bodies in the river basins are useful as they can point towards specific problems (e.g. nutrient pollution) and the types of activities that may be causing them (e.g. discharge of untreated wastewater, agriculture).

As a first step, the approach used for this element of the screening entails calculating what proportion of the total number of surface water bodies located in the RBD is reported as failing to achieve Good Ecological Status/Good Chemical Status or for which conditions are unknown. Similarly for groundwater bodies, the proportion is calculated of those who are reported as failing to achieve Good Chemical Status/Good Quantitative Status or for which conditions are unknown. In the case of Strumica, groundwater monitoring in the region is performed within 23 piezometric wells established in 1953. Unfortunately, since 2000 only two of the monitoring wells are operating. In addition, organized groundwater data collection and management, as well as user register, are not in place, therefore the status on the groundwater is marked as unknown. The resulting ratios are then compared to the respective EU proportions, which are used as (arbitrary) thresholds. According to the latest assessment published by the EEA in 2018, "around 40% of surface waters (rivers, lakes and transitional and coastal waters) are in good ecological status or potential, and only 38% are in good chemical status" (EEA, 2018). Accordingly, "good chemical status has been achieved for 74% of the groundwater area, while 89% of the area achieved good quantitative status" (EEA, 2018). Using these markers, the following step is to rank the current conditions of the Strumica Region using an ordinal risk rating (high, moderate, low) based on the distance of the result of each indicator to the EU level results. On this basis, the thresholds and ordinal ranking convention suggested by the authors of this report are as shown in Table 2 and Table 3.

Table 2 - Proposed thresholds for the water section of the sustainability screening

Water body type	Status category	2018 EU-level assessment results (proportion of water bodies achieving good status)	Proposed thresholds for the sustainability screening		
			High concern	Moderate concern	Low concern
Surface water bodies	Ecological status	~40%	0-40%	41-89%	90-100%
	Chemical Status	38%	0-38%	39-89%	90-100%
Groundwater bodies	Chemical status	74%	0-74%	75-89%	90-100%

	Quantitative status	89%	0-89%	-	90-100%

Source: Anzaldúa et al., 2022.

Table 3 - Ordinal ranking convention for the water section of the sustainability screening

Ordinal ranking for water resources		Chemical status		
		High concern	Moderate concern	Low concern
Ecological or Quantitative status	High concern			
	Moderate concern			
	Low concern			

Source: Anzaldúa et al., 2022.

This initial appraisal based on the thresholds shown above is then supplemented with a review of the reported data only for the types of significant pressures, omitting the quantity impacts (due to lack of data) on surface and groundwater bodies classified as unknown. In this case percentage values are already given, and so this step in the screening simply entails the listing of the reported pressures and impacts and the identification of those which are more frequently reported. From here, the screening team can seek potential correlations between the most reported pressure types and the most reported impact types (e.g. diffuse sources causing nutrient pollution).

The final step in the approach is to draft a note describing the share of water bodies failing to reach good status and formulating preliminary statements on the types of bioeconomy activities that could be considered, those that should be considered with reserve, and those that should be avoided. These initial statements are used to frame the discussion of the group of stakeholders involved in the development of the bioeconomy value chains in focus in the SCALE-UP project.

2.1.3 Data uncertainties

The data resulting from the assessments reported in the RBMP are subject to the limitations of the scientific and methodological approaches used by their authors. It thus must be considered that the official assessments are based on estimates, include assumptions, and will therefore carry a margin of error.

An important limitation bound to the implementation of the sustainability screening is that the RBMP data used refer to the Strumica RBD of the , whose territorial boundaries do not coincide entirely with those of the Strumica Region. A future iteration of this exercise by the local stakeholders could increase the resolution of the screening of water resources by tapping on additional information sources, like significant impacts or measuring data on groundwater bodies in the Strumica region, if they become available.

Lastly, another issue to consider is the data currently available on RBMP is from 2016, however it happens that there is no updated data on this regard as the plan is spanning over the period 2016 up to 2027. In addition, when the WFD will be fully transposed in North Macedonia, the data gathering and reporting on waters will be simplified and more punctual and that is the goal that the country is aiming to.

2.1.4 Methodological uncertainties

The proposed methodology for the water section used in this application of the sustainability screening is straight-forward and accessible, yet it must be used with care and, where possible, should incorporate higher resolution data evaluated by thematic experts. As previously mentioned, the thresholds set in this case have been the proportions, at EU-level, of water bodies that fail to achieve good status or for which conditions have been reported as unknown. This has been a pragmatic, yet easy to challenge way of defining a benchmark for the Strumica Region. The conditions and context of the Strumica RBD are not necessarily comparable to those of other European regions, and thus the ordinal classification of the water resources in Strumica used for the screening could be contested. Further, the territorial outline of the Strumica RBD does not match the NUTS3 level of Strumica (it scopes a broader area). This can generate additional noise in the results. For this, the authors envision the contributions and guidance from the team of local and foreign experts as briefly described in Section 3.2 of Anzaldúa et al., 2022. Optimally, these thematic experts should know the regional context well and thus be in a good position to guide the setting of such thresholds. Beyond this, the simplicity of the necessary calculations and the fact that the data on significant pressures are used without further computation and compared in relative terms within the RBD limit the possibility of additional accuracy or uncertainty issues emerging.

2.2 Soil data and indicators

2.2.1 Description of the data / definition of the indicators employed

The selected indicators for vulnerability to soil depletion are closely interrelated and refer specifically to soil erosion **by water**. These are:

- Estimated mean soil erosion rate (in $t\ ha^{-1}\ a^{-1}$)
- Share (%) of area under severe erosion (>10 $t\ ha^{-1}\ a^{-1}$)

In broad terms, soil erosion describes the process through which land surface (soil or geological material) is worn away (e.g. through physical forces like water or wind) and transported from one point of the earth surface to be deposited somewhere else (Eurostat, 2020). The above-mentioned indicators describe particularly the amount of soil (in t) per unit of land surface (in ha) that is relocated by water per year.

