SCALE UP
community-driven
bioeconomy development

Sustainability Screening – Upper Austria, AT

March 2024

Luise Dauwa (Business Upper Austria), John Tarpey, Gerardo Anzaldúa, Elisa Thomaset (Ecologic Institute)

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
Responsible author(s):	Luise Dauwa (Business Upper Austria), John Tarpey, Gerardo Anzaldua, Elisa Thomaset (ECO)
Internal peer review:	-
Planned delivery date:	M18
Actual delivery date:	M18
Reporting period:	RP1

Dissemination level of this report		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
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.

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EXECUTIVE SUMMARY

This report is a product of the SCALE-UP project, which receives funding from the Horizon Europe research and innovation programme. The project's objective is to facilitate the development and support of small-scale bioeconomy solutions in rural areas throughout varying European regions. This regional sustainability screening encompasses the study of different ecological parameters in the Upper Austrian region. The constraints focused on are water, soil, and biodiversity, which hold high significance for the bioeconomy. The bioeconomy, which relies on renewable biological resources, is intricately linked to the health and resilience of regional ecosystems. Water availability and quality directly impact the growth and vitality of bio-based crops and processes, making it imperative to assess and manage water resources sustainably. Similarly, soil health is a fundamental determinant for successful bioeconomic activities, influencing plant productivity, nutrient cycling, and carbon sequestration. Biodiversity, the intricate web of life, plays a pivotal role in maintaining ecosystem stability and resilience, thereby safeguarding the foundation of the bioeconomy. Regional sustainability screening ensures that bioeconomic initiatives not only thrive but also contribute positively to environmental and social well-being, fostering a balanced and resilient bio-based economy for the future.

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Abbreviations

BFW	Bundesforschungszentrum für Wald
BMK	Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie
BMLRT	Bundesministerium für Landwirtschaft, Regionen und Tourismum
BMUB/UBA	Umweltbundesamt
BORIS	Bodeninformationssystem
CAP	Common Agriculture Policy
CCI42	Context indicator 42
CORINE	Coordination of Information on the Environment
CR	Critically endangered
DD	Data Deficient

DORIS	Digitales oberösterreichisches Raum-Informations-System
DRBD	Danube River Basin District
EC	European Commission
EEA	European Economic Area
EEC	European Economic Community
EN	Endangered
EU	European Union
EUSO	EU Soil Observatory
FAO	Food and Agriculture Organisation
GAEC	Good Agricultural Environmental Conditions
ha	hectares
HQ100	100-year flood events
ICPDR	International Commission for the Protection of the Danube River
IUCN	International Union for Conservation of Nature
JRC ESDAC	Joint Research Centre European Soil Data Centre
LC	Least Concern
LUCAS	Land Use and Coverage Area frame Survey
MBT	Mechanical Biological Treatment
MFC	Microbial Fuel Cells
NE	Not Evaluated
NGO	Non-governmental Organisation
NGP	Nationaler Gewässerbewirtschaftungsplan
NT	Near Threatened
NUTS	Nomenclature des Unités territoriales statistiques
NWMP	National Water Management Plan
OÖ	Oberösterreich (Upper Austria)
RBD	River Basin District
RBMP	River Basin Management Plan
RMP2021	flood risk management plan 2021
RUSLE2015	Revised Universal Soil Loss Equation
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
USA	United States of America
VU	Vulnerable
WEI+	Water Exploitation Index Plus
WFD	European Water Framework Directive
WISE	Water Information System for Europe

WWF	World Wide Fund for Nature

1 Resource management profiles

1.1 Water resources management profile

Water management in Austria

The European Water Framework Directive (WFD), implemented in 2000, takes a holistic approach to water bodies in Austria, viewing them as habitats (river basin districts). The directive establishes a standardized legal framework for the European Union's water policy, with the overarching goal of promoting sustainable and environmentally compatible water utilization (Federal Ministry of Agriculture, Forestry, Regions and Water Management, n.d.a). The aim of the directive is to gradually improve the status of aquatic ecosystems and to prevent further deterioration. Sustainable water use based on the long-term protection of existing resources is promoted. The directive was transposed into national law with the 2003 amendment to the Water Rights Act 1959, the national Austrian water law (Water Rights Act, 1959).

For the management of water resources in frame of the WFD, Upper Austria is part of the Danube River Basin District (DRBD), which is managed on national level through the Federal Ministry for Agriculture, Forestry, Regions, and Water Management. At regional level, the directory State of Upper Austria manages Upper Austrian water resources and bodies and directly reports to the Federal Ministry. In order to achieve the objectives and principles of the Water Framework Directive, the Austrian federal ministry draws up a National Water Management Plan (NWMP) every six years in cooperation with the water management planning departments of the federal states. The water agencies and the responsible departments of the federal states are responsible for implementing the objectives of the NWMP). The current water management planning period (2022-2027) feeds into the 3rd National Water Management plan (Nationaler Gewässerbewirtschaftungsplan, NGP 2021) and includes the planned measures for water management. It defines the guidelines for the balanced and sustainable management of water resources; sets the quality and quantity objectives to be achieved for each water bodies in the basin (rivers, water bodies, groundwater, estuaries), and determines the developments and provisions needed to prevent deterioration and ensure the protection and improvement of the status of water and aquatic environments, to achieve these objectives. Further, it includes the impact of climate change on water economics and the resulting water shortages. Lastly, the main findings for flood control management within the flood risk management plan (RMP2021) are focused on (Federal Ministry of Agriculture, Forestry, Regions and Water Management, 2021). For facilitated implementation of the federal water management actions, and for the management of drinking water supply, wastewater disposal, melioration (drainage) and irrigation, water cooperatives act under the public law and are a main contact for residents and the federal state representatives (Land Oberösterreich, n.d.a). Finally, the management of urban water services (drinking water and sanitation), the management of aquatic environments and flood protection are the responsibility of the municipalities or their groupings. Each municipality has to pay a fee for the connection to the water supply and in each municipality, households directly pay a water usage fee in periodic intervals for the use of the water supply (drinking water and sanitation) (Land Oberösterreich, n.d.b).

Water resources and use

In this report, we look at the main river basin in Austria, and Upper Austria respectively, which is the Danube River basin district. A small percentage of water bodies in Northern Upper Austria drain into Elbe River basin at the border of the Czech Republic, but the data has not been regarded for this report, since the scale of the area and the impact on the overall study is respectively low. The administrative region, which implements and manages the water sources is the Federal State of Upper Austria and their respective Sectors for Water Management. (Fig. 1)

Figure 1: River Basin Districts (Danube, Elbe, Rhine) in Austria and Upper Austria (Federal Ministry of Agriculture, Forestry, Regions and Water Management, 2021)

In general, the Danube River Basin District covers around 817,000 km^2 catchment area and stretches over 19 countries in Europe, which is the most international river basin in the world. The Danube River springs in the Black Forest in Germany and flows into the Black Sea in Romania. The basin area is home to more than 80 million people and with a total length of 2,800 km the Danube River is the second longest river in Europe. In Austria, just over 96% of the territory (80,565 of 83,851 km^2 total area) drains to the Danube and contributes around 25% of the Danube inflow into the Black Sea.

