bioeconomy development

Sustainability Screening – Mazovia, PL

March 2024

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This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101060264.

Document information	
Project name:	SCALE-UP
Project title:	Concepts, tools and applications for community-driven bioeconomy development in European rural areas
Project number:	101060264
Start date:	1st September 2022
Duration:	36 months

Report:	**This synthesis report of the sustainability screening will feed into *D2.1: Report on regional biomass availabilities, nutrient balances and ecological boundaries***
Work Package:	WP2: Knowledge for Bio-based Solutions
Work Package leader:	BTG
Task:	Task 2.3: Regional biomass availabilities, nutrient balances and ecological boundaries
Task leader:	[Subtask] ECO
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Internal peer review:	-
Planned delivery date:	M18
Actual delivery date:	M18
Reporting period:	RP1

Dissemination level of this report		
PU	Public	x
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CO	Confidential, only for members of the consortium (including the Commission Services)	

ACKNOWLEDGMENT & DISCLAIMER

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101060264.

EXECUTIVE SUMMARY

This report has been elaborated as part of the SCALE-UP project funded by the Horizon Europe research and innovation programme. The aim of this project is to support the development of small-scale bioeconomy solutions in rural areas across Europe.

The main objective of this study is to raise awareness of the ecological limits in the Mazovia region (*województwo mazowieckie*) in Poland, based on three resources: water, soil and biodiversity. The bioeconomy is by definition the economy of bioresources (from agriculture, forestry, aquaculture and biowaste), therefore of the living. It is essential to design bioeconomy sustainably, and that its development takes into account the potential impact on the environment. Furthermore, in the current context of fighting against climate change and environmental degradation, bioeconomy activities that provide environmental benefits (water quality, preservation of biodiversity, etc.) must be sought and encouraged.

Mazovia region is one of the six focal regions for the SCALE-UP project and is characterized by high industry diversification, low unemployment and high economic development speed and young and well qualified staff. It is also one of the most internally diverse areas in Poland, showing high internal diversification in science, research, education, industry and infrastructure. Agriculture is one of the most important sectors in the Mazovia and it is characterized by very fertile soils enabling a thriving development of agricultural economy with usable agricultural land covering about 65% of the area. The role of horticulture – especially apple production – is significant, as Poland is the largest producer of apples in Europe and almost half the country's production of apples is concentrated in the Mazovia region. Additionally, Mazovia region is one of the most populated areas in Poland, where renewable water resources play a key role in providing drinking water to residents.

Having in mind that Mazovia region is affected by the impacts of climate change, rising temperatures and significant pressure on water resources, soils and biodiversity, this report is therefore aimed at project leaders and stakeholders in the bioeconomy willing to develop an activity, to enable them to integrate these environmental considerations into the development of their product or service.

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1.1 Water resources management profile

Poland counts with a modest volume of renewable water resources every year, one of the lowest in Europe. The average water resources in Poland are approximately 60 billion m3 and in dry seasons this level may drop below 40 billion m3. In comparison, France, Sweden and Germany have water resources (in absolute values) of respectively: 206 billion m3, 196 billion m3, 188 billion m3. Surface water in Poland is characterized by high temporal and territorial variability, which causes periodic excesses and deficits of water in rivers (Environment 2023, GUS Statistics Poland Warszawa 2023).

The country's multi- annual average river discharge for years 2000-2022 was 56 km^3. (Environment 2023, GUS Statistics Poland Warszawa 2023). Considering Poland's current population of 38.5 million, this amounts to ca. 1,600 m3 of water resources available per capita per year (compared to a global average of ca. 6,500 m3 and a European average of ca. 4,500 m3). Poland also has one of the lowest water retention rates in Europe, of only ca. 6%. This rate is the ratio of the current, total capacity of the water in retention reservoirs (ca. 4 km3) and the multi-annual average river discharge mentioned above. In many European countries this rate exceeds 12%.

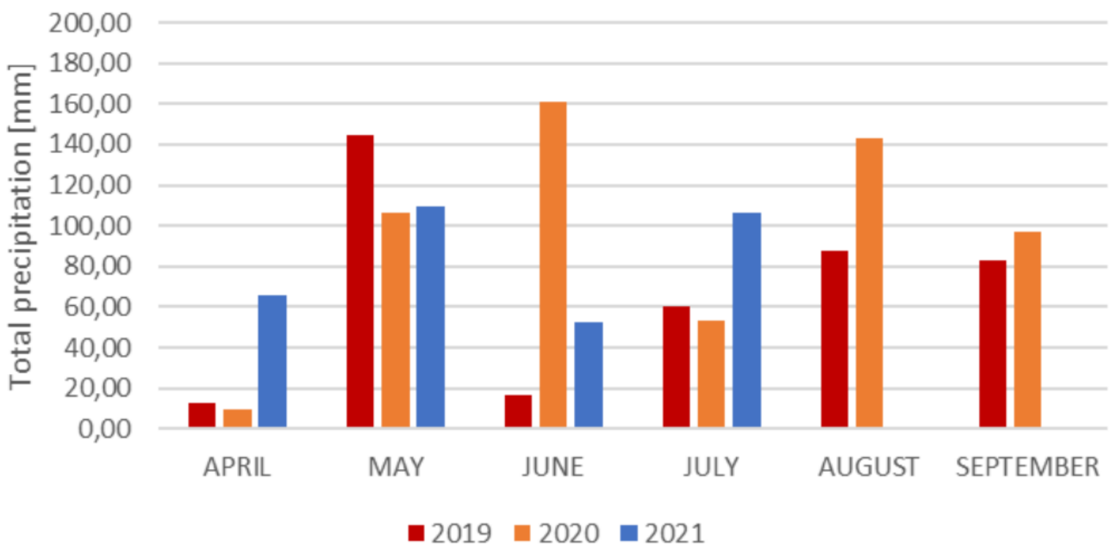


Figure 1 - Average sum of monthly precipitation over the Mazovian voivodeship. Source: Institute of Geodesy and Cartography, igik.edu.pl 2023

As shown in the figures below, the total water abstraction in Poland is 9385,4 m3, and is roughly distributed as follows: industry (69%), agriculture (9%), and municipal economy (22%) (GUS 2023).

Wykres 3. **Pobór wody na potrzeby gospodarki narodowej i ludności**
Chart 3. Water withdrawal for the needs of the national economy and population

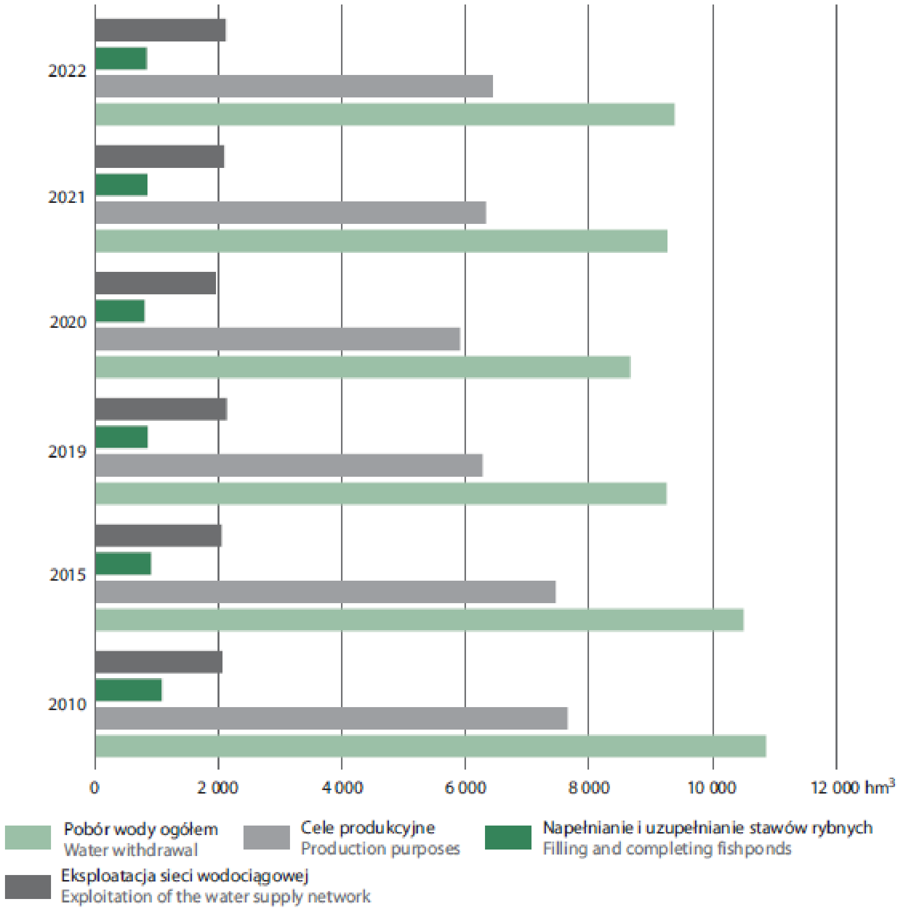


Figure 2 - Water withdrawal for the needs of the national economy and population. Source: Environment 2023, GUS Statistics Poland Warszawa 2023