Variations of these indicators can be calculated by considering different combinations of land cover classification groups, such as *all land*[3] and *agricultural land*[4]. As shown in Figure 5, at EU level in 2016, about three quarters of soil loss occurred in agricultural areas and natural grasslands, while the remaining quarter occurred in forests and semi natural areas (Eurostat, 2020). Therefore, since it is the type of land cover that is most vulnerable to erosion, the present sustainability screening will consider in first line the above-mentioned indicators specifically for agricultural areas and natural grasslands. This scope of the indicators is also in line with the two sub-indicators for soil erosion considered by the Joint Research Centre European Soil Data Centre (JRC ESDAC). Moreover, both

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[3] This refers to all potentially erosive-prone land (in simplified terms), specifically to CORINE Land Cover classification groups: Agricultural areas (2), forest and semi natural areas (3) excluding beaches, dunes, sand plains (3.3.1), bare rock (3.3.2), glaciers and perpetual snow (3.3.5). These, as well as other classes, are excluded because they are not subject to soil erosion.

[4] This refers only to agricultural land (agricultural cropland as well as grassland in simplified terms), specifically to CORINE Land Cover classification groups: Agricultural Areas (2) and Natural Grasslands (321)

the *mean erosion rate for agricultural land* and the *share of agricultural area under severe erosion* are part of the EU Common Agriculture Policy (CAP) context indicator 42 (CCI42) for the period 2014-2020.

Figure 5 - Share of land cover and soil loss across the EU-27 in 2016. Source: JRC, Eurostat.[5]

Gathering data for Strumica region regarding the soil component is challenging task, mostly due to the fact that as non-EU country, the EUROSTAT and Joint Research Center (JRC) data are not applicable. In this case several sources were used to populate the data required for the baseline scenario in the SCALE-UP sustainability screening and to comply with the adopted methodology. For the data on the forest land the Local Environmental Action Plan for Municipality of Strumica in the period 2024-2029[6] was used. Additionally, some recalculations were conducted in order the data to match the Land Use Cover (LUC) class according to CORINE. Moreover, State Statistical Office (SSO) data from 2022[7] was used to depict the agricultural land status in Strumica region. The erosion indicators for arable land were integrated based on the expert's data which was extracted from a map for soil loss developed under the RUSLE method. Because this methodology is not suitable for forest land, there is no data for it. For forest land, the expert's calculations are expressed in m^3 per ha, however, they provided a mean erosion indicator on the forest land converted in tonnes per hectares.

Mean soil erosion rate, which undergirds both selected indicators, is considered useful because it provides a solid baseline to estimate the actual erosion rate in the regions (Panagos et al., 2015). This indicator is based on the latest Revised Universal Soil Loss Equation of 2015 (RUSLE2015), specifically adapted for the European context (see Panagos et al., 2015), which is a model that takes into account various aspects, including two dynamic factors, namely the cover-management[8] and policy support practices[9] (both related to human activities) (Panagos et al., 2020).

The estimated mean soil erosion rate value obtained through the RUSLE2015 model refers to water erosion only, but it is considered to be the most relevant at least in terms of policy action at EU level,

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5 Excluding not erosion-prone land (e.g. beaches, dunes, etc.). Forest and natural areas exclude also natural grasslands, which are evaluated together with agricultural areas.
6 https://strumica.gov.mk/leap/
7 https://makstat.stat.gov.mk/PXWeb/pxweb/en/MakStat/MakStat__Zemjodelstvo__RastitelnoProizvodstvo/425_RastPr_Op_PovrsNtes13_ml.px/
8 Known as the c-factor, it has a non-arable component, which includes changes in land cover and remote sensing data on vegetation density, as well as an arable component, which includes Eurostat data on crops, cover crops, tillage and plant residues.
9 Known as the p-factor, it reflects the effects of supporting policies in estimating the mean erosion rate by including data reported by member states on Good Agricultural Environmental Conditions (GAEC) according to the CAP, specifically contour farming, as well data from LUCAS Earth observation on stone walls and grass margins.

due to the relative predominance of water erosion over other types of erosion. Furthermore, it offers the important advantage of providing a viable estimation for erosion vulnerability at a relatively small geographic scale, i.e. the local or regional level. This can serve as an important tool for monitoring the effect of local and regional policy support strategies of good environmental practices (Panagos et al., 2015, 2020, and Eurostat, 2020).

2.2.2 Methodology applied

The near-universal indicators available to track soil vulnerability are related to either erosion or the decline in soil organic carbon (SOC)/soil organic matter (SOM) (Karlen & Rice, 2015). However, there are major data gaps regarding to SOC/SOM and data is currently only available at national level. According to Panagos et al. (2020), soil organic carbon does not change so quickly and therefore is not so sensitive to human influence on short term. Therefore, they recommend using just a sole indicator for monitoring impact of policies: "estimated mean soil erosion rate" (by water), which they calculate using the RUSLE2015 model. For our purposes, we have complemented the *mean soil erosion rate* indicator, with the *share of agricultural area under severe erosion* in order to gain a comprehensive picture of soil erosion in a region.

Soil erosion is considered generally as a sort of proxy indicator of soil degradation, which in turn is the most relevant component of land degradation at EU level (EC, 2018). However, not all types of bio-based activities have a direct effect on erosion, but rather primary production of biomass. Nonetheless, as these are currently the most widespread bioeconomy activities in rural areas, we will consider their impact on soil degradation, and therefore on soil erosion, to be the most relevant one for this assessment.