Table 1: Key figures for the Danube River basin in Austria (Federal Ministry of Agriculture, Forestry, Regions and Water Management, 2021)

Key figures for the Danube River basin in Austria (Federal Ministry of Agriculture, Forestry, Regions and Water Management, 2021)	
Surface area	80,565 km²
River	30,751 km
Water bodies	7,769

The average annual precipitation in Upper Austria is around 1150 Liters per m^2, although the distribution of rain fall is greatly uneven across the federal state. In the western part of Upper Austria, the accumulation of precipitation is higher, due to the geographical conditions as the Alp line progresses (Land Oberösterreich, n.d.c).

The overall annual water demand in Austria is approx. 3,14 km^3, which corresponds to an approximate of 3% of available volume annually. Around 60% of the annual water demand is covered by surface water bodies and the remaining 40% are from groundwater bodies. The average consumption in households (not including trade, industry or large-scale users) amounts to about 126 litres per day and capita. This results in an average consumption of drinking water per 4-person household of about 184 m^3 per year. Around 70% of the annual water demand is used by industry and commerce, whereas 24% to water supply and 4% to agriculture. The rest is used by selected services, such as water for snowmaking in winter (Federal Ministry of Agriculture, Forestry, Regions and Water Management & University of Natural Resources and Life Sciences, 2021). Despite a high availability of water resources, studies show that the average amount for water supply needed will increase around 11-15% until 2050 due to the effects of climate change and intensive drought periods in Austria. Especially the groundwater resources available could decrease by up to 23% from the current status. At the moment, the amount of water needed for agriculture in comparison to other sections is comparably low, the study shows assumptions that the water resources needed for irrigation will double in the next 25 years. The sector with the highest demand of water in Upper Austria is industry and commerce, which mostly use surface water (around 84%) as a cooling water source and partly well waters. It is assumed that the water supply needed in this sector will remain at a similar level in the future, yet effective water management actions need to be further implemented to maintain the sustainability of the water ecosystem (ibid.). The satisfaction of all uses and the development of all activities with a potential impact on water resources therefore requires sustainable management in consultation with the various stakeholders.

Ecological status of surface water bodies in Upper Austria

The assessment of the ecological status of surface water bodies is based on the framework of the WFD and is a five-level assessment system to show the quality of structure and functionality in the water ecosystem of. The assessment takes place on the basis of specific data from the fields of biology, hydro-morphology and chemistry, in which a “high” or “good” status water section must not be deteriorated and mainly uninfluenced in comparison for the typical status of the respective type of water body. Water bodies or sections which are in a status that is worse than “good” must be brought into the “good status” until 2027 (Federal Ministry of Agriculture, Forestry, Regions and Water Management, n.d.a).

Data from the last reporting period shows, that more than half of rivers and lakes in the Upper Austrian region fail to achieve Good Ecological Status, which is only slightly above the EU-average. Economic activities and management practices that could have substantial negative impacts on river and lake ecology should thus be avoided, and those that could improve the ecological conditions of these water bodies should be explored and favoured.

According to the data from the second reporting cycle of the WFD (EEA, 2018a), no surface water body in Upper Austria achieve Good Chemical Status. The reasons for this are not clear, although it is assumed, that atmospheric deposition as a diffuse source of pollution affects the status tremendously. Around 1/5 of the surface waters show increased nutrient levels – mainly Nitrogen (Land Oberösterreich, n.d.d). Economic activities that could exacerbate pollution through atmospheric deposition should be avoided in the region. Further, the survey of water pollution in the course of the current status survey has shown that Upper Austria's watercourses are significantly affected by hydromorphological interventions, for example structural changes. Economic activities that associate or contribute to the restoration of these water bodies could have a positive influence. Within the new reporting actions from 2021-2027, renaturation measures are planned (depending on the financial feasibility), in which around 770 km of watercourses and around 300 restoration sites in Upper Austria are to be established in order to achieve ecological continuity (Land Oberösterreich, n.d.e).

Ecological status of groundwater bodies in Upper Austria

The groundwater landscape in Upper Austria is divided into 19 near-surface groundwater bodies and groups of groundwater bodies, two deep groundwater bodies and one thermal groundwater body in accordance with the requirements of the Water Framework Directive (WFD).

To assess the chemical status, a monitoring network was set up in accordance with the Water Cycle Survey Ordinance with a total of 290 monitoring sites. The quantitative assessment is based on the

Hydrographic Service's monitoring network on the one hand and on a balance of groundwater and usage conditions on the other. Upper Austria's groundwater bodies are in good chemical and good quantitative condition according to the criteria of the Water Act (Land Oberösterreich, n.d.f). All of the groundwater bodies in Upper Austria are in Good Quantitative Status and the majority (97%) are in Good Chemical Status as well. 126 groundwater bodies are in good chemical condition, whereas 4 of them have poor chemical status as a result of diffuse pollution from agriculture. The NGP foresees precautionary actions to maintain this status.

Water Risk Filter and Floodings in Upper Austria

The WWF Water Risk Filter (WWF, n.d.a) gives an assessment of the water risks of water basins in a specific region/area, using a scoring system from 1-5, in which 1 represents low risks and 5 indicates a high risk score. The definition of the physical risk according to the data base is as follows:

"The Water Risk Filter physical risk layer represents both natural and human-induced conditions of river basins. It comprises four risk categories covering different aspects of physical risks: water scarcity, flooding, water quality, and ecosystem services status. Therefore, physical risks account for if water is too little, too much, unfit for use, and/or the surrounding ecosystems are degraded, and in turn, negatively impacting water ecosystem services." (WWF, n.d.b)

According to the Basin Physical Risk Assessment for the Danube River Basin District and the national data, Austria shows an average physical risk of water sources of 2.68, which indicates medium risk in total. There is a very low risk of water scarcity in Austria. The factor with the highest physical risk is within the water quality (4.26), which is in accordance with the evaluations from the last WFD reporting period, which shows very high chemical pollution in the surface water bodies. Figure 2 shows the Basin Risk Map for Water quality, in which can be seen that the whole federal state of Upper Austria is affected by medium water quality. Furthermore, it shows, that the high risk areas are mainly in central Upper Austria and centred geographically around the main cities Linz, Wels and Steyr. This could indicate a high influence of industrial water circles as well as urbanisation as potential pollution source.

Figure 2: Water Risk Filter Map for the Danube River Basin District in Upper Austria (Federal Ministry of Agriculture, Forestry, Regions and Water Management, n.d.b)

With a risk score of 3.07 there is a medium risk of flooding in Austria in general. The WFD as well as the national water management plan foresee actions in regards to flood control and measures to counter flooding, also to reduce soil erosion in high risk areas. The basin water risk map of Upper Austria (Figure 3) shows that in the north-eastern parts of Upper Austria, the flooding risk increases to a high-very high risk. This might be caused due to several hydroelectric plants and dams, that are stationed at the border to the eastern state Lower Austria.