Tabela 3. **Pobór wody na potrzeby gospodarki narodowej i ludności według źródeł poboru**
Table 3. Water withdrawal for the needs of the national economy and population by sources of withdrawal

Wyszczególnienie Specification	2010	2015	2019	2020	2021	2022
	w hektometrach sześciennych in cubic hectometers					
Ogółem Total	10 866,4	10 502,6	9 253,6	8 666,3	9 267,1	9 385,4
Wody powierzchniowe Surface waters	9 172,6	8 770,2	7 439,9	6 900,8	7 484,7	7 586,0
Wody podziemne Underground waters	1 625,2	1 677,3	1 772,1	1 720,2	1 738,3	1 761,0
Wody z odwadniania zakładów górniczych oraz obiektów budowlanych (użyte do produkcji) Water from mine and building constructions drainage (used for production)	68,6	55,2	44,2	45,3	44,1	38,4

Figure 3 - Water withdrawal for the needs of the national economy and population by source. Source: Environment 2023,GUS Statistics Poland Warszawa 2023

A large share of industrial water use is employed for cooling turbine condensers in thermal power plants. While this type of use does not result in a significant volumetric difference between input and effluent water at the plant level, it does have important implications on water quality (e.g. due to thermal pollution). As regards the agriculture sector, while irrigation often represents an important share of agricultural water use in other countries, Polish agriculture is based entirely on rainfall (Majewski, 2015).

Mazovia is the most populated area in Poland (14 percent of the country's population) and mainly abstracts water resources from rivers such as the Vistula, Bug and Narew to supply drinking water to its residents. There are numerous water reservoirs in the region that are used to irrigate farmlands and produce electricity. Some of these reservoirs, such as Lake Zegrze, also serve recreational and tourism functions. Currently, access to exact numbers regarding the volume of water resources in Poland and Mazovia is limited.

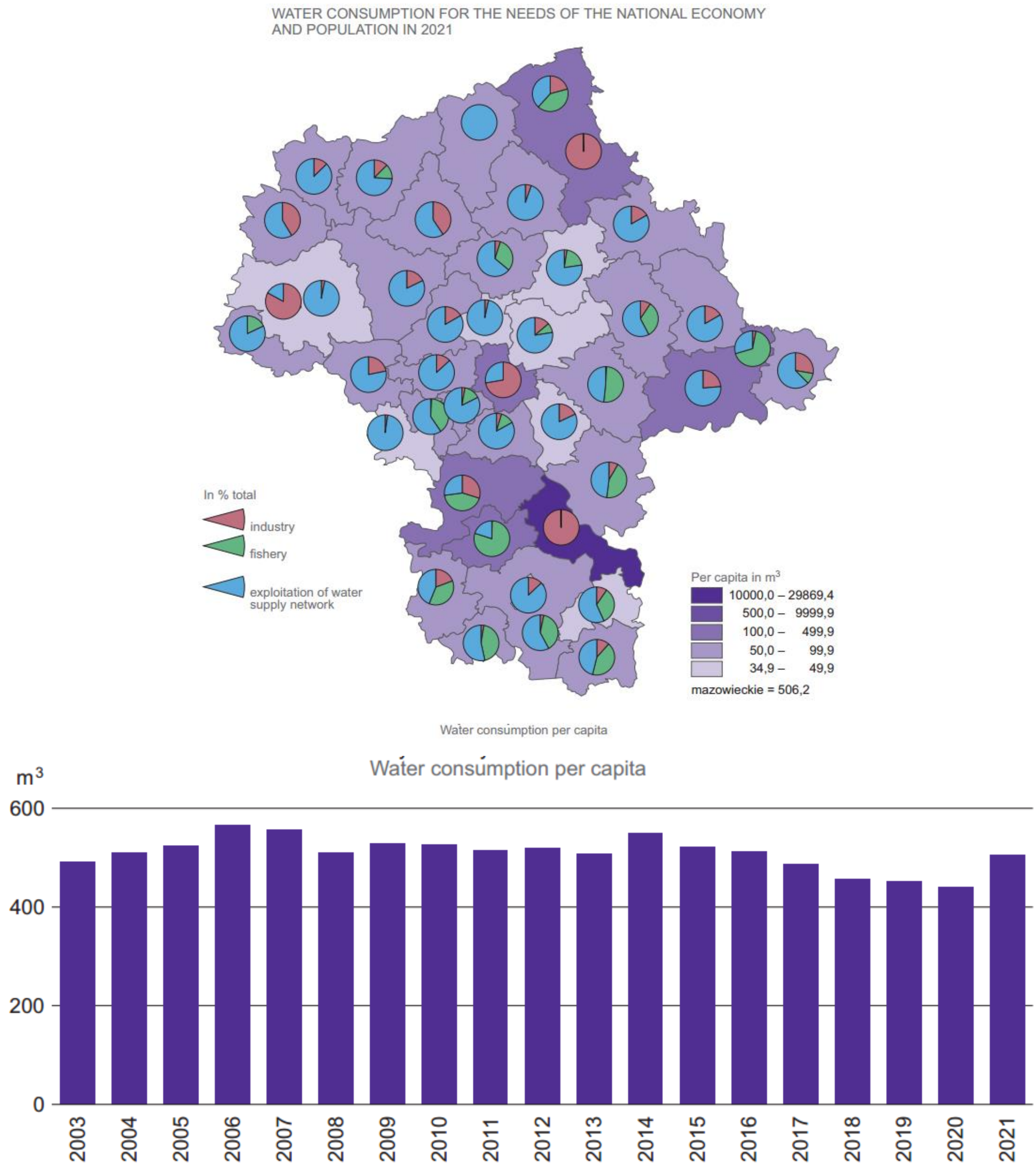


Figure 4 - Water Consumption per capita and per sector in Mazovia. Source: Statistical Office in Warszawa, 2022.

In relation to data from the Statistical Yearbook of Mazowieckie Voivodship (Mazovia region), in terms of the population connected to wastewater treatment plants in 2021 in Mazovia, there are considerable differences (see figure below), as urban population is widely connected to these kind of plants while people living in rural areas do not have it accessible in such extension.