The indicators for vulnerability to soil degradation were selected, on one hand, due to the limited number of soil indicators available at the required regional scale. On the other hand, the RUSLE2015 model used for this data also represents the current state-of-the-art methodology for calculating soil erosion. These aspects are crucial, since the choice of indicators needs to be: a) acceptable to experts, b) routinely and widely measured, and c) have a currency with the broader population to achieve global acceptance and impact (Stockmann et al., 2015). In order to carry out the screening of soil vulnerability, a number of datasets need to be accessed. As mentioned above, these data can be accessed via Eurostat, however in this particular case of non-EU countries, other datasets or expert's judgment needs to be into consideration

In terms of processing the erosion data, it is important to consider that the overall erosion rate changes across geographic areas, meaning the vulnerability/risk is not necessarily evenly distributed. In cases where the mean soil erosion rate exceeds the 10 t ha^{-1} a^{-1}, erosion is considered severe and activities that can generate, or are associated with a high erosion impact should be strongly discouraged. Erosion rates between 5 and 10 t ha^{-1} a^{-1} are considered moderate, requiring some attention towards practices that have a high impact on erosion, but with less urgency. However, it is relevant to take a look not only at the mean erosion rate for the area itself, but also at its spatial distribution, which is roughly reflected on the indicator of share of (agricultural) area under severe erosion.

2.2.3 Data uncertainties

The data used is produced from an empirical computer model (RUSLE2015) and produces estimates. Hence, there are several uncertainties related to the figures if compared to data collected on the ground. However, the purpose of the model is to generate data for a large spatial scale taken into account human intervention, which is not possible to do only through empirical measurements. That being said, like every model, assumptions have to be made and there is an intrinsic level of uncertainty. Specifically related to the RUSLE methodology, Benavidez et al. (2018) critically reviewed the RUSLE methodology, upon which RUSLE2015 is based, and identified following main limitations:

- its regional applicability to regions that have different climate regimes and land cover conditions than the ones considered (in the original RUSLE for the USA, in RUSLE 2015 for Europe)
- uncertainties associated generally with soil erosion models, such as their inability to capture the complex interactions involved in soil loss, as well as the low availability of long-term reliable data and the lack of validation through observational data of soil erosion, among others.

- issues with input data and validation of results,
- its limited scope, which considers only soil loss through sheet (overland flow) and rill erosion, thus excluding other types of erosion which may be relevant in some areas, e.g. gully erosion and channel erosion, to name a few. Moreover, it also excludes wind erosion.

A further factor of uncertainty in the data is the fact that the RUSLE model is calculated using mean precipitation data over multiple years and a large territorial scale (in this case Europe). Thus, it fails to account the changes in rainfall intensity, which are highly relevant for determining water erosion accurately. This is the case not only considering the seasonality of rainfall, but also its distribution across the continent (Panagos et al., 2020). Another important uncertainty identified by Panagos et al. (2020) is the lack of georeferenced data for annual crops and soil conservation practices in the field at a continental level, which has had to be estimated from statistical data.

Nonetheless, when considered best available estimates, the mean soil erosion values generated through the application of RUSLE2015 model offer a very suitable basis for assessing vulnerability to soil loss in general terms, even if the generated absolute values are to be taken with caution (Benavidez et al., 2018).

2.2.4 Methodological uncertainties

Among the most relevant uncertainties regarding the application of the sustainability screening in terms of soil vulnerability are the selection of the threshold against which the severity of erosion is evaluated and the selection of the land cover types that will be considered.

Regarding the threshold of 10 t ha^{-1} a^{-1} for severe erosion, it is important to mention that the value from EUROSTAT database is being followed in the case of Strumica as well, as there is no other verified and official source to compare the data.[10] However, it is still an arbitrary value which can be adapted. For instance, some sources like Panagos et al. (2015, 2020), who were involved in the generation of the data for the JRC ESDAC, consider severe erosion to be above 11 t ha^{-1} a^{-1}. In this regard, it is reasonable to proceed with the lower value described in the Eurostat dataset because it is more conservative and, as such, more suitable for an initial (and indicative) sustainability screening like the one we are proposing.

The selection of land cover types presents another area for potential uncertainty. Choosing between "all lands" and "agricultural lands" can have considerable implications for interpreting the data. For example, it is possible that the mean soil erosion rate is 5 t ha^{-1} a^{-1} (moderate erosion) in one land cover type, but lower in the other. This would have an effect on the assessment, which would present any potential concerns about erosion and steps that should be taken. As such, it is important to have solid grounding for the choice of dataset. The ultimate decision whether to consider all lands (including forests) is arbitrary and lays with the group performing the sustainability screening. Particularly when that decision is based on considerations of the economic relevance of forestry related industries in the region rather than on the actual share of the area that is covered with forest (it should be high to justify their inclusion), the values of soil erosion (for all lands) shall be taken with some reservations. This is because these values tend to be lower than the value for agricultural land and can create the impression that vulnerability to erosion is lower than it actually is. However, due to the indicative (and non-exhaustive) nature of the present sustainability screening, this uncertainty is not especially relevant for cases such as the Strumica Region, where both values (for forest and agricultural land with natural grassland) are low (see section 4.1).

2.3 Biodiversity data and indicators

2.3.1 Description of the data / definition of the indicators employed

Unlike water- and soil-related risks, there are no reliable indices or standardized metrics to operationalize and compare risks to biodiversity at the regional level and in an integrated manner.

[10] See https://ec.europa.eu/eurostat/cache/metadata/en/aei_pr_soiler_esms.htm

Biodiversity is intricate and multifaceted, spanning genetic, species, and ecosystem diversity across various regions. Attempting to consolidate this diversity into a singular index may oversimplify it, leading to the loss of crucial information (Ledger et.al 2023; Brown & Williams 2016). Instead, biodiversity risks in a given region could be uncovered by considering the status of all species known to inhabit the region under scrutiny on a one-by-one basis, without trying to synthesize their collective status in a single index. Accordingly, our methodology suggests screening for biodiversity risks of a region by taking stock of its species of flora, fauna and fungi present in the demarcation and considering their conservation status. The Red List of Threatened Species of *the International Union for Conservation of Nature* (IUCN) is a globally recognized system for classifying the conservation status of species[11]. It is structured along the following risk categories (IUCN 2001, 2003):

(1) Critically Endangered (CR): This is the highest risk category assigned by the IUCN Red List for wild species. Species in this category are facing an extremely high risk of extinction in the wild.
(2) Endangered (EN): Species in this category are facing a high risk of extinction in the wild.
(3) Vulnerable (VU): Species in this category are facing risks of extinction in the wild.
(4) Near Threatened (NT): Species in this category are close to qualifying for, or are likely to qualify for, a threatened category soon.
(5) Least Concern (LC): Species in this category have been evaluated but do not qualify for any other category. They are widespread and abundant in the wild.
(6) Data Deficient (DD): A category applied to species when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution or population status.
(7) Not Evaluated (NE): A category applied to species that have not yet been evaluated against the criteria.