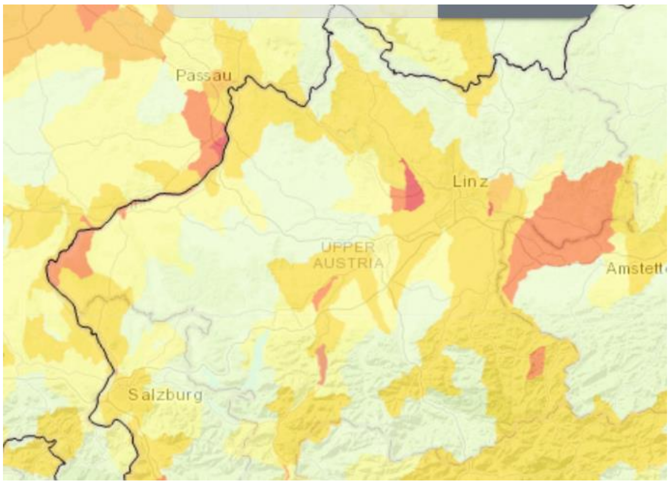


Figure 3: Flood Risk Map for the Danube River Basin District in Upper Austria (Federal Ministry of Agriculture, Forestry, Regions and Water Management, n.d.b)

For settlements and important economic and transport facilities a protection against 100-year flood events (HQ100) should be achieved. Particularly high living, cultural, and economic values, as well as areas with a high damage and hazard potential can also be protected against less frequent flood events. The construction of flood control facilities is only part of the responsibilities of the Austrian flood control sector. In addition, preventive and passive flood control, i.e. avoiding all activities that add to the flood discharge, are of great importance (Federal Ministry of Agriculture, Forestry, Regions and Water Management, n.d.b).

1.2 Soil resources management profile

Soil is integral to biodiversity in regional areas due to its role as a diverse habitat supporting a wide array of organisms, from microorganisms to insects and small animals. It plays a crucial part in nutrient cycling, offering essential elements for plant growth and influencing plant diversity. The physical structure of soil provides a foundation for plant establishment, contributing to the varied vegetation that, in turn, sustains a rich web of interconnected species. Microbial diversity within the soil enhances nutrient cycling, disease suppression, and decomposition, while certain soils emerge as biodiversity hotspots, fostering unique and endemic species. Additionally, soil regulates water flow, mitigates erosion, and serves as a reservoir for water resources, influencing the availability of vital hydration for diverse organisms in regional ecosystems.

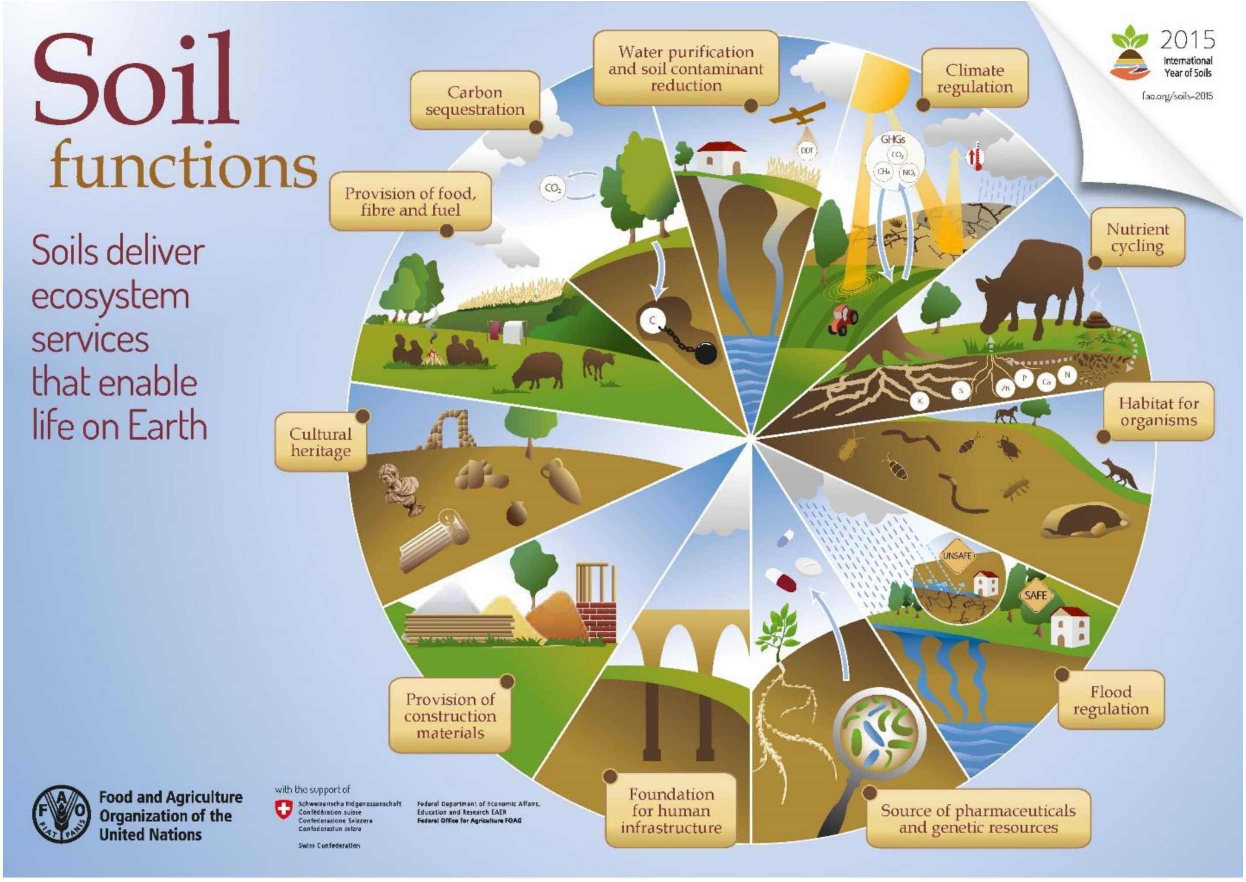


Figure 4: Functions of soil (FAO, 2015)

Land use in (Upper) Austria

The legal basis for soil protection and soil management is the Upper Austrian Soil Protection Act 1991. According to § 32, the Upper Austrian provincial government is obliged to prepare a soil information report every 5 years. The contents of the soil information report are information on measures and surveys in accordance with the Upper Austrian Soil Protection Act 1991, as well as soil analysis results and the soil balance pursuant to § 31 of the Upper Austrian Soil Protection Act. At the same time as the soil information report, the Upper Austrian provincial government must submit the soil development programme to the state parliament. This programme measures and objectives to be pursued regarding the conservation and protection of the soil and to improve soil health (Amt der Oö. Landesregierung, 2020).

The province of Upper Austria covers an area totalling around 1.2 million hectares (ha). The total area is divided into agricultural land (46 %), forest (40 %), settlement-related land (9 %), water areas (2 %) and other land areas (3 %). (Figure 5)

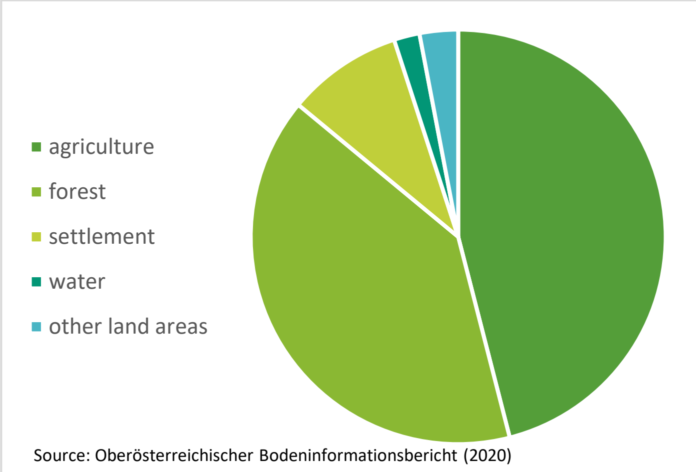


Figure 5: Overview of land use in Upper Austria according to sectors (BFW, n.d.)