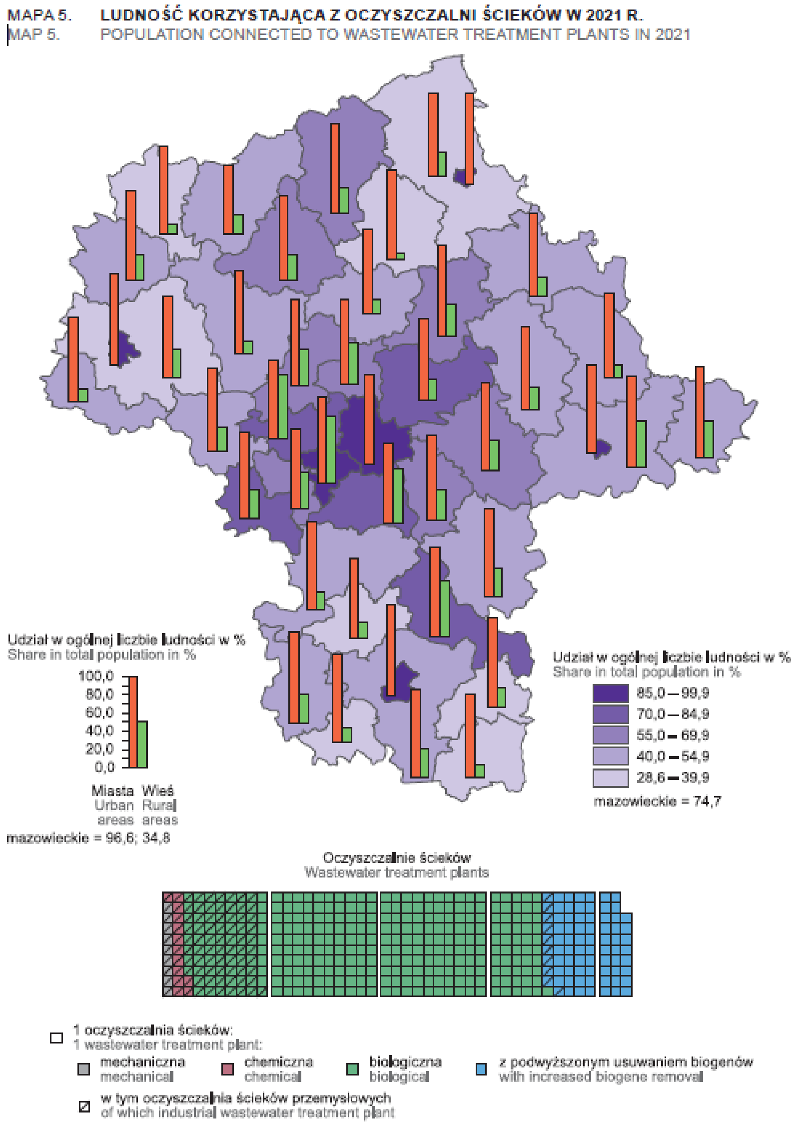


Figure 5 - Population connected to wastewater treatment plants in 2021 in Mazovia region. Source: Statistical Yearbook of Mazowieckie Voivodship

Water management in Poland involves multiple stakeholders and hierarchical structures responsible for overseeing various aspects of water resource utilization and protection. At the national level, the National Water Agency (Gospodarstwo Wody Polskie), along with the Ministry of Environment, plays a pivotal role. The National Water Agency supervises key entities such as the National Board for Water Management and Regional Water Management Boards. It holds ownership rights over state-owned waters and administers water use fees and taxes. Additionally, it oversees the preparation and implementation of River Basin Management Plans, Flood Risk Management Plans, and the National Programme for Urban Wastewater Treatment. The Ministry of Environment, on the other hand, is tasked with adopting the National Environmental Policy and overseeing institutions like the Chief Inspectorate of Environmental Protection (Główny Inspektorat Ochrony Środowiska) and the National

Fund of Environmental Protection and Water Management (Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej).

At the regional level, the Regional Water Management Boards (RWMBs) take charge of water management within their respective demarcations. They undertake various activities including identifying pressures on water resources and assessing their impacts; developing terms of water use, conducting economic analyses, and preparing flood studies and protection plans. RWMBs also coordinate flood and drought protection efforts and approve tariffs for municipal water supply and sanitation services. Furthermore, they issue consents for water use and provide opinions on draft regulation pertaining to water supply and sanitation. Voivodeship-level institutions are tasked with implementing and enforcing national water policies at the regional level, issuing permits for investments and monitoring water quality, while counties play a limited supervisory role over water companies.

At the local level, authorities collaborate with regional and national authorities to protect drinking water sources and implement measures outlined in River Basin Management Plans, Flood Risk Management Plans, and the National Programme for Urban Wastewater Treatment. Local authorities also oversee companies responsible for water supply and wastewater treatment within their jurisdictions. The delineation of responsibilities among national, regional, and local entities aims to establish a structured approach to water management in Poland, which is meant to facilitate effective resource utilization and environmental protection across different administrative levels.

Challenges related to water resource management in Mazovia include more extreme and shifting seasonal fluctuations and the associated droughts and floods that can cause difficulties in access to water, especially during periods when it is most needed.

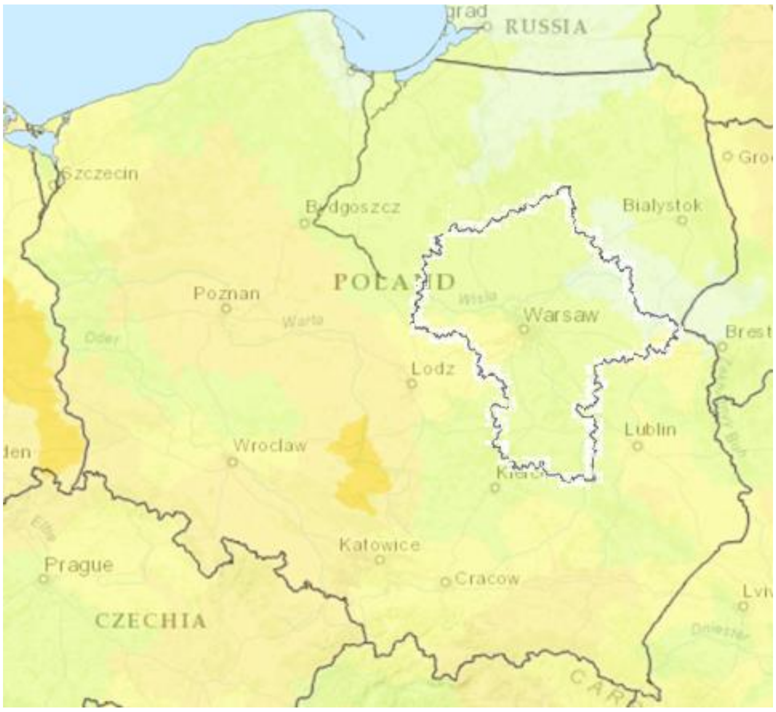
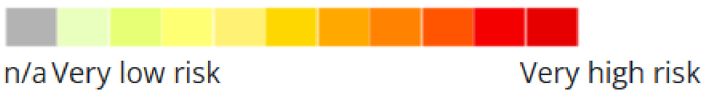


Figure 6 - Water scarcity risk in Poland and Mazovia. Source: WWF Risk Filter Suite, 2023, riskfilter.org/water/explore/map



Additionally, recent years have seen an increase in the amount of pollutants in water (Kuziemska et al., 2021), which poses a threat to the quality and safety of drinking water and the health of aquatic ecosystems. The density of water supply and sanitation networks in Mazovia is very poor (see Figure 7).

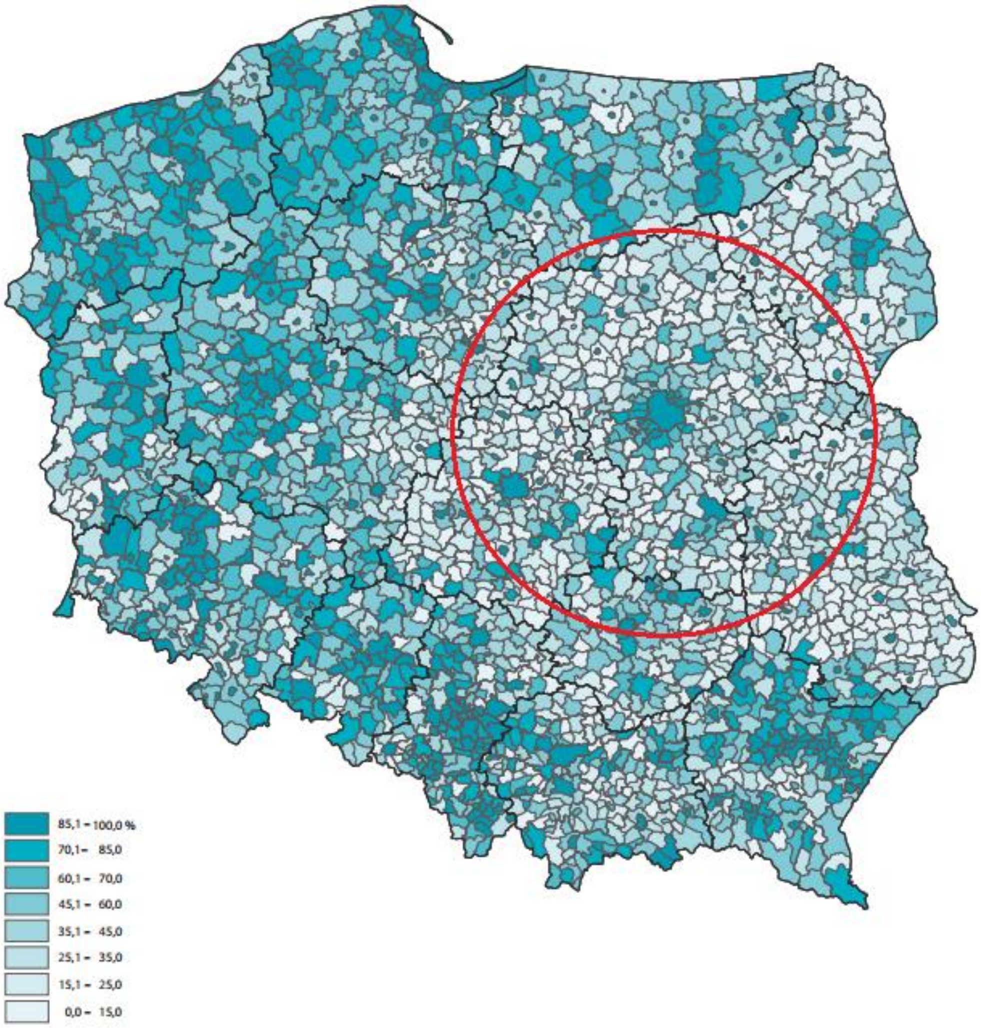


Figure 7 - Population using sewerage system in 2016. Source: Statistical Atlas of Poland, Statistics Poland, 2018.