Data description

Data on the risk category of each species found in the SCALE-UP regions is accessed through the online database of the IUCN Red List website. The IUCN Red List serves as a comprehensive repository of information, offering insights into the present extinction risk faced by assessed animal, fungus, and plant species. In 2000, IUCN consolidated assessments from the 1996 IUCN Red List of Threatened Animals and The World List of Threatened Trees, integrating them into the IUCN Red List website with its interactive database, currently encompassing assessments for over 150.300 species. Since 2014, assessors of species have been mandated to furnish supporting details for all submitted assessments. Among the recorded details are the species' (1) IUCN Red List category, (2) distribution map, (3) habitat and ecology, (4) threats and (5) conservation actions. The assessment of these dimensions is elaborated below:

(1) The IUCN Red List category: The IUCN Red List categories (CR, EN, VU, NT, LC, DD, NE) are determined through the evaluation of taxa against five quantitative criteria (a-e), each grounded in biological indicators of population threat:
    a. Population Size Reduction: This criterion evaluates the past, present, or projected reduction in the size of a taxon's population. It considers the percentage reduction over a specific time frame, with different thresholds indicating different threat levels.
    b. Geographic Range Size and Fragmentation: This criterion assesses the size and fragmentation of a taxon's geographic range. Factors such as few locations, decline, or fluctuations in range size contribute to the evaluation.

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[11] The International Union for Conservation of Nature (IUCN) is a global environmental organization that was founded on October 5, 1948. It is the world's oldest and largest global environmental network. The IUCN works to address conservation and sustainability issues by assessing the conservation status of species, promoting sustainable development practices, and providing guidance and expertise on environmental policy and action. The IUCN also plays a crucial role in influencing international environmental policies and fostering collaboration among governments, NGOs, and the private sector to promote conservation efforts worldwide (IUCN 2018).

c. Small and Declining Population Size and Fragmentation: This criterion focuses on taxa with small and declining populations, considering factors like population size, fragmentation, fluctuations, or the presence of few subpopulations.
d. Very Small Population or Very Restricted Distribution: This criterion addresses taxa with extremely small populations or limited distributions. It assesses whether the taxon is at risk due to its small population size or restricted geographic range.
e. Quantitative Analysis of Extinction Risk: This criterion involves a quantitative analysis, such as Population Viability Analysis, to estimate the extinction risk of a taxon. It considers various factors influencing population dynamics and extinction risk.

While listing requires meeting only one criterion, assessors are encouraged to consider multiple criteria based on available data. Quantitative thresholds of the IUCN Red List categories were developed through wide consultation and are set at levels judged to be appropriate, generating informative threat categories spanning the range of extinction probabilities. To ensure adaptability, the system permits the incorporation of inference, suspicion, and projection when confronted with limited information.

(2) The distribution map: The IUCN Red List distribution map serves as a reference for the taxon's occurrence in the form of georeferenced data and geographic maps. This data is available for 82% of the assessed species (>123.600) and is based on the species' habitat, which is linked to land cover- and elevation maps. The indicated area marks the species extent of occurrence, which is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred, or projected sites of present occurrence of a species, excluding cases of vagrancy. This measure may exclude discontinuities or disjunctions within the overall distributions of species, such as large areas of obviously unsuitable habitat. For a detailed explanation of the mapping methodology, please refer to the *Mapping Standards and Data Quality for the IUCN Red List Spatial Data* (IUCN 2021).

(3) Habitat and Ecology: The IUCN classifies the specific habitats that a species depends on for its survival. These habitats are categorized into three broad systems: terrestrial, marine, and freshwater. A species may inhabit one or more of these systems, and so the possible permutations result in seven categories of natural systems. Beyond these seven system categories, the IUCN offers a more nuanced classification system for habitats, comprising 18 different classes at level 1 (e.g., forest, wetlands, grassland, etc.), and 106 more specific classes listed at level 2 (e.g., Forest – Subtropical/tropical moist lowland, Wetlands (inland) – Permanent inland deltas; Grassland - Temperate) (IUCNa n.d.). For SCALE-UP's sustainability screening, the IUCN classification of the seven systems is sufficient to refine the search while not excluding relevant habitats. The EU Habitats Directive, in contrast, distinguishes 25 habitat types that are considered threatened and require active and recurring conservation action. The Directive demands member states to take measures to maintain or restore these natural habitats and wild species. If data on these became accessible in the future, it could be used in future iterations of the sustainability screening to supplement the results that using the IUCN classification yields.

(4) Threats: The IUCN database encompasses various general threats that can negatively impact a species. Direct threats denote immediate human activities or processes impacting, currently impacting, or potentially affecting the taxon's status, such as unsustainable fishing, logging, agriculture, and housing developments. Direct threats are synonymous with sources of stress and proximate pressures. Assessors are urged to specify the threats that prompted the taxon's listing at the most granular level feasible within this hierarchical classification of drivers. These threats could be historical, ongoing, or anticipated within a timeframe of three generations or ten years. These generalized threat categories encompass residential and commercial development, agriculture and aquaculture, energy production and mining, transportation and service corridors, biological resource use, human intrusion and disturbances, natural system modifications, invasive and other problematic species, genes and diseases, pollution, geological

events, and climate change and severe weather. Beneath each general threat, more specific threats are detailed. Please refer to the IUCN Red List's website[12] for a detailed list of all threats, including explanations.