A comparison with the 2015 land balance shows: The annual growth in settlement and transport areas (2020: +796 ha, 2015: +766 ha) continues to increase. Around 2.2 ha are consumed per day. The proportion of garden areas in the settlement area remains at around 55 %. At 35,995 ha, transport areas account for around 35 % of settlement-related usable land and continues to increase (2016-2020: +371 ha). Around 42 % of the settlement and transport areas used are sealed.

In 2019, the following crops were predominantly primarily represented on arable land in Upper Austria: Grain/silo maize (82,500 ha), winter wheat (48,000 ha), winter barley (40,000 ha), soya (15,500 ha), rapeseed (8,000 ha), and sugar beet (5,300 ha).

The forest area in Upper Austria currently amounts to approx. 508,000 ha12. This corresponds to an increase in forest area of 10,000 ha in the period from 2008-2017 or an average annual average annual increase of around 1,000 ha.

The Upper Austrian Soil Protection Act 1991 provides that in Upper Austria, in order to create the basis for soil health (in particular for determining the nutrient supply of soils, the contamination with pollutants and the impairment of soils through erosion and compaction) soil condition analyses are to be carried out regularly. These results are then summarised in an Upper Austrian soil register. In Upper Austria, the dominant soil type is brown earth. Other soil types are gley, pseudogley, aubic soils, podsole, rendzina and bog soil.[20]

There are several official online sources, geoinformation systems and online tools for the indication of soil quality and type:

- DORIS interMAP - Startseite (ooe.gv.at)
- eBOD2 (bodenkarte.at)
- BORIS Datenzugang (umweltbundesamt.at)

The BORIS-Tool (Bodeninformationssystem– Digital Soil Information System) is also used for monitoring the soil quality and updated with the latest data from the annual reporting periods.

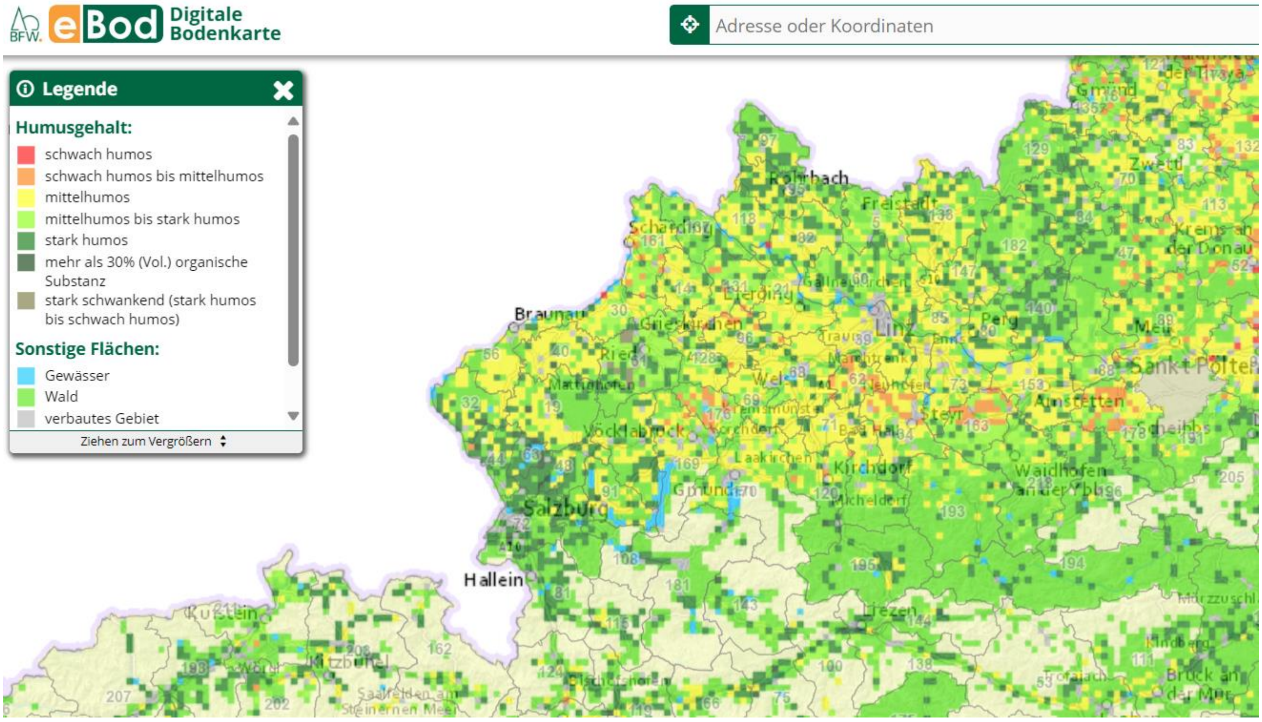


Figure 6: Digital soil map of Upper Austria (BFW, n.d.)

Approximately 35,000 soil samples were taken in recent years by Upper Austrian farmers over the past few years. The results of the pH value show that arable land at 6.43 and grassland at 5.69 are on average in an optimal range. The phosphorus content on arable land is in a low range. Around 44 % of the sampled areas are in content classes A and B; a further 38 % are in C1. From this content level upwards, the areas are sufficiently with plant-available phosphorus. On grassland the low phosphorus supply is more evident. 75 % of the areas are in a very low (content class (content class A) and low (content class B). Both the sampled arable land and the grassland areas are for the most part sufficiently supplied with potassium. A similar picture emerges for the humus. About 86 % of the arable land and over 70 % of the grassland areas are in content class C. The nitrogen replenishment potential is in the medium range with around 65 % of the arable range (Oö. Bodenschutzgesetz, 1991).

Governance and soil regulation

Soil protection is a cross-sectoral issue in Austria and is anchored in a multitude of legal provisions on federal and provincial level, often with references to the relevant hazard sources. Relevant provisions are for example contained in the Law on the Remediation of Contaminated Sites ("Altlastensanierungsgesetz"), the Smog Alarm and Ozone Act ("Smogalarm- und Ozongesetz"), the Fertilisers Act ("Düngemittelgesetz"), the Forestry Act ("Forstgesetz"), the Water Rights Act ("Wasserrechtsgesetz"), the Waste Management Act ("Abfallwirtschaftsgesetz"), the Chemicals Act ("Chemikaliengesetz"), the Austrian Trade Act ("Gewerbeordnung") and, in particular, the Soil Protection Acts of the Federal Provinces (Federal Ministry of Agriculture, Forestry, Regions and Water Management, n.d.c).

The protection of soil is based within two main regulations in Upper Austria, which are listed in Table 2. There are several sub-regulations and the protection and improvement on federal level is embedded in different strategies within the framework of the EU-sustainability goals.