The uncontrolled wastewater discharges from the sparsely built-up areas, from fish ponds, or due to disordered sewage management in rural areas, still cause a high level of pollution of river waters. Other wastewater discharges, even when in compliance with the permits concerning contaminant load, can significantly affect the quality of water resources. Freshwater ecosystems in areas of very high risk are estimated to have extremely poor water quality due to high levels of biochemical oxygen demand (BOD), electrical conductivity (EC) and nitrogen (Kuziemska et al., 2021).

In Mazovia ensuring that water resources meet the established quality standards can be associated with high costs, which in fact must be borne by the consumers. On the other hand, law enforcement and other measures carried out by the authorities to improve water quality are insufficient at present. The volume of untreated or insufficiently treated sewage reaching the environment remains too high. As a result, the goal of reaching the desired environmental quality standards still seems very distant.

Table 1 - Industrial and municipal wastewater discharged into waters or into the ground. Source: Statistical Office in Warszawa, 2022

SPECIFICATION	2010	2015	2020	2021	
	in hm^3				in percent
TOTAL	**2637,4**	**2613,6**	**2313,1**	**2595,5**	**100,0**
discharged directly by plants [a]	2403,3	2408,3	2084,1	2363,8	91,1
of which cooling water	2365,2	2367,3	2033,0	2312,3	89,1
discharged by sewage network	234,1	205,3	229,0	231,7	8,9
Of which wastewater requiring treatment	272,2	246,3	280,0	283,2	10,9
treated	221,4	239,4	262,7	265,9	10,2
mechanically	4,0	4,1	3,2	3,7	0,1
chemically [b]	5,5	2,8	7,5	6,9	0,3
biologically	54,6	50,7	55,4	58,1	2,2
with increased biogene removal	157,4	181,8	196,6	197,1	7,6
untreated	50,8	6,9	17,3	17,3	0,7
discharged directly by plants	0,3	4,0	7,9	7,3	0,3
discharged by sewage network	50,5	2,9	9,4	9,9	0,4

a Including cooling water and polluted water from drainage of mines and building structures as well as from contaminated precipitation water. b Data concern only industrial wastewater.

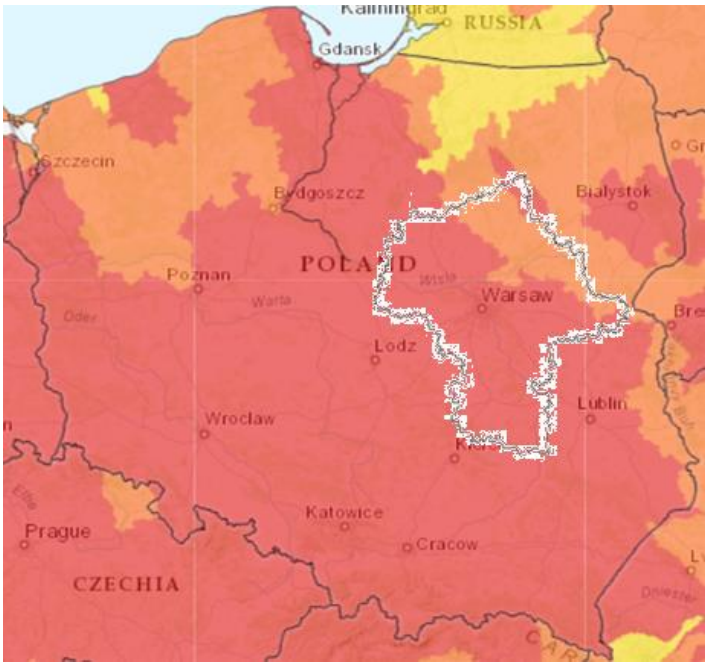


Figure 8 - Water Quality Risk in Poland and Mazovia. Source: WWF Risk Filter Suite, 2023, riskfilter.org/water/explore/map.

1.2 Land and soil resources management profile

Poland is rich in land and soil resources. Most of the soil resources in the country are moderately fertile, and approximately 40% of the country's area consists of class II and III soils. Nearly 80% of Poland's area is covered by brown soils, podzols and luvisols. They occur commonly in lowland areas and lakelands. There is less of them in the highlands and in the mountains (especially podzols). In terms of agricultural suitability, the most valuable of them are brown soils. Areas with highest quality soil in the country are scarce – chernozem occupies only about 1% of the territory (zpe.gov.pl, accessed December, 2023).

Mazovia also has diverse soil resources. Here there are mainly leached brown soils, which are very fertile and favorable for growing plants. They are well related to agriculture and constitute the basis for agricultural production in the region. Farms in north-western Mazovia have mainly coarse textured soil. Moreover, podzolic soils and alluvial soils are also found in the Mazovian voivodship.

Forests constitute approximately 30% of Poland's area and underpin ecological, economic and social functions. They also make up an important part of Mazovia's natural resources.

Table 2 – The Voivodship against the background of the country in 2021.

SPECIFICATION	Polska Poland	Województwo Voivodship	
	ogółem total		Polska=100 Poland=100
AREA – as of 31 December			
Area in km^2	312705	35559	11,4
AGRICULTURE			
Agricultural land in good agricultural condition [f] (as of June) in thousand ha	14754,9	1955,0	13,2
Sown area [f] in thousand ha	10961,8	1286,9	11,7
Production in thousand tonnes:			
cereals	34640,8	3523,9	10,2
potatoes	7081,5	821,0	11,6
ground vegetables[g]	3898,5	468,9	12,0
Yields per 1 ha in dt:			
cereals	46,5	39,1	84,1
potatoes	300	321	107,0
FORESTRY			
Forest area (as of 31 December) in thousand ha	9264,7	832,2	9,0
Forest cover in %	29,6	23,4	.

Source: Statistical Office in Warszawa, 2022.

Poland and Mazovia have diverse land and soil resources that constitute the basis for agriculture, forestry and other economic sectors. The level of land use in Poland is very high because agriculture plays an important role in the country's economy. About 60% of Poland's area is agricultural land. In Mazovia, the level of land use is also high because the region is one of the most important agricultural areas in Poland. Many farms in Mazovia specialize in growing cereals, especially wheat and corn, but also grasses and fodder plants. Other important crops include rapeseed, sugar beet, legumes and vegetables.

Table 3 - Geodetic area by land use in Mazovia as of 1 January 2022.

SPECIFICATION	2010	2015	2021	2022	
	in ha				in percent
Total area	**3555847**	**3555847**	**3555847**	**3555881**	**100,0**
of which:					
Agricultural land	2445710	2385087	2407529 [a]	2404370	67,6
Forest land as well as woodland and shrubland	839091	880976	847117	847338	23,8
Lands under surface waters	41003	42252	42641	42409	1,2
Built-up and urbanised areas	184689	201767	217338 [b]	220721	6,2
Wasteland	35721	34378	33918	33871	1,0

a Including woodland and shrubland on agricultural land, classified in the item ”forest land as well as woodland and shrubland” until 2017.
b Including areas used for the construction of public roads or railways.
S o u r c e : data of the Head Office of Geodesy and Cartography, 2022.

Poland has the largest agricultural area within the Baltic Sea drainage basin and one of the regions most focused on agriculture is Mazovia. Reducing the risk of phosphorus (P) and nitrogen (N) leaching from agricultural soils to water is therefore essential. Farmers in Mazovia often use acidifying N mineral fertilizers (in the form of ammonium sulphate or urea) as a cheaper option to alternatives. Increased acidity is known to reduce soil fertility and may trigger P leaching from certain soil types. Soil P content has been documented to be positively and significantly correlated with soil pH in Polish farms, including in Mazovia. It is generally higher in pig farms in the country, where farm-gate P balance surpluses have been demonstrated. In contrast, surveying of farm-gate balances for many small mixed farms in the country have indicated deficits of P and potassium (K), and the soil can be expected to be nutrient-depleted. A coordinated approach to manure management could thus be a relevant lever to secure soil health among Polish farms. In general, more export of manure from pig farms and intensive dairy farms is needed to use the manure as a P source effectively and not build up soil the nutrient to a higher level than at present on some farms and to avoid soil depletion on other farms (Ulén et al., 2015).