(5) Conservation Actions: The IUCN database contains conservation action needs for each species, providing detailed information on the current conservation efforts and recommended actions for protecting the taxon. It includes general conservation actions such as research & monitoring, land/water protection, management, and education. Specific conservation actions are listed under each general action, along with a description of the current conservation status and recommended actions to protect the taxon. A hierarchical structure of conservation action categories (see the IUCN Red List's website[13]) indicates the most urgent and significant actions needed for the species, along with definitions, examples, and guidance notes on using the scheme. Assessors are encouraged to be realistic and selective in choosing the most important actions that can be achieved within the next five years, informed by the conservation actions already in place.

2.3.2 Methodology applied

The methodology aims to derive a list of species which would require special consideration (e.g. close monitoring and safeguarding) in the context of implementing bioeconomy activities. To generate this list, the search function of the interactive IUCN database is used following five steps:

(1) Scope of Assessment: Selection of Europe as the scope of assessment to evaluate the conservation status of the European population rather than the global population. This approach ensures that species are identified as threatened based on their status in Europe, irrespective of their global abundance.

(2) Geographical Delineation: Utilization of the interactive map of the IUCN database to draw a polygon that exceeds the region of interest. Exceeding the regions ensures that the entire region is covered, as it is not possible to draw a polygon exactly matching the boundaries of the region. Moreover, a larger polygon also respects the uncertainty of delineating a species area of extent, since the actual area of extent is possibly more fluid than its statically indicated geolocations. Consequently, the larger polygon minimizes the risk of excluding any relevant species for which geolocations are registered just minimally outside of the regions' administrative boundaries, but which could inhabit parts of the region in the future. There is no rule of thumb for a correct distance between polygon boundary and region boundary.

(3) Species Selection: Limiting the search results to endangered and critically endangered species to focus on those facing the most severe risks. Additionally in the case of Strumica region, vulnerable criteria is also taken into consideration, as the region do not have any critically endangered species.

(4) Habitat Selection: selection of all habitats to ensure the full coverage of habitat types present in the geographical delineation defined in step 2.

(5) Threat Selection: Selection of threats associated with the respective regional bioeconomy and/or value chain to refine the search results to species likely to be impacted by them.

By following these steps, a targeted list of species is derived, focusing on species facing significant risks within the context of the regional bioeconomy strategy or value chain being explored, aligning with the specific conservation and bioeconomic priorities of the region.

[12] See here: https://www.iucnredlist.org/resources/threat-classification-scheme
[13] Ibid.

2.3.3 Data uncertainties

It is important to acknowledge certain limitations and uncertainties associated with the data and methodologies used:

(1) Inaccurate representation of relevant area: The IUCN database allows for the interactive drawing of a map for a regional assessment. However, this drawn map might not accurately represent the area directly relevant to the bioeconomy strategy or value chain being explored. Since the selected polygon is larger than the actual bioregion, the assessment risks to include species that are not relevant to the bioregion and the bioeconomic strategy of the region.

(2) Lack of local habitat differentiation: The spread of species is indicated as its extent of occurrence without differentiating between habitats at the local level. This means that certain species might solely inhabit very particular habitats within the indicated extent of occurrence. An endangered amphibious species, for instance, might have an area of extent covering an entire country. However, it will only be found in very rare habitats within this area of extent (e.g., pond with very specific qualities). Accordingly, a regional assessment as outlined here (e.g., at the municipal level) might list certain species that do not occur in the assessed regions due to a lack of suitable habitats on the local level.

(3) Potential oversights in conservation status: Using Europe as a scope of assessment might hide any problematic conservation status of a species at the global or at the local level.

(4) Outdated data: The IUCN aims to have the category of every species re-evaluated at least every ten years and aims to update the list every two years (IUCNb n.d.). Nevertheless, the data might be outdated, which could lead to inaccuracies in the assessment of biodiversity risks. For the screenings carried out in SCALE-UP for the Strumica region, 32% of the data is published within the last 5 years (2019-2024), and 66% is published during the period 2010-2017.

(5) Incomplete data: The data might be incomplete, which could limit the comprehensiveness of the assessment.

(6) Limited species coverage: It is estimated that the world hosts about 8,7 million species (Sweetlove, 2011). As of now, more than 150.300 species (16.120 in Europe) have been assessed for the Red List, leaving large data gaps at the global level.

(7) Taxonomic standards: The taxon being assessed must follow the taxonomic standards used for the IUCN Red List. Any deviation from these standards could lead to inaccuracies in the assessment.

At both the national and regional levels, there exists the National Biodiversity Strategy with Action Plan covering 2018-2023[14] and the Biodiversity Strategy and Action Plan for the Southeast Planning Region starting from 2020[15]. Although these documents could potentially validate data in the IUCN database, this validation was not conducted as part of the SCALE-UP project's current task. However, it is

[14] https://www.moepp.gov.mk/wp-content/uploads/2018/05/STRATEGIJA%20ZA%20BIOLOSKA%20RAZNOVIDNOST%20SO%20AKCISKI%20PLAN%202018_2023.pdf

[15] https://southeast.mk/wp-content/uploads/2021/07/%D0%A1%D1%82%D1%80%D0%B0%D1%82%D0%B5%D0%B3%D0%B8%D1%98%D0%B0-%D0%B7%D0%B0-%D0%B1%D0%B8%D0%BE%D0%BB%D0%BE%D1%88%D0%BA%D0%B0-%D1%80%D0%B0%D0%B7%D0%BD%D0%BE%D0%B2%D0%B8%D0%B4%D0%BD%D0%BE%D1%81%D1%82-%D0%B8-%D0%90%D0%BA%D1%86%D0%B8%D0%BE%D0%BD%D0%B5%D0%BD-%D0%9F%D0%BB%D0%B0%D0%BD-%D0%B7%D0%B0-%D0%88%D1%83%D0%B3%D0%BE%D0%B8%D1%81%D1%82%D0%BE%D1%87%D0%B5%D0%BD-%D0%BF%D0%BB%D0%B0%D0%BD%D1%81%D0%BA%D0%B8-%D1%80%D0%B5%D0%B3%D0%B8%D0%BE%D0%BD-%D1%84%D0%B8%D0%BD%D0%B0%D0%BB%D0%BD%D0%BE.pdf

recommended as a future initiative for regional experts and stakeholders to ensure a unified approach within the project.