Table 2: Main soil protection policies in Upper Austria

Main soil protection policies in Upper Austria	
Upper Austrian Soil Protection Act 1991	*The objectives of the Upper Austrian Soil Protection Act are the conservation of soil, the protection of soil health from harmful influences and the improvement and restoration of soil health (Oö. Bodenschutzgesetz, 1991).*
Upper Austrian Soil Values Values Regulation 2006	*Regulates the agricultural inputs that are permissible for application to soils within the framework of proper agricultural soil management defined in the Upper Austrian Soil Protection Act 1991 (Oö. Bodengrenzwerte-Verordnung, 2006)*

Summary of soil conditions in Upper Austria

In general, Upper Austria is not vulnerable to erosion. Erosion in arable lands is 5,65 T/ha per year, which is considered a moderate level according to European risk/vulnerability thresholds. Nonetheless, the share of agricultural land under severe soil erosion is about 9%, which is not negligible. In areas where soil erosion crosses this 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.

1.3 Biodiversity management profile

Biodiversity in Upper Austria

With the present biodiversity strategy 2020 Austria fulfils the pro-visions of Article 6 of the Convention on Biological Diversity (Federal Law Gazette No 213/1995). According to this Article, each Contracting Party shall for one develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes and additionally integrate the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.

The Biodiversity Strategy Austria 2020+ defines five fields of action and twelve targets, in which it describes the priorities, which are in future to serve as an orientation for stakeholders of the Federal Government, Federal Provinces and municipalities, NGOs and all the other relevant stakeholders, in order to conserve and promote biodiversity and its ecosystem services over the long term. To conserve biodiversity we urgently need to scale up joint efforts. The implementation of the Biodiversity Strategy is a shared responsibility. In legal and administrative terms, the Biodiversity Strategy Austria 2020+ is implemented by the territorial authorities competent to do so according to the Federal Constitution as well as by the other actors and stakeholders involved in the field of biological diversity and indicated in the Strategy. The implementation is to be financed from a broad mix of public and private funds as well as through the EU co-financing system. For the federal level, financing of the implementation must be covered by the funds provided for in the relevant framework financial legislation (Federal Ministry of Agriculture, Forestry, Regions and Water Management, 2014).

The National Biodiversity Commission, which is composed of representatives from all groups in society, will assist and review the implementation of the strategy and the achievement of its objectives. The members of the Commission present an annual report on the measures taken in their scope of responsibility to implement the strategy and reach the objectives. In 2017, these annual reports will be summarised and presented to the Commission. In 2020, in a comprehensive evaluation report, the changes are to be presented compared to 2010 – unless the reporting obligations require that other reference years are used. Any adjustments and further strategic planning will be developed from 2020 onward (The Biodiversity Information System Europe, n.d.)

The biodiversity strategy Austria 2020+ is embedded in a variety of legal and political framework conditions. The most essential legal foundations at an international and EU level are formed by the Convention on Biological Diversity, the Habitats Directive and the Birds Directive, the Water Framework Directive and the new regulation on Invasive Alien Species. At a national level, the nature conservation laws adopted by the Federal Provinces are significant, which are complemented by further legal standards of the Federal Provinces, such as regulations on species protection and protected areas. Of relevance for biological diversity is also the National Parks Strategy. Moreover, legal 6 Non-governmental organisation regulations such as the Austrian Forest Act and regulations relating to other sectors that have a significant impact on land use, such as spatial planning, traffic planning, water management, hunting and fishing, are of further significance. Also, the relevant protocols of the Alpine Convention, the Berne, Bonn and the Ramsar Convention, as well as environment-related criminal law and the Aarhus Convention constitute further important framework conditions. The EU Biodiversity Strategy 2020, the strategies of the Federal Government and the Federal Provinces on various topics define fundamental political objectives and intentions. Also relevant to biological diversity are the strategies and planning concepts of other sectors, for example Austria's Energy Strategy, the National Action Plan on Plant Production Products (= pesticides), the Austrian Tourism Strategy, the Austrian Spatial Development Concept, the Austrian Traffic Master Plan or plans at a regional level, such as regional development programmes or zoning plans. We can conclude by pointing out that almost everything people do and, consequently, practically all legal rules and regulations may have an impact on the conservation and development of biological diversity. The protection of biological diversity helps to secure the business location Austria and should continue to do so in the future. In many areas, it is therefore crucial to develop holistic solution strategies by involving all societal stakeholders (The Biodiversity Information System Europe, n.d.).

Protecting biodiversity in Upper Austria

The Environmental Liability Directive 2004/35/EC creates a Europe-wide regulatory framework for the prevention and remediation of environmental damage. It is implemented in Austria by the Federal Environmental Liability Act, Federal Law Gazette No. 55/2009 (in relation to damage to water and soil) and in Upper Austria by the Upper Austrian Environmental Liability Act, Federal Law Gazette No. 95/2009 (in relation to damage to protected animal and plant species and natural habitats and damage to soil caused by the performance of certain professional activities) (BMK, n.d.a).

The basic principle is that an operator who causes environmental damage or the imminent threat of such damage through his or her professional activity and thus damages certain protected environmental assets should bear the costs of the necessary preventive and remedial measures. (polluter pays principle) This is intended to encourage operators to take measures and develop practices to minimize the risk of environmental damage in order to reduce the risk of financial liability (Federal Ministry of Agriculture, Forestry, Regions and Water Management, 2014).

Table 3: Main policies for protecting biodiversity in Upper Austria

Main policies for protecting biodiversity in Upper Austria	
Upper Austrian Nature and Landscape Conservation Act 1995	*The aim of the legislation is the preservation of the diversity, uniqueness and beauty of nature and landscape, the preservation of the efficiency of the natural balance as well as the preservation of biodiversity in terms of animal and plant species in Upper Austria*
Natura 2000	*European ecological network of natural sites designated under the "Habitats" and "Birds" Directives, with the aim of conserving habitats and species of Community interest (BMK, n.d.c.).*
Directive No 2009/147/EC	*The Directive aims at protecting all wild birds naturally occurring on the territory of the European Community. This goal is achieved by means of establishing bird protection areas as well as by specific provisions concerning the utilisation of species. Protected areas according to the Birds Directive are part of the Natura 2000 network (BMK, n.d.b).*
Council Directive No 92/43/EEC of 21 May 1992	*The aim of this Directive shall be to contribute towards ensuring the protection, conservation, and restoration of a sufficient and representative sample of an area of a sufficient and representative size of natural habitats in Europe. The directive is part of the Natura 2000 network (BMK, n.d.c.).*

In terms of biodiversity reporting, there are several institutions that are members of the IUCN, including the Austrian nature conservation association, the ministry for Climate Protection, Energy, Mobility, Innovation and Technology (BMK) which is also responsible for reporting, the World Wide Fund for Nature (WWF) and several associations and institutions centered around wild life protection and conservation (BMK, n.d.c).

Based on the national Red List of Threatened Species, the authors of this report have looked into the list of "endangered" and "critically endangered" species (flora and fauna) that are likely to be impacted by the development of bioeconomy activities in Upper Austria. In general, 1,274 ferns and flowering plants are on Austria's "Red List". 66 species are extinct or lost throughout Austria, 235 species are threatened with extinction and a further 973 species are endangered to a lesser or, in rare cases, unknown extent. Further, more than half of all amphibians and reptiles are critically endangered, as are almost half of all fish and a third of all birds and mammals (Umweltbundesamt, n.d.).

2 Methodology of appraisal of available capacity of the regional ecosystem

Using existing indicators and expert opinion from within and beyond the screening team, this part of the screening will yield a qualitative (ordinal) categorization of the capacity of the ecological systems in the region to underpin bioeconomy activities. Thus, the key output to be presented here is the baseline setting from which a regional bioeconomy strategy/roadmap could be updated or developed. 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 Upper Austrian region, the authors of this report have reviewed the data reported in the 2nd River Basin Management Plans (RBMPs) of the Danube 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 Danube river basin district in Upper Austria. 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 districts 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, 2018b).