Soil organic matter plays an important role in maintaining soil fertility, binding nutrients and influencing its structure. Good soil management and maintaining high organic matter content is crucial for sustainable agriculture and environmental protection. Soil management and agricultural regulations in Mazovia are controlled by various institutions, including the Ministry of Agriculture and Rural Development and the Agency for Restructuring and Modernization of Agriculture. There are also subsidy and subsidy programs for farmers that aim to encourage the use of sustainable agricultural practices and environmental protection.

1.3 Biodiversity management profile

The country profile elaborated by the Convention on Biological Diversity (CBD) states that „the total number of species in Poland is estimated to be 63,000 species, with approximately 28,000 plant species and 35,000 animal species, including 700 vertebrate species.“ According to various estimates, between 33,000 and 45,000 animal species are found in Poland. Over 90% of them are insects. Vertebrates, around 700 species (CBD, n.d.), constitute a small percentage of all fauna in the country. The most diverse group of vertebrates are birds, with around 428 known species. Despite the richness of species in Poland, declining trends of 1,318 animal- and 310 plant species reflect a need for enhanced biodiversity protection measures. Currently, 147 animal- and 133 plant species are at risk of extinction –with 89 and 74 species classified as critically endangered, respectively. Simultaneously, various ant (e.g. Formica polyctena), butterfly (e.g. Euphydryas maturna) and vertebrate (e.g. Lutra lutra) species which are classified as endangered (some critically) in Europe and beyond are faring well in Poland (CBD, n.d.).

There are few endemic species in the country. This is mainly because the living nature in Poland is relatively young, developing since the retreat of the Scandinavian ice sheet approximately 10,000 years ago (the north of the country was covered by ice, and south of it the polar desert and tundra vegetation dominated in the periglacial climate). Moreover, the area of Poland is mostly lowland (without barriers hindering the spread of plants and animals), and the main geographical areas extend into neighboring countries. Most endemics occur in the mountains - the Tatra Mountains, the Pieniny Mountains and the Sudetes (especially in the Karkonosze Mountains).

Endemic plants (mainly perennials - herbaceous perennial plants) include:

- Tatra bluegrass (Poa nobilis) from the Poaceae/grass family - found in the Tatra Mountains,
- Carpathian urdzia (Soldanella carpatica) from the primrose family - occurring abundantly in the Tatra Mountains and Babia Góra, sparsely in Pilsko, Poliska, the Gorce and Pieniny Mountains,
- the Pieniny moth (Erysimum pieninicum) from the cabbage family - occurring in 4 locations in the Polish part of the Pieniny Proper and Małe Pieniny,
- Karkonosze bluebell (Campanula bohemica) from the bellflower family - occurring (as 2 subspecies) in the Karkonosze Mountains and the Wielki Jeseník.
- or the Polish spoonbill (Cochlearia polonica) from the cabbage family - formerly found in the area of the Błędowska Desert, now in several locations in the region.

There are even fewer endemics among animals. These include, among others;

- Allogamus starmachi - an aquatic insect from the order of caddisflies, found in the Tatra Mountains (larvae live in periodically flowing Tatra streams),
- or the Tatra voles (Microtus tatricus), a rodent from the vole subfamily - a Carpathian endemic, found mainly in the Tatra Mountains.

A characteristic of Mazovia's biodiversity is un-diverse vegetation. Mazovia is marked by characteristic forests, including deciduous and coniferous forests, pine forests and riparian forests. There are also meadows and fields hosting several species of herbaceous plants. The Mazovian region is home to many animal species. In the country there are, among others: moose, deer, roe deer, martens, foxes, badgers, ferrets, hares and many species of rodents. Rivers and lakes here are common habitats of water birds such as the mute swan, cormorant, gray heron, great crested grebe and lapwing. Many species of land birds are also known, such as magpies, kings, nuthatches and woodpeckers. Mazovia also has many accessible nature areas that are particularly important for maintaining diversity. The most important of them include Puszcza Kampinoska. The biological diversity of Mazovia is threatened by pressures of urbanization, deforestation, and agriculture. It is important to take action to protect and preserve this unique diversity.

According to the research conducted by Lisek (2012) on synanthropic flora in the orchards of central Poland (near Skierniewice, Łowicz and Grójec), a total of 186 species belonging to 39 botanical families was noted and 60% of the found species occurred occasionally or rarely. The most numerous group in the examined orchards was made up of the therophytes (50%), while within the vascular flora segetal species (26%) were predominant.

Error! Reference source not found. below shows the locations of Key Biodiversity Areas (KBAs) in Poland and the Mazovian region. KBAs are defined as "*globally important sites that are large enough or sufficiently interconnected to support viable populations of the species for which they are important*" (Bibby, 1998, as cited in Eken et al., 2004).

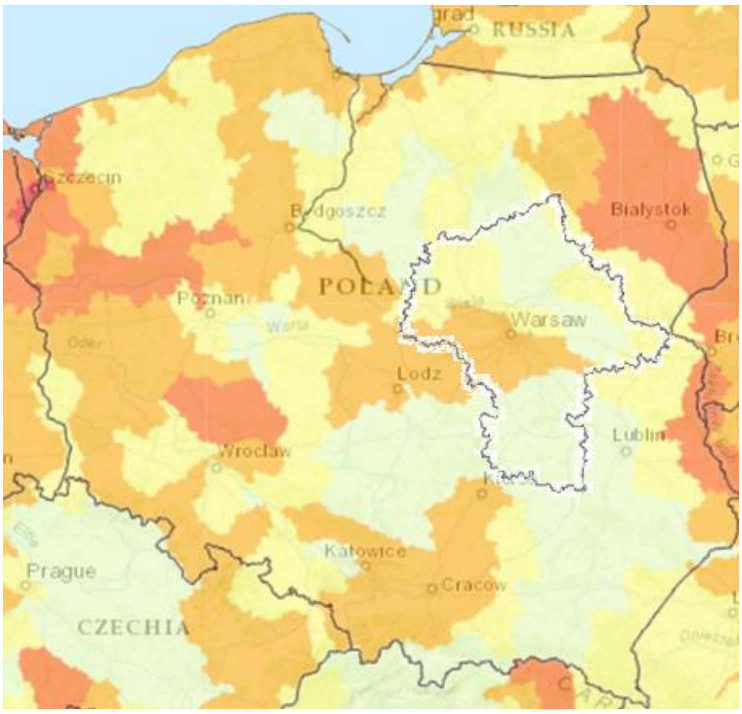


Figure 9 - Key Biodiversity Areas in Poland and Mazovia. Source: WWF Risk Filter Suite, 2023, riskfilter.org/water/explore/map

Currently, 39.6% of Poland's terrestrial territory is designated as protected areas, which is significantly above the EU value of 26.4%. The EU Biodiversity Strategy has set a target of reaching 30% protected area coverage at the EU level by 2030. With a coverage of 21.87% in its marine waters, Poland surpasses the EU value of 12.1%.[1] Poland has a total of 3,063 protected areas, comprising 2,061 sites designated under national laws and 1002 recognized as Natura 2000 sites. These Natura 2000 sites are designated under the Birds Directive, encompassing 145 Special Protection Areas, and the Habitats Directive, encompassing 867 Sites of Community Importance. Many sites are designated under both Directives.