3 Potential ecological burden of regionally relevant bioeconomic activities

3.1 Bioeconomic activity selected for the screening

The agricultural land use in the Strumica region covers nearly 25,000 hectares, mainly for pastures, meadows, and garden crops like tomatoes and peppers. Garden crops contribute over 140,000 tons annually. Fruit production, particularly apples, is significant, with substantial orchard areas and high production numbers. Wine production, though not the primary focus, yields a considerable amount, emphasizing the potential use of pruning residues for composting. Forest residues, afforestation, and gross felled timber provide additional biomass resources. Municipal biowaste from households and commercial sectors, especially organic waste, is considerable, with a focus on composting. The regional municipal waste generation in 2022 was 71,724 tonnes, of which 60% is estimated to be organic waste. Industries, including vegetable and fruit processing, wood processing, and beverage production, contribute to secondary residues. As a result, the Strumica region has a potential for utilization of agricultural residues for compost production. Although it has good examples to some extent, further systematic approach is needed, thus willingness of the farmers to contribute to the enhancement of the region in a sustainable manner.

3.2 Overview, management practices and potential burden on the resources examined

3.2.1 Potential burden on water resources

Water Eutrophication and Acidification: Giuntoli et al. (2014) elaborate on general tendencies related to the impact of agricultural residue removal on water ecosystems. In particular, increased removal of agricultural residues could lead to greater soil erosion and nutrient runoff, leading to problems with sediment delivery and eutrophication in nearby water bodies.

Moreover, an analysis by Persiani et al. (2020) of several procurement systems of bulking agents and agricultural crop residues allocated to composting on-farm in Southern Italy identifies the least environmentally harmful approaches. Such include transportation of agricultural residues in pallets on a small truck as well as manual loading and uploading (ibid.). With this system, eutrophication amounts to 4.7E-04 kg PO4 – eq and acidification is 1.5E-03 kg SO_2 eq, according to the conducted LCA (ibid.).

Water Pollution and potential implications on water availability: In general, the risks of water contamination by surface runoff are found to be reduced through composting of agriculture wastes in comparison to conventional land management (stock piling manure) (Mukaetov, 2013). Specifically for Strumica, a study by Kovacevik et al. (n.d.) has shown the presence of arsenic pollution in groundwater bodies located in the central valley of the Strumica region. The presence of contaminants here has been related to natural processes, yet its potential implications (e.g. reduced overall availability of safe drinking water for human and animal use and potential toxicity threats for future agricultural production in the Strumica region) would call for careful consideration when scaling up activities that could disproportionately increase the demand for such resources in the future. This can be especially relevant for agricultural operations in Strumica, where water availability is already a limiting factor and where plant stress due to insufficient water has been documented (Mukaetov et al., 2014).

3.2.2 Potential burden on soil resources

Soil quality (incl. SOC, SOM, erosion): Long periods of drought alternating with intense rains are common in North Macedonia, which causes soil erosion and land degradation. Extreme changes in temperature and precipitation are expected to increase due to climate change, and they put large pressure on agricultural production. The southeastern region of the country, where Strumica is located, already shows sharp and progressive increases in air temperature (Mukaetov et al., 2014). Composting helps to disseminate nutrient levels across the area thereby fertilizing the soil (Persiani et al., 2020; Vlachokostas et al., 2021). Compost amended soil is also more resistant to wind and water erosion due to the improved soil structure and enhanced soil moisture-holding capacity (Mukaetov, 2013). This can be very relevant in the Strumica Region, where runoff from intense rainfall and flooding has been a challenge in the past (.e.g in the Spring of 2013) and is projected to increase due to climate change (Mukaetov et al., 2014). However, if improperly managed, composting of fresh residues is likely to release a large quantity of leachates alongside undesirable by-products (Persiani et al., 2020). Adding a bulking agent or structural material, for instance, wood chips, straw, rice husks, cotton waste, helps to eliminate these issues improving ventilation and water penetration as well as enhancing microbial growth and activity (ibid.). Also, these bulking agents may be employed to modify the availability of carbon, the C/N ratio, and the pH level throughout the composting process. These adjustments can accelerate the breakdown of materials, improve the stability of the composted organic matter, and inhibit the growth of pathogens and parasites (ibid.).

Another way to utilize agricultural residues is anaerobic digestion which allows recovering the energy content in addition to producing digestate, the final bioproduct of the procedure (Vlachokostas et al., 2021). The digestate can be used on farmland as liquid organic fertilizer soil improver or a component in growing media on account of its significant nutrient content (ibid.). Simultaneously, it should be kept in mind that removing agricultural residues from the land for different purposes, for example, to use as an energy source can adversely affect the soil. Possible effects include reduced soil carbon and nutrient levels, a decline in organic matter, decreased water retention capacity of soils, and a heightened risk of erosion (Chukaliev, 2010; Kluts et al., 2017). Keeping agricultural residues on the ground can contribute to the enrichment of the soil ecosystem with nutrients and to its enhancement with organic matter, reducing the risk of soil erosion, and helping to maintain soil moisture, thereby supporting soil health and quality (Chukaliev, 2010; Ristakjovska Shirgovska & Prentovikj, 2021).