All data described above were accessed on 11.10.2023 from the WISE WFD data viewer (Tableau dashboard) hosted on the European Environment Agency’s website (EEA, 2018a).

Table 4: Indicators used for the water component of the sustainability screening

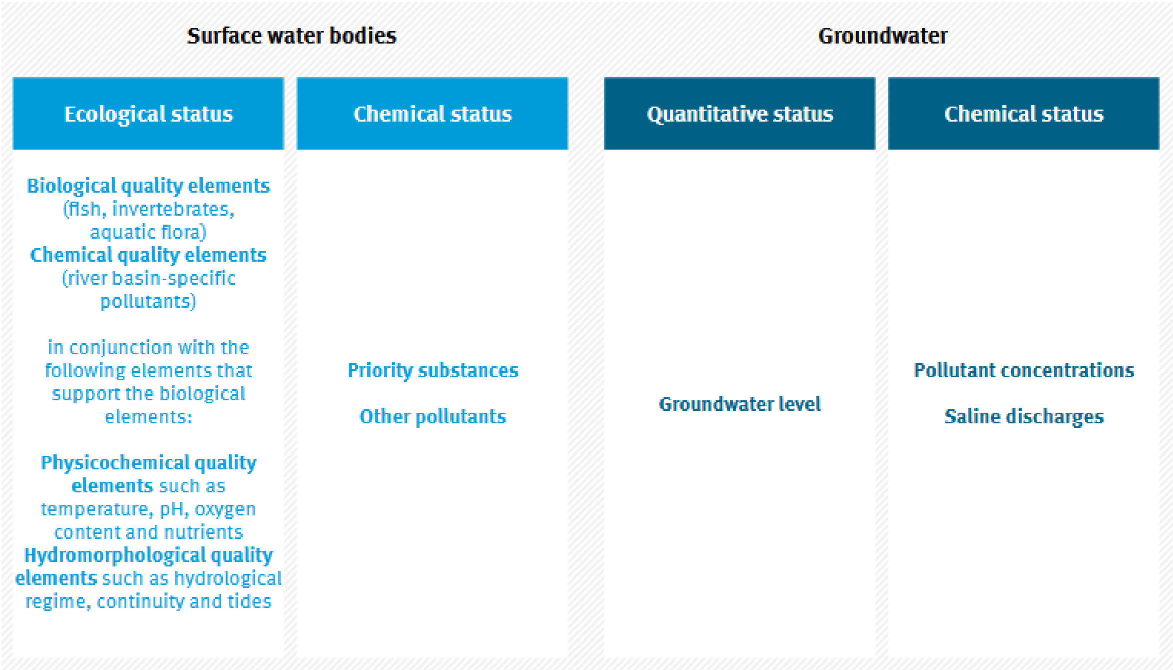
Category	Indicator Family	Indicator	Spatial level	Unit of measure	Comments/Reference
Water	Water quality	Status of water bodies according to the EU Water Framework Directive	River Basin District	Number of water bodies in high, good, moderate, poor, bad or unknown status	WISE WFD Data Viewer (EEA, 2018a) 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 hydro-morphological 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 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).

Figure 7 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 devised an approach 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 Upper Austrian 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 developing 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 Upper Austria 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. chemical 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, 2018b). Accordingly, “good chemical status has been achieved for 74% of the groundwater area, while 89% of the area achieved good quantitative status” (EEA, 2018b). Using these markers, the following step is to rank the current conditions of the Upper Austrian 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 5 and Table 6.

Table 5: 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 6: 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 intended 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 (BMLRT, 2021).

2.1.3 Data uncertainties

Water management in Upper Austria relies heavily on accurate and reliable data to make informed decisions regarding resource allocation, environmental protection, and disaster prevention. However, the nature of water systems and the dynamic environment introduces various uncertainties in the data collected and analysed. This chapter explores the key sources of data uncertainties in water management and the challenges they pose in the regional context.

Monitoring water quality is critical for assessing the health of water bodies and ensuring compliance with environmental standards. However, the spatial and temporal variability of pollutants, as well as the limited number of monitoring stations, contribute to uncertainties in water quality data. Additionally, the detection limits of analytical methods and the presence of emerging contaminants further complicate the assessment of water quality.

The data resulting from the assessments reported in the Upper Austrian region and subsequently in WISE are subject to the limitations of the scientific and methodological approaches used by their authors. For instance, the summary of the 2016-2021 RBMP for the Danube River Basin District (DRBD) makes references to actions undertaken to improve the accuracy and reliability of the assessment of the conditions of water bodies in the RBD relative to the first cycle reporting. Further, the implementation of the WFD within the DRBD is substance to individual implementation measures on national level, which creates uncertainties in the interpretation of data for the nations included in the DRBD. Additionally, in Austria, each of the federal states, including Upper Austria, is responsible for implementing the national management plan individually, which results in further uncertainties in measuring and reporting the respective data. Lastly, the national water management plans are open for the public to discuss and comment, which could potentially carry a margin of error.[1]

Lastly, another issue to consider is the data currently available on WISE is from 2016, while more updated (interim) 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 publicly available. The data used from the literature review is mainly based on state of water quality in the water districts in 2020, based on data from 2016-2017.

[1] National Management Plan Updates 2021 | ICPDR - International Commission for the Protection of the Danube River

2.1.4 Methodological uncertainties

In the EU, the Water Framework Directive requires that the costs of water services provided to households are sufficiently recovered through water tariffs. Notably though, both water tariffs and their contribution to financial cost recovery are subject to a combination of intrinsic factors that often vary across, or even within, countries. Among others, such factors may range from disparities in the quality of the service itself to conceptual inconsistencies in the calculation of cost recovery levels, and from differences among management models and institutional frameworks to varying levels of dependency on public and EU funding. Thus, direct comparisons between countries are deemed unfeasible, and comparisons between national subdivisions (e.g. municipalities, RBDs) should carefully account for intrinsic differences (e.g. what services and other items, like asset depreciation, are included in the price and considered in the cost recovery calculations). Further, it should be noted that a higher rate of recovery of financial costs does not necessarily hold correlation with a higher average price for the water service. This responds to the fact that the weight of water tariffs in the mix of the service providers' total revenue, and/or in the calculation of financial cost recovery levels, varies. For instance, reported average prices between 0.58 and 4.18 Euros per cubic meter all result in more than 100% recovery of financial cost in different RBDs.

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. 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 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.

In case of the Upper Austrian sustainability screening, the data for the ecological status of water bodies, especially regarding the failure of all surface water bodies in terms of "chemical status", was evaluated with the responsible representative at the section for water management and reporting at the federal office of the state Upper Austria. It was reported that there are still no clear indications to why all of the surface water bodies fail in regard to chemical pollution. It was discussed that uncertainties in the measurements, the influence of industrial sites – especially around the state's capital Linz which has a large-scale industrial area located along the Danube – and their wastewaters could be main impact factors to the results of the water reporting.