[1] See: https://www.eea.europa.eu/en/analysis/indicators/marine-protected-areas-in-europes-seas

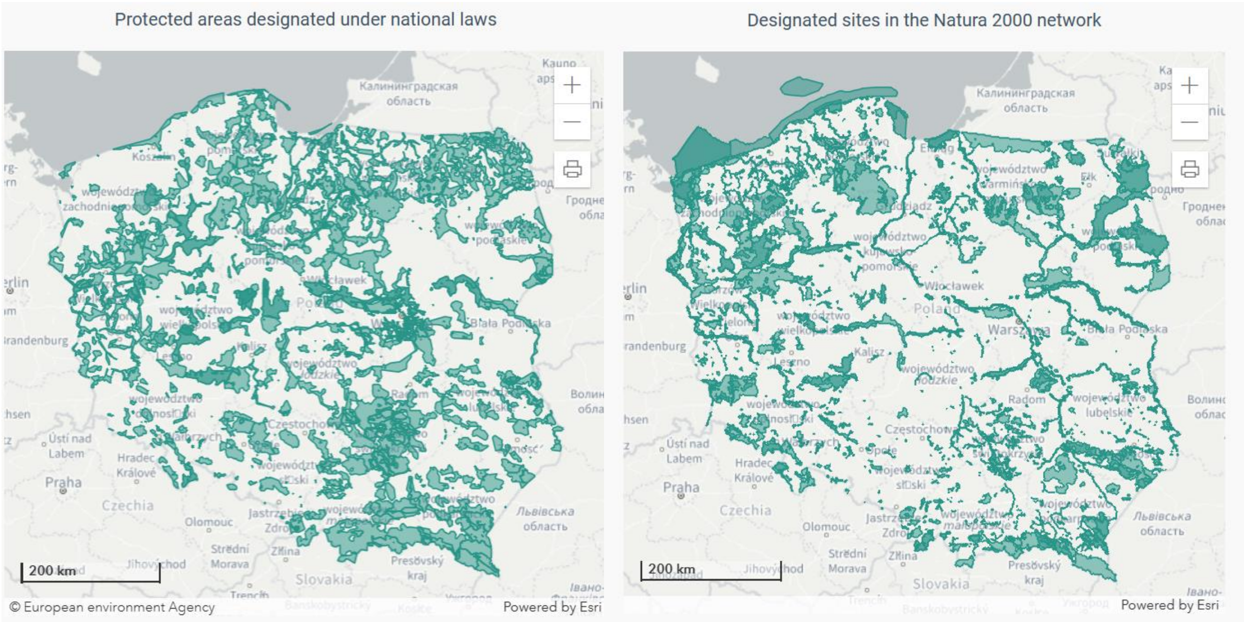


Figure 10 - Protected areas in Poland. Sites designated under national laws (left) and in the Natura 2000 network (right). Source: EEA, n.d.

Natura 2000 sites in Poland cover 270 species and 81 habitats from the nature directives. The number of species and habitats protected in each site varies depending on the location of the site, the biodiversity in the region, the designation being used, and the features the site is being created to protect.

Table 4 - Area of special nature value under legal protection in Poland[a]

SPECIFICATION	2010	2015	2020	2021		
	in ha				in % of total area of the Voivodship	per capita in m^2
TOTAL	**1055243**	**105573 8**	**1058139**	**1057050**	**29,7**	**1917**
National parks	38476	38476	38476	38476	1,1	70
Nature reserves	18203	18861	19539	19537	0,5	35
Landscape parks[b]	168396	168662	168674	168567	4,7	306
Protected landscape areas[b]	822506	822064	823407	822456	23,1	1492
Documentation sites	522	522	521	537	0,0	1
Landscape-nature complexes	5316	5316	5642	5591	0,2	10
Ecological areas	1824	1837	1880	1886	0,1	3

Source: Statistical Office in Warszawa, 2022

[a] Data do not include information concerning the areas of the Natura 2000 network, data include only the part located within other legally protected areas.

[b] Excluding nature reserves and other forms of nature protection located within those areas.

The Mazovian Natura 2000 network covers an area of approximately 466,497 ha, constituting approximately 13.12% of the voivodeship's territory. It consists of 16 areas of special protection for birds, 59 special areas of conservation of habitats or areas of Community importance (future special areas of conservation of habitats) and one area protected under both the Birds and Habitats Directives - Puszcza Kampinoska PLC140001.

Of the 16 areas established under the Birds Directive indicated above, the largest located entirely in the Mazovian Voivodeship is Puszcza Biała PLB140007 (83,779.74 ha), and the smallest is Bagno Pulwy PLB140015 (4,112.4 ha). The largest among those created under the Habitats Directive is Puszcza Kozienicka (28,230.37 ha), and the smallest is Aleja Pachnicowa (1.1 ha).

Legal framework for biodiversity conservation in Poland

Protection of nature and biodiversity in Poland is organized at the central and local government levels (regional, counties and communes).

At central level, Ministry of Climate and Environment (*Ministerstwo Klimantu i Środowiska*) is responsible for mainstreaming environmental issues in all legislation and for overall environmental policy. In its activities, the ministry is supported by the Chief Inspectorate f Environmental Protection (*Główny Inspektorat Ochrony Środowiska*).This Inspectorate is in charge of different tasks, including monitoring the implementation and enforcement of regulations on environmental protection and the use of natural resources, assessing the impact of the adopted environmental protection policies, plans, and programmes, as well as monitoring of the state of the environment.

Within other relevant institutions, it is possible to distinguish Instytut Ochrony Środowiska (The Institute of Environmental Protection) and Instytut Ekologii Terenów Uprzemysłowionych (The Institute for Ecology of Industrial Areas) that are responsible for performing planning, research, monitoring, educational and other functions.

At regional level, regional authorities are responsible for environmental protection and adopting regional protection plans for implementing the national guidelines. Counties (*powiaty*) are responsible for environmental protection and agriculture (including the conduct of the land merging procedures and land exchange, issuing a decision declaring the forest to be protective or depriving it of this character, issuing a decision on conversion of forest to agricultural. Local authorities at commune level (gminy) are responsible for protecting the local environment.

The monitoring of the status of species and habitat biodiversity is carried out by the State Environmental Monitoring System. Research conducted by science centres is also an important source of information about the state of biodiversity. Current research findings as well as results from monitoring are made available on the website of the Chief Inspectorate for Environmental Protection. A database on Alien Species in Poland has also been under development since 1999 at the Polish Academy of Sciences Institute for Nature Conservation.

Numerous educational programmes and campaigns are undertaken in the area of biological diversity. At the central level the Ministry of the Environment launched research on the ecological awareness and environmental behavior of Polish citizens as part of a long-term project. The Ministry of Environment has also carried out a campaign on biodiversity and ecosystem services.

For many years, the National Fund for Environmental Protection and Water Management, the Voivodship Funds for Environmental Protection and Water Management, the EcoFund Foundation and others have played and continue to play a very important role in the implementation process. Actively operating since 1992, EcoFund's income has been primarily provided by Polish debt-for-environment swaps with the United States, France, Switzerland, Italy and Norway. Moreover, significant financial opportunities are made available as result of Poland’s membership in the EU (e.g. access to a number of funds, including the European Regional Development Fund, European Social Fund, European Fisheries Fund, European Agricultural Fund for Rural Development, LIFE+ Financial Instrument for the Environment).

Significant progress has been made in enhancing the role of environmental impact assessments and limiting negative pressures on protected areas during planned economic undertakings. Recognizing the need to increase the efficiency of the EIA system, especially in regard to biological diversity protection issues, and to align EIA requirements with those of the EU, Poland adopted the Act on Sharing Information on the Environment and its Protection, Involvement of Society in Nature Conservation, and on Environmental Impact Assessment. Through this Act, a new compact system for supervising EIA procedures was created, comprised of a General Directorate for Environmental Protection and regional directorates for environmental protection, responsible for environmental impact issues and protection of the Natura 2000 network. The Act's provisions significantly strengthened the role of public consultations in EIA procedures and introduced the requirement for repeated assessments in undertakings that could considerably impact on the environment.

Supervision over implementation of the National Strategy is entrusted to the Steering Committee, consisting of the representatives of all stakeholders. Additionally, the effectiveness of the implementation of the NBSAP will be subjected to periodic assessments and cyclical meetings with the participation of stakeholders.

2 Methodology for the appraisal of 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. It has been included here in its full extent instead of simply referring to the cited report to allow this document to be used as a stand-alone piece.

2.1 Water data and indicators

To run the sustainability screening of surface and groundwater bodies potentially relevant to the Mazovian Region in Poland, the authors of this report have reviewed the data reported in the 2nd River Basin Management Plans (RMBPs) of the Vistula River Basin District published in 2016 (data from the 3rd reporting cycle was not yet available on the WISE Database at the time of the analysis). 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 (every six years). Authorities in charge of developing a regional bioeconomy strategy would generally be expected to have good access to the entity in charge of developing the River Basin Management Plan (i.e. the River Basin Authority), and so could theoretically consult it if necessary.

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 RBD that roughly coincide territorially with the Mazovian region. These data give indications on water quality in the river basin according to the five status classes defined in the WFD. 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 river basin district 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).

All data described above were accessed on 20.06.2023 from the WISE WFD data viewer (Tableau dashboard) hosted on the European Environment Agency's (EEA) website[2].