Maintaining and increasing SOC content in soil is especially important for Southern Europe where it is found to be already low or decreasing (Giuntoli et al., 2014). Znaor et al. (2022) list several common carbon practices that can be employed in North Macedonia to increase SOC, among other things, conservation tillage is named. This practice implies that at least 30% of crop residues are left in the field which also help to reduce soil erosion (Mukaetov, 2013). Kluts et al. (2017) find that sustainable removal rates of 40% for cereal crops and 50% for maize, rice, rapeseed and sunflower are used most often. Chukaliev (2010) draws an example of straw incorporated in soil, calculating equivalences between nutrient loads of residues and those of fertilizers (per 1 t of straw: 6-7 kg N; 2-2,5 kg P_2O_5; and 14-17 kg K_2O) and evaluating which leads to more carbon sequestrated in the soil, enrichment of soil with organic matter and erosion protection. Ristakjovska Shirgovska & Prentovikj (2021) confirm that cereal residues should be considered for the purpose of enhancing soil organic matter, due to their high carbon and nitrogen ratio and slow decomposition rates.

Lastly, it is not recommended to discharge residues if they were subject to substantial processing. For example, looking further into the value chain of wine, one of the relevant products of the Strumica Region, this could be the case for leftover distilled wine lees no longer used for alcohol production and subsequently usually treated as waste. Naziri et al. (2014) found the direct discharge of lees in the agricultural field harmful. A possible way of valorising them is as a component for plant growing media. However, the limitation of this approach is that the nutritional value of wine lees is reduced after distillation.

Soil Acidification and Pollution: The Third National Communication on Climate Change for North Macedonia indicates that between 30 and 80 thousand hectares of irrigated agricultural land in the country are susceptible to salinization and other forms of degradation (Mukaetov et al., 2014). Among other things, composting is found to help minimize soil contamination (Vlachokostas et al., 2021). As regards the management and collection of agricultural crop residues and bulking agents necessary for composting, the study by Persiani et al. (2020) cited earlier in this section also provides insights on the positive effects of employing more extensive procurement systems on soil ecotoxicity and acidification.

3.2.3 Potential burden on biodiversity

The impacts of these bioeconomy activities on biodiversity in North Macedonia remain largely understudied. Some general tendencies can be inferred from above-described practices, such as leaving part of agricultural residues on the farmland or utilizing compost which leads to increase in SOM and SOC. Znaor et al. (2022) point out that these components determine the state of biodiversity. Moreover, compost itself contains a large number of microorganisms (e.g., bacteria, fungi, algae) the diversity of which defines the compost quality (Persiani et al., 2020). Therefore, compost environment provides living space for microbial communities.

In addition, it is possible to examine specific examples and cases of biodiversity-related applications of agricultural residues. For instance, a possible solution for the utilization of distilled wine lees is as supplement in animal nutrition or for plant growing media. Here, it is still important to consider the limitations of such approach linked to the finding that nutritional value of wine lees after distillation is reduced (Naziri et al., 2014).

Giuntoli et al. (2014) describe some general trends how agricultural residue removal can affect biodiversity. For example, species reliant on farmland environments, e.g., farmland birds, may be adversely affected. A reduced addition of new organic matter to the soil may affect species that live on the soil surface and within it, potentially leading to a cascading effect on these ecosystems overall (ibid.).

Giuntoli et al. (2014) further claim that digestate enhances soil microbial biomass and dehydrogenase activity, which is recognized as a reliable biomarker for indicating shifts in microbial activity. In such a way, biological activity in soil is maintained with digestate application.

4 Screening results and recommendations

4.1 Overview - Strumica

Resources screened		Ordinal Baseline Rating	Use of agricultural and food production residues for compost production	
Category	**Sub-Category**		**Potentially beneficial to the baseline status**	**Potentially detrimental to the baseline status**
Water	**Surface water bodies**		- Shifting from stockpiling of agricultural waste (e.g. manure) in the field, to preparation of compost in securely lined spaces and its controlled application - Implementing natural water retention measures to deal with limited water resources in the region - Increasing irrigation efficiency while keeping expansion of agricultural operations in check	- Unrestrained removal of agricultural residues (e.g. driven by a created demand for byproducts) that could potentially lead to nutrient runoff and eutrophication - Continued lack of maintenance and investment on (ground)water monitoring infrastructure, prolonging the current lack of insight on the state of aquifers in the region
	Groundwater bodies	**n/d**		
Land & Soil Resources	**-**		- Conservation tillage, leaving 30% (or more, depending on the crop) of crop residues in the field, to maintain/increase Soil Organic Carbon and nutrient levels, and reduce soil erosion - Incorporating bulking- or structure-enhancing agents (e.g. wood chips, straw) to fresh residues used in the compost to avoid leachate	- Unrestrained removal of agricultural residues (e.g. driven by a created demand for byproducts) that could potentially lead to increased soil erosion - Discharge of substantially processed agricultural- or food and beverage production residues (e.g. wine lees) onto the agricultural field, resulting in soil contamination
Biodiversity	**Endangered Species**	**2**	- Carefully controlling the compost quality so that the desired microorganisms can thrive and pathogen and parasite growth is inhibited - Where applicable, considering applying digestate at proportionate levels to enhance the soil microbial biomass	- Large-scale removal of residues on which farmland birds may depend - Introduction of new crop hybrids or varieties (to maintain production levels under a changing climate) without diligent consideration of their impact on local species, water and nutrient requirements.
	Critically Endangered Species	**0**		

4.2 Recommendations

The RBMP for Strumica delineates a comprehensive Program of Measures aimed at preserving and reinstating water quality, with a focus on addressing significant challenges within the RBD. These measures encompass regulatory actions, involving the implementation of stringent regulations to ensure the protection of water quality. The plan includes initiatives to monitor and manage the discharge of urban wastewater and regulate wastewater discharge from areas lacking proper sewer systems. Agricultural pollution is tackled through strategies encompassing the management of waste and hazardous materials, soil management, erosion control, and the regulation of fertilizer and pesticide use. Furthermore, the RBMP addresses water withdrawals by regulating both municipal and irrigation water withdrawals to sustainably manage water resources. The plan also incorporates various additional measures, covering actions in protected areas, flood protection, and enhancements in solid waste management and sludge control. In essence, the RBMP for Strumica is a comprehensive strategy aimed at safeguarding and restoring the water status by implementing a diverse array of measures across regulatory, agricultural, and environmental domains.