According to the water management plan 2021, following reasons were stated as main causes for the failure of the chemical assessment:

"*…due to the contamination with ubiquitous EU pollutants (primarily mercury, brominated diphenylethers), 100% of water bodies are at risk of failing to meet the target. If only the other EU and national pollutants (here mainly fluoranthene and individual metals), 11.7% of water bodies show a risk of failing to meet the target. The reason for this is predominantly diffuse inputs. Discharges from point sources are only responsible for a very small contributors to a very small extent. Chemical pollution from industry (paper, metal, chemicals, etc.) and untreated wastewater, chemicals, etc.) and untreated municipal wastewater, which characterized the pollution pattern of Austrian waters in the 1970s and 80s have now been reduced, mainly thanks to thanks to technical wastewater treatment measures and operational prevention, retention, and purification measures*" *(Federal Ministry of Agriculture, Forestry, Regions and Water Management, 2021).*

Further uncertainties could be derived from deviation in the interpretation of satellite imagery, scalability of the data and the scale at which the data is collected, deviations from predictions made from outdated data sources or uncertainties from variations in sampling techniques.

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*[2] and *agricultural land*[3]. As shown in 14, 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 8: Share of land cover and soil loss across the EU-27 in 2016

Source: JRC, Eurostat

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.

[2] 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.
[3] 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).

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[4] and policy support practices[5] (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 data sources used were those published in the JOINT RESEARCH CENTRE (JRC). Within this database, the EUROPEAN SOIL DATA CENTRE (ESDAC) has been consulted. ESDAC is the thematic centre for soil-related data in Europe and within it is the EU Soil Observatory (EUSO). The EU Soil Observatory (EUSO) aims to become the main provider of reference data and knowledge at EU level for all soil-related issues.

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, 2018b). 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, this data can be accessed via Eurostat.

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[4] 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.

[5] 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.

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 this was obtained directly from the dataset that was used (Eurostat, 2019). 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 cover type, but lower in the other. This would influence 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 Upper Austria, which has a high proportion of forest land and where both values (for all lands and agricultural land with natural grassland) are low.

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[6]. It is structured along the following risk categories (IUCN, 2001; IUCN, 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 (IUCN, 2001; IUCN, 2003).

[6] 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).

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) <u>The IUCN Red List category</u>: 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) <u>The distribution map</u>: 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) <u>Habitat and Ecology</u>: 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.

(4) 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) (IUCN, n.d.a). 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.

(5) 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 appendix for a detailed list of all threats including explanations.

(6) 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 appendix) 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.

IUCN Red List and Habitat 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 European Union, 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 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 a bioeconomy strategy or rolling out 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 region 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 region's administrative boundaries, but which could inhabit parts of the region in future. There is no rule of thumb for a correct distance between polygon boundary and region boundary, but it would be advisable to keep this distance below 100 km.
(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 region 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 (IUCN, n.d.b). Nevertheless, the data might be outdated, which could lead to inaccuracies in the assessment of biodiversity risks. For this screening carried out for Upper Austria, 71 percent of the data was older than 5 years, the most dated being from 2010.

(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 regional strategy formulated for Upper Austria explores the use of side products and waste from the food industry, specifically bakeries, for use in bio-based packaging, cosmetics, and fertiliser production; production of novel fibres; production of nutraceuticals and dietary supplements. We have therefore carried out a sustainability screening of the valorisation of bakery 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. The rest of this chapter aims to synthesise the results of a literature review on potential impacts of the use of bakery waste on water, land, and biodiversity, respectively.

3.2 Overview of bakery waste and side-products and their potential burden on the resources examined

3.2.1 Definitions

Cereals are grains that usually come from cultivated grasses, such as wheat, rye, spelt, oats or millet (BZfE, n.d.).

Summer cereals are sown in spring and need only a couple of months before they are ready to harvest. On account of climate change and the tendency of summers to be hot and dry, summer cereal crops in Austria are declining (Federal Ministry of Agriculture, Forestry, Regions and Water Management, n.d.d).

Winter cereals are planted in autumn (as of September) and, depending on crop growth and weather conditions, harvested as of mid-June in the following year. Due to the longer period of growth and thanks to winter humidity, winter cereals bring in higher yields than summer cereals. Unlike summer cereals, winter cereals need exposure to cold as a stimulus to induce the flowering process and seed production (vernalisation) (Federal Ministry of Agriculture, Forestry, Regions and Water Management, n.d.d).

Common wheat is the main crop grown in Austria with an annual average production of 1.6 million tonnes. Wheat is ranked into 9 quality categories, category 1 representing the lowest and category 9 the highest baking quality. It is produced as summer and winter cereal (Gartner, 2018).

Bakery Products/Baked Goods is the generic term for foods with cereals or cereal products as the main ingredient that are baked and is one of the main staple foods in Austria and Europe.

3.2.2 Overview of grain cultivation practices and side-products and waste from bakeries

Commonly used grains used for the production of flour and milling products for the production of baked goods are for instance wheat, rye, spelt, oats, maize or others. Depending on the grain type, there are different cultivation and crop management practices that are commonly used in Upper Austria. Table 7 shows an overview of the main crop types used for the production of baked goods and their cultivation practices.

Table 7: Grain cultivation practices for the production of baked goods

Grain cultivation practices for the production of baked goods	
Wheat	• **Cultivation**: planting either in fall (winter cereal) or spring (summer cereal); prefers well-drained loamy soils; soil fertility is crucial (adding of organic matter and nutrients); fertilization with nitrogen, phosphorus and potassium; harvesting time during summer months • **Management practices**: crop rotation with soy and corn and avoidance of continuous singular-field wheat cultivation for managing soil quality
Rye	• **Cultivation**: planted in fall (winter cereal) and harvested in late spring; adaptable to various soil types but thrives in well-drained, fertile soils; • **Management practices**: incorporating organic matters (e.g. deep-root crop) to enhance soil structure; utilization of rye as cover/top crop to prevent erosion and enhance soil health; crop rotation with legumes or brassicas advisable
Spelt	• **Cultivation**: plant in fall (winter cereal) or spring (spring cereal); Spelt prefers well-drained loamy soils with good fertility • **Management practices**: 5-year crop rotation with clover grass, broad bean and protective cereal (e.g. rye)
Oat	• **Cultivation**: planted in spring (spring cereal) as fast growing crop (spring-sown crop); adaptable to a variety of soils but thrive in well-drained loamy soils; needs adequate soil fertility with • **Management practices**: crop rotation with canola, peas, lentils, soybeans or other legumes to increase soil quality and reduce weed risk

Moving along the bakery value chain, the crops are harvested, dried and milled. Depending on the regions, bakeries and used crop, there is a large variety of bakery products produced in Upper Austria by micro-, small-, and large-scale companies.

In the bakery sector, 90% of the market is shared by commercial bakers and 10% by industrial companies. It also includes the flour milling, baking agent and pasta industries (Baier et al., 2016).

- By-products from the manufacturing process:
  - Mainly dough types from bakeries, pastries and pasta production
  - losses generated by the cutting processes (biscuits, pasta,...)
- Finished baked goods

- Free returns from supermarkets (going back to bakeries)
- Bread, pastries, et. left in supermarkets

A distinction must be made here between by-products that are generated in the manufacturing process during production and finished bakery products that are left over in sales as scrap goods. By-products of production are mainly dough types (Hietler et al., 2021).