Table 5 - 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	WISE WFD Data Viewer[3] Disaggregated data for ecological and chemical status of surface water bodies; quantitative and chemical status of groundwater bodies, per River Basin District
	Burden on water bodies	Significant pressures on water bodies	River Basin District	No. and % of water bodies under significant pressures per pressure type	WISE WFD Data Viewer
	Burden on water bodies	Significant impacts on water bodies	River Basin District	No. and % of water bodies under significant impacts per impact type	WISE WFD Data Viewer

Source: 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).

[2] https://www.eea.europa.eu/data-and-maps/dashboards/wise-wfd
[3] WISE WFD Data Viewer (https://www.eea.europa.eu/data-and-maps/dashboards/wise-wfd)

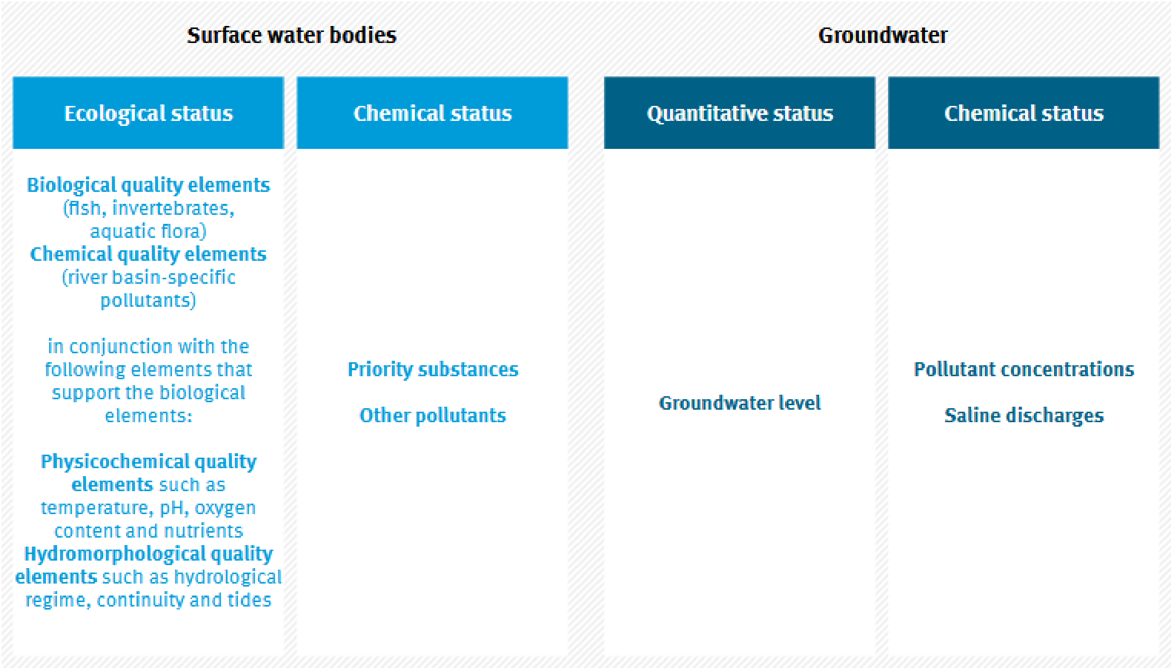


Figure 11 - Overview of surface water body and groundwater status assessment criteria, as per the Water Framework Directive. Source: BMUB/UBA, 2016.

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 WFD reporting described in the previous sub-section that 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 Mazovian waters. 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. The preferred option for this part of the assessment would have been to supplement the WFD data with a water quantity balance indicator like the Water Exploitation Index plus (WEI+) developed by the EEA and its partners. That indicator compares the total fresh water used in a country per year against the renewable freshwater resources (groundwater and surface water) it has available in the same period. This could have strengthened the water quantity element in the screening. However, the calculation of the WEI+ at regional level is currently not conducted or foreseen by its developers, and it would entail a disproportionately large effort that falls beyond the scope of this task in SCALE-UP. For these reasons, the reported data from the WFD process has been employed exclusively within the following methodology.

The overall apportionment of rivers, lakes and groundwater bodies in the Mazovian region according to their 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. 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 Mazovian 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 6 and Table 7.

Table 6 - 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 7 - 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 on the types of significant pressures and impacts on surface and groundwater bodies. 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 WISE Database 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. Further, some of the reported data may differ from what the Central Statistical Office in Poland currently makes available (e.g. due to updates or differences in the indicators measured).

An important limitation bound to the implementation of the sustainability screening is that the WFD data used refer to the Vistula RBD, whose territorial boundaries do not coincide entirely with those of the Mazovian region (the former is much larger). 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 higher resolution data for the specific territorial demarcation of the Mazovian region, if they become available.

Lastly, another issue to consider is the data currently available on WISE is from 2016, while more updated assessments are already available at the time of writing of this document. These come as part of the 3rd cycle of river basin management planning (2022-2027), but are not yet reflected on the WISE Database hosted by the EEA. Here as well, such sources could be considered by the stakeholders performing the sustainability screening to avoid overlooking any relevant recent developments.

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 Mazovia. Conditions and context in other European RBDs may be significantly distinct to those in Central Poland, and thus a more appropriate reference point could be defined in those cases. 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. This would hopefully help address any discrepancies between assumptions and methodological arrangements made in this study and others carried out on the Mazovian context. Beyond this, the simplicity of the necessary calculations and the fact that the data on significant pressures and impacts 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*[4] and *agricultural land*[5]. As shown in **Error! Reference source not found.**, 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 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 12 - Share of land cover and soil loss across the EU-27 in 2016.[6] Source: JRC, Eurostat

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[4] 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.

[5] 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)

[6] 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.

The data has been extracted from EUROSTAT, specifically the dataset “Estimated soil erosion by water, by erosion level, land cover and NUTS 3 regions (source: JRC) (aei_pr_soiler)”. For determining the baseline in the sustainability screening, we have selected the latest available data, i.e. for 2016.

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[7] and policy support practices[8] (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, 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.

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.

[7] 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.
[8] 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.

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, or to those that the Central Statistical Office in Poland may generate in national level surveys. 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 this was obtained directly from the dataset that was used[9]. 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, we have also decided to stick to 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

[9] See metadata of the used dataset at https://ec.europa.eu/eurostat/cache/metadata/en/aei_pr_soiler_esms.htm

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 Mazovia, where both values (for all lands 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 for 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. 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[10]. 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

[10] 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).

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.
   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 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[11] 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[12]) 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.

Note: the IUCN Red List and the EU Habitats Directive
Both, the EU's Habitats Directive and the IUCN Red List aim to preserve biodiversity, but they employ distinct methods and standards for evaluating conservation status. The Habitats Directive is centered on preserving natural habitats and wild species of flora and fauna within the EU, mandating that member states establish Special Areas of Conservation for habitats and species listed in its annexes. The Directive categorizes conservation status into three groups: favorable, unfavorable-inadequate, and unfavorable-bad. This classification system of habitats and species is based on how far they are from the defined 'favorable' conservation status, not their proximity to extinction (Sundseth 2015). Conversely, the IUCN Red List is a worldwide evaluation of the conservation status of species, categorizing them according to their extinction risk. The Red List employs a set of five rule-based criteria to assign species to a risk category (see above). However, there are inconsistencies and weak agreement between the conservation status assessments of the Habitats Directive and the IUCN Red List. These inconsistencies can be significant, and correlations can vary greatly between taxonomic groups. Specifically, the Red List assessment tends to be more pessimistic

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

than the Directive's Annex (Moser et.al 2016). Amos (2021), on the other hand, has found strong correlations between the two classifications systems for plants, while recognizing the Red List's quicker reaction to changes in the conservation status.

In summary, while both the Habitats Directive and the IUCN Red List aim to protect and conserve biodiversity, they use different methodologies and criteria to assess conservation status, leading to discrepancies in their assessments. However, they can complement each other in providing a comprehensive view of the conservation status of species and habitats at both the European and global levels (IUCN 2010).

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 of the search results to endangered and critically endangered species to focus on those facing the most severe risks.

(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.

2.3.3 Data and methodological 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 this screening carried out for Mazovia, 17 percent of the data were older than 5 years, with the most dated being from 2011.

(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.

3 Potential ecological burden of regionally relevant bioeconomic activities

3.1 Bioeconomic activity selected for the screening

The focus in the area is on the use of waste and byproducts from apple orchards and juice production for bio-based packaging and organic fertilizers. We have therefore carried out a sustainability screening of the valorisation of this waste, to identify potential environmental impacts associated with this value stream. Given the relatively specific field, literature on the topic remains somewhat limited.