To address soil quality and utilization concerns in the municipality of Strumica, a set of recommendations is proposed in the scope of the Local Environmental Action Plan for Strumica for the period 2024- 2029.[16] This includes completing urban and spatial planning documentation, enhancing collaboration between central and local authorities, and documenting agricultural activities in rural areas. Soil quality tests are recommended, along with the creation of a map to identify suitable areas for organic farming. The transition to micro-irrigation systems is suggested for efficient water use. Additionally, implementing reduced or protective tillage techniques and continuing farmer education on proper agronomic practices are emphasized. The installation of sewage systems in all populated areas, afforestation, and controlled forest cutting are also recommended measures to combat erosion and adapt to climate change. Biochar application on low-fertile land is a recommended mitigation measure, offering a strategy for carbon sequestration and "negative emissions." This technology involves the thermal conversion of biomass, resulting in long-term carbon sequestration with additional benefits, such as reducing nitrous oxide emissions and improving nutrient and water-use efficiencies.

In order to overcome biodiversity concerns, several recommendations are given by the experts and stakeholders responsible for conducting the Local environmental action plan for Strumica. This includes conducting comprehensive monitoring across four seasons to identify persistent biodiversity, assess habitat conditions, and propose protective measures. The revitalization of the Monospitovo Swamp is suggested, emphasizing inter-municipal collaboration in the Southeastern region. Additionally, documentation for the valorization of Mount Elenica is recommended, focusing on the protection and proper management of specific areas, habitats, or species. Revitalization efforts for degraded areas of Mount Elenica and Plavush are also recommended. Public awareness campaigns are proposed to highlight the importance of natural wealth preservation, and efforts to raise awareness about the use of agrochemicals and promote organic farming are encouraged.

Furthermore, having feedback from the regional stakeholders which are directly involved in the advancement and development of the Strumica region is significantly critical and greatly contribute to the general recommendation. The feedback is gathered during a regular platform meeting held in February 2024 and it is based on the experience and knowledge of four regional stakeholders.

In recent years, efforts have been made to improve water-related activities in Stumica river basin region. Cleaning of the Trkanja River was done last year, and plans are in place to do the same for the Vodoshnica River this year. Canals stretching 2.5 km were constructed, and new channels for stormwater were established in collaboration with the MoEPP. Recommendations for the future include improving groundwater monitoring and updating data on groundwater, building a new sewage treatment plant for smaller settlements, since the current one caters to 55,000 households, and its capacity is already fulfilled, implementing atmospheric sewage in Murtino, establishing a water

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purification station in Bansko, and efficiently utilizing thermal waters, potentially through the construction of a spa center.

To enhance sustainable agriculture, a series of measures are proposed. This includes improving practices to address erosion, advocating against burning crop residues, and encouraging plowing instead. Crop rotation and diversification are promoted for soil health, with a recommended cycle of changing crops every 1-3 years. Citizen involvement is crucial, urging them to compost and adopt good practices from the region and European countries. Instead of burning plant waste, a system of collection and compost distribution as an incentive is proposed. Planting on erosive areas is emphasized, along with the establishment of dedicated areas for separating organic production and other plant residues. Lastly, strict enforcement of regulations is advocated to prevent the construction of photovoltaic installations on specific agricultural land categories and discourage their conversion for alternative purposes.

Preserving biodiversity in the Strumica region requires proactive measures and initiatives. One crucial step is to declare the Monospitovo Swamp as a protected area, recognizing its ecological significance. Similarly, there is a need for initiatives aimed at safeguarding Belasica, acknowledging the importance of preserving this natural habitat. Additionally, attention must be directed towards the endangered status of ferns, necessitating the implementation of appropriate measures to prevent their disappearance. These initiatives collectively contribute to the conservation and sustainable management of the region's biodiversity, ensuring the long-term health and balance of the local ecosystems.

Following the recommendations mentioned above regarding the water, soil and biodiversity, could significantly enhance compost production and the management of inputs (residues) in the Strumica region. Initially, it is strongly recommended to promote successful composting practices among farmers, households, and businesses. Establishing community composting facilities or decentralized units can efficiently manage organic waste. Source segregation of organic waste at various levels is crucial for high-quality compost production. Providing training programs and capacity-building workshops for farmers and waste management personnel can improve composting techniques. Developing and implementing regulations supporting composting and organic waste management, along with public awareness campaigns, can encourage community participation. Investing in research and development, and fostering partnerships with local stakeholders, will further strengthen the composting ecosystem in the region.

In terms of sustainable agriculture, integrated composting systems offer innovative solutions that synergize with water and soil management practices. Incorporating treated wastewater into composting processes enhances nutrient content, promoting soil enrichment and water conservation. Furthermore, biochar integration, derived from agricultural residues, contributes to carbon sequestration, improved soil structure, and enhanced nutrient retention. This dual-purpose approach supports both environmental and soil health goals. To foster biodiversity, composting practices are designed to attract and sustain beneficial organisms, promoting ecological balance. Nutrient cycling takes center stage, tailoring compost mixes to meet the specific needs of local soils and crops, ensuring a holistic approach to soil enrichment. Nonetheless, precision agriculture techniques, including soil mapping and monitoring, optimize compost application, maximizing its efficacy. Encouraging cover cropping and green manure practices alongside composting enhances organic matter content, soil structure, and pest management. Finally, establishing monitoring and evaluation systems ensures continuous refinement of composting practices for optimal results.

In conclusion, the integration of recommendations, including improved composting practices, sustainable agriculture, and proactive biodiversity preservation, collectively forms a holistic strategy to enhance the ecological well-being and long-term sustainability of the Strumica region.

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