Free returns from supermarkets: bread and pastries that the bakeries first deliver to the supermarket in the form of chilled dough pieces and then receive back as baked goods that could not be sold. The bakeries credit the supermarkets for the quantity returned, so the supermarkets do not suffer any financial losses, disposal problems or risks (Hietler et al., 2017).

There are common recycling routes for used bakery products (Table 8), which could potentially influence the ecological burden in different aspects. One ecological burden of the wasted bakery products are the greenhouse gas emissions that are emitted along the whole value chain.

Table 8: Recycling routes for used bakery products from 44 Austrian bakeries

Recycling route	Shares in %
Feeding	86,6
Internal utilization (e.g. breadcrumbs)	3,3
Social Institutions	3,3
Biogas Production	4,8
Composting	1,8
Residual Waste (waste incineration plant or MBT)	0,01
Other Utilization (e.g. alcohol production)	0,03

3.2.3 Potential burden on water resources

Hassan et al. (2021) note the strong environmental impact of cereal industrial waste due to its high organic load, solid waste, and nutrient levels. As mentioned above, algal growth on water can pollute the water resource and have harmful effects on freshwater ecosystems. This is partially attributed to the pesticide residues and nutrients present in the runoff, leading to hypertrophication and groundwater pollution.

Looking at the use of food waste in general for biogas production, Chew et al. (2021) note that the anaerobic digestion step can cause eutrophication, acidification, and create photochemical oxidants. In a study on the use of bakery waste for microbial fuel cells (MFC), Hussain et al. (2022) point to their potential as an ecologically friendly and cost-effective approach to wastewater treatment. Using food waste as a substrate, these MFCs are good at removing pollutants and reducing the concentration of metal ions in water.

3.2.4 Potential burden on land resources

Looking at the use of food wastes in general for feed and compost production, Vandermeersch et al. (2014) note that while these uses lead to lower global warming potential and higher resource recovery than landfill disposal, they can also cause negative impacts for soil resources including acidification.

In their assessment of the use of agro-industrial residues for biorefineries, Tonini et al. (2015) warn that such a valorization, where residues may otherwise be used for animal feed, presents the risk of expanded crop production and intensification and indirect land-use change with potential negative environmental impacts, including to soil.

Govindaraju et al. (2021) studied the implications of using bakery waste in the production of compost, and conclude that use of the waste, even of creamy bakery products, can indeed lead to an effective compost, complying with standard chemical values for composts and thus having helpful effects for soil health.

Looking at the waste materials from cereals processing, Hassan et al. (2021) note that cereal and corn waste can cause soil pollution, enhancing acidification in areas with caustic soils. Thus, it is safe to assume that the use and valorization of these waste streams could lead to beneficial effects for soils where they may otherwise be released.

3.2.5 Potential burden on biodiversity

In a study different uses of bakery waste, Ungureanu-Comanita et al. (2021) note that during the process of anaerobic digestion, about 100% of nutrients from the organic matter is recovered if the fermented material is incorporated immediately after spreading on arable land. This can lead to an effective fertilizer which does not spread plant or animal diseases.

There are concerns surrounding improper treatment and discharge of cereal industrial waste on ecosystems. Notably, it can lead to a high level of algae on water surfaces, which can prevent the growth of marine animals (Hassan et al., 2021).

4 Screening results and recommendations

4.1 Overview

Resources screened		Ordinal Baseline Rating	Use of side products and waste from the baking industry, and their potential impact on environmental dimensions	
Category	**Sub-Category**		**Potentially beneficial to the baseline status**	**Potentially detrimental to the baseline status**
Water	**Surface water bodies**		**Use of value chain for wastewater treatment,** which can be effective at removing pollutants and reducing metal ions in water **Adequate fertilizer and chemical management**	**Improper waste discharge**, which has high organic load, solid waste, and nutrient levels. **Excessive fertilizer use,** especially ortho-phosphate fertilizers.
	Groundwater bodies			
Land Resources	**-**		- Creating incentives against planting crops on high slopes; in order to reduce crops contributing to erosion risks - Creating incentives for erosion control practices such as contouring, - Conservation tillage or mulching leaving 30% (or more, depending on the crop) of crop residues in the field, as a means to maintain/increase Soil Organic Carbon and nutrient levels, and reduce soil erosion	**Poor fertilizer management** **Expanded production and intensification**, leading in land use change with potentially harmful effects on soil.
Biodiversity	**Endangered Species**	**40**	Concrete statements or generalised evidence from scientific literature on the impact of the considered bioeconomic activities on biodiversity have not been found (or were insufficient) in the studies reviewed.	
	Critically Endangered Species	**11**		

4.2 Recommendations

Surface water bodies: the screening of reported data has shown that the majority of rivers and lakes in Upper Austria fail to achieve the objectives of the EU WFD. The chemical status of surface water bodies is especially concerning, with every river and lake failing to achieve good status. This raises concern for new or increased pressures that could arise from the development of new economic activities in the region or the expansion of existing operations. The literature indicates that cereal industrial waste can have negative impacts on water resources as a result of its nutrient levels and organic load. As such, care should be taken that no waste materials or side-products are improperly discharged. At the same time, these byproducts can be effectively used for wastewater treatment, which could be a potential valuable use case for the region. Similarly, fertilizers and chemical inputs should be kept only to the absolutely necessary levels and reduced as much as possible, especially orthophosphate fertilizers. Adequate fertilizer management will be imperative to ensure that the chemical status of surface water bodies is not further impacted by the valorisation of the value chain.

Groundwater bodies: The quantitative and chemical status of groundwater bodies remains of low concern in the area. However, given the impacts of climate change of water availability, care should be taken with regards to water use in the value chain. Water use must be carefully managed, especially in summer months and periods where water shortages may be a concern. Although the chemical status of groundwater is reported as being in good status, potential surface-ground water interactions could cause risks where waste products are improperly discharged and so care must be taken in this regard. Similarly, fertilizer and chemical management must be handled very carefully to ensure that there is no excessive runoff or leaching into groundwater bodies.

Soil: Soil resources in the region must be treated cautiously. Average erosion in arable lands is considered moderate, according to European thresholds, with 9% of arable lands facing “severe” erosion. Special care should be taken in areas where soil erosion crosses this threshold, or where erosion rates are increasing. Within the wheat and cereal growing domain, a number of measures can be taken to reduce the risks of erosion: creating incentives against planting crops on high slopes; creating incentives for erosion control practices such as contouring, conservation tillage or mulching. Activities and practices that restore and preserve soils should be promoted. For example, conservation tillage and mulching not only has benefits with regards to erosion but can also maintain or even increase soil organic carbon and nutrient levels, leading to overall beneficial impacts on soil health. Care should be taken that the use of side products from the baking industry does not lead to expanded production or intensification of the associated crops, which can lead to land use change and negative impacts on soil.

Biodiversity: The production of the crops relevant for the bakery value chain in Upper Austria can have important benefits for biodiversity. Although there are no specific concerns related to biodiversity in the region, these crops are subject to high scientific research in order to ensure long-term food security and therefore well researched in terms of creating locally adapted varieties that are in line with the regional biodiversity management plans. As mentioned for the other resources, improper discharge of cereal waste materials can have harmful effects on ecosystems, and so waste management must be adequately considered. In addition to the recommendations regarding biomass, awareness raising and building measures on consumer level can initiate more open-mindedness towards more non-conventional cereals for baked goods that show higher sustainability and biodiversity characteristics, for example sorghum.

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