The following sections provide some working definitions and an overview of the value chain. This chapter aims to synthesize the results of a literature review on potential impacts of the use of apple pomace and orchards on water, land, and biodiversity, respectively.

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

3.2.1 Potential burden on water resources

Orchards can have significant implications for water resources management, especially concerning nitrogen usage and irrigation practices. Efficient nitrogen management is crucial for mitigating nitrate water pollution, with carefully managed fertilizer use imperative for preserving water quality (Goossens et al., 2017). Modern irrigation methods like drip irrigation help optimize water use, particularly in arid regions where water diversion for agriculture is substantial. Techniques such as regulated deficit irrigation are also being adopted to reduce water consumption without compromising crop productivity. Additionally, the perennial nature of orchards poses challenges for pest and disease management, indirectly affecting water resources. Integrated pest management strategies are essential for minimizing water-intensive treatments and ensuring sustainable water management in orchards (Demestihas et al., 2017).

3.2.2 Potential burden on land and soil resources

While there is a possibility for soil carbon sequestration in orchards (as in all agricultural soils), the potential linked specifically to orchards is debated. Orchards may also contribute to denitrification of soils, though this can depend on irrigation practices and weather conditions. Furthermore, the frequent use of cover crops in orchards has the possibility of increasing the fungi and bacteria leading to humification of soils, while also reducing the need for herbicides and fertilizers. In general, improved soil health and biological activity will depend on management practices – not only cover crops, but also reduced tillage and drip irrigation. Overall, the impact of orchards on soil resources is multifaceted, influenced by agricultural practices that can either degrade or enhance soil health and ecosystem functioning (Demestihas et al., 2017).

A life cycle assessment carried out by Goossens et al. (2017) identified concerns related to soil acidification impacts from fertilizer use and changes of soil organic matter due to the use of diesel in machinery. The assessment also pointed to potential benefits for soil fertility and biodiversity where reduced tillage practices are applied.

A study by Dyjakon et al. (2019) explored the environmental implications associated with energy use of waste biomass from apple orchards. They note that pruning residues can provide important ecosystem services related to maintaining soil organic carbon levels or reducing soil erosion. The removal of these materials for other uses, such as energy generation, may have adverse effects on soil fertility and stability. The study outlines a number of conditions where prunings should not be removed, depending on e.g. vegetation cover between trees, soil structure, or if the topsoil is prone to water logging. The study does note that in typical apple orchards in Poland, there are other sources of nutrient and mineral supply for the soil, such as spoiled fruit, mowed grass, or leaves. As such, activities in Mazovia should be conscious of the local situation when deciding when and how to remove extra biomass from orchards.

3.2.3 Potential burden on biodiversity

Orchards exhibit a dichotomy in their impact on biodiversity, stemming from their perennial nature and diverse habitat characteristics alongside intensive agricultural practices. The presence of multi-strata habitats and plant diversity within orchards fosters high levels of biodiversity. Pesticides have historically had significant impacts on wild farmland species and crucial functions like pollination, as well as disrupting food webs and natural nutrient decomposition processes. There is, however, a growing awareness among producers to adopt methods that minimize pesticide reliance. Yet, complex landscapes with dense, interconnected perennial habitats, including orchard areas, have shown potential for enhancing natural enemy populations, aiding in pest control. However, the effectiveness of biodiversity-supported pest management in orchards remains debated, with research on the impacts of agricultural practices on biodiversity still incomplete. Orchards also benefit from management practices that introduce planned plant biodiversity, initiating ecological processes that influence pest niche and dispersal dynamics. However, pesticides and other factors like hail nets can impair bee colonies, impacting pollination and biodiversity conservation efforts. Efforts to address habitat provision for biodiversity conservation extend to landscape-scale modifications, such as planting fruit trees to enhance connectivity across various taxa, offering promising avenues for mitigating the negative impacts of orchards on biodiversity (van der Meer et al., 2020; Demestihas et al., 2017).

4 Screening results and recommendations

4.1 Summary/Overview

Resources screened		Ordinal Baseline Rating	Use of waste and byproducts from apple orchards and juice production and its potential impact on environmental dimensions	
Category	Sub-Category		Potentially beneficial to the baseline status	Potentially detrimental to the baseline status
Water	Surface water bodies		- Drip irrigation/regulated deficit irrigation - Effective fertilizer management	- Overuse of chemical inputs, particularly nitrogen fertilizers
	Groundwater bodies			
Land Resources	-		- Consistent use of cover crops - Creating incentives against planting crops on high slopes; - Creating incentives for erosion control practices such as contouring, - Conservation tillage or mulching - Responsible use of drip irrigation	- Overuse of fertilizers and chemical inputs - Diesel use in heavy machinery - Removal of prunings (depending on soil health)
Biodiversity	Endangered Species	5	- Planting a diversity of species - Focusing on connectivity	- Overreliance on harmful pesticides - Hail nets
	Critically Endangered Species	1		

4.2 Recommendations

Surface water bodies: The proportion of rivers and lakes in the river basin district that achieve Good Ecological Status is significantly below the EU average. Simultaneously, more than half of the rivers and half of the lakes in the region still fail to achieve this WFD target. Thus, the scale and placement of any economic activities that could have substantial negative impacts on river and lake ecology should be planned very carefully to ensure that progress attained so far in meeting regulatory targets is not lost and instead continues to expand. According to the reported data, just above two-thirds of surface water bodies achieve Good Chemical Status. However, the chemical status of more than three-quarters of lakes is unknown, a figure that should be verified with the respective authority responsible for reporting these data. If they are failing to achieve good status, then economic activities that keep this situation from improving, or that could further deteriorate the chemical properties of lakes, should be avoided. Bioeconomy activities and management practices that could contribute to improve the chemical status of water bodies in the river basin district should be sought and promoted. According to the reported data, just over half of the rivers in the river basin district are affected by unknown anthropogenic pressures. If possible, further information on this should be gathered from the relevant authorities to understand the source of the pressure. Diffuse sources of pollution affect more than half of lakes, and one-fifth of rivers. The causes of this pollution should be verified with authorities, and economic activities that could exacerbate such pollution should be avoided. According to the reported data, half of rivers in the river basin district are subject to unknown impacts. This figure should be verified with the responsible authority for further clarification. Over half of all lakes have significant impacts from nutrient pollution. This is consistent with the reported data on diffuse pollution as a pressure and most probably directly related. It should anyway be confirmed via consultation with the responsible authority. In any case, economic activities associated to moderate or high discharges of nutrient pollutants to the environment should be avoided."

Groundwater bodies: Nearly all groundwater bodies in the river basin district are in Good Quantitative and Chemical Status, and only 11 of them are being affected by point and diffuse sources of pollution or a combination of both. A low number of these groundwater bodies suffer significant impacts from chemical, nutrient, or microbiological pollution. Similarly, low numbers of groundwater bodies are affected by pressures from groundwater recharge or water level (7), and these also suffer impacts related to their water balance. There are other impacts related to saline intrusion or terrestrial ecosystems, for example, but they are low numbers. It is important that any expansion of existing economic activities, and/or development of new ones, is planned thoroughly and located smartly to avoid the exacerbation of existing pressures on currently affected aquifers as well as the affectation of others.

Soil: With a soil erosion rate in all lands of 0.69 T/ha per year, Radomski is not vulnerable to erosion. Erosion in arable lands is 1.2 T/ha per year, which is still well below the European threshold for low risk/vulnerability. both in all lands and arable lands. In this context, soil erosion does not pose a risk for the sustainability of the bioeconomy in the region. However, in areas where soil erosion crosses the risk threshold, or where erosion rates are increasing, some measures can be taken: creating incentives against planting crops on high slopes; creating incentives for erosion control practices such as contouring, conservation tillage or mulching. Specific alternative tillage and mulching practices will depend on the crops being planted, and can often increase yields and reduce costs, however they can lead to an increase in pesticide consumption.

Biodiversity: As with any agricultural practices, the use of pesticides can have negative impacts on biodiversity. In orchards, the impacts of pesticides are especially significant for pollinators, food webs, and nutrient decomposition processes. As such, pesticide use should be kept to a minimum whenever possible. Additionally, hail nets should also be avoided when possible, as they can also have negative impacts on pollinators and other insects. In general, cultivation practices should focus on connectivity, especially between perennial habitats and species, as this can have a natural effect of enhancing pest enemy populations, thus supporting a more natural balance of plant and insect biodiversity.

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