bioeconomy development

Sustainability Screening Report – Andalusia, ES

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EXECUTIVE SUMMARY

This report has been produced as part of the SCALE-UP project funded by the Horizon Europe research and innovation programme. The aim of this project is to support the development of small-scale bioeconomy solutions in rural areas across Europe. The aim of this study is to raise awareness of the ecological limits on Andalusia (southern Spain), based on three resources: water, soil and biodiversity. The bioeconomy is by definition the economy of bioresources (from agriculture, forestry, aquaculture and biowaste), therefore of the living. It is essential to ensure the sustainability of the bioeconomy and that its development takes into account the potential impact on the environment. Furthermore, in the current context of fighting against climate change and environmental degradation, bioeconomy activities that provide environmental benefits (water quality, preservation of biodiversity, etc.) must be sought and encouraged. This report is therefore aimed at project leaders and stakeholders in the bioeconomy willing to develop an activity, to enable them to integrate these environmental considerations into the development of their product or service.

The region of Andalusia is located in the Southwest of Europe with an area of more than 87,000 km² (ca. 9Mha) and approximately 940 kilometers of coastline. The agricultural area represents about 4.4 Mha and the forestry area is about 4.6 Mha. This makes it the fourth-largest region in the European Union in terms of surface area and the most populated region in Spain, with some 8,400,000 inhabitants. Spanish agriculture is very diverse, however, it is notable that the surface area of olive groves in Spain is 2.75 million hectares, with 2.55 million hectares dedicated to olive mills (93% of the total olive grove). This crop is present in 15 of the 17 autonomous communities, with Andalusia producing the most with 1.67 million hectares (The olive tree: Spain's treasure, 2022). The sector is not only of undeniable economic importance, but also has important social, environmental, and territorial implications. Finally, this large territory is fully affected by the impacts of climate change, with rising temperatures and significant pressure on water resources, soils and biodiversity. These considerations about climate change and its consequences need to be considered in the development of bioeconomy activities.

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Abbreviations

ESDAC	European Soil Data Centre
EU	European Union
EUSO	EU Soil Observatory
JRC	Joint Research Centre
RBD	River Basin District
RBMP	River Basin Management Plan
REDIAM	Red de Información Ambiental de Andalucía (Andalusian Environmental Information Network)
RENPA	Network of Protected Natural Spaces of Andalusia
SAC	Special Areas of Conservation
SAIH	Sistema Automático de Información Hidrológica (Automatic Hydrological Information System)
SCI	Sites of Community Interest
SIA	Sistema Integrado de Información del Agua (Integrated Water Information System)
SIOSE	Spanish Land Use Information System
SIRSEIH	Sistema de Información de Redes de seguimiento del estado e información hidrológica (Information System of Hydrological Status and Information Monitoring Networks)
SNCZI	Sistema Nacional de Cartografía de Zonas Inundables (National Flood Zones Cartography System (Inventory of Dams and Reservoirs))
SPA	Special Protection Areas
TRLA	Recast Text of the Water Act (Royal Legislative Decree 1/2001, of 20 July)
WFD	Water Framework Directive

1 Resource management profiles

1.1 Water resources management profile

Water management in Spain

The management of water resources in Spain is based on the European Water Framework Directive (WFD), which came into force on 22 December 2000 (Directive 2000/60/EC). The transposition of this Directive was carried out through Law 62/2003, of 30 December, on fiscal, administrative, and social measures (Demográfico, s.f.).

National water legislation is very extensive and complex. Table 1 shows Spanish water legislation in three areas: Basic, Public Water Domain, and Planning:

Table 1 - Water legislation in Spain.

BASIC LEGISLATION	Water Law, approved by Legislative Royal Decree 1/2001 of 20 July 2001. Amended by Law 53/2002 of 30 December 2002 on fiscal, administrative, and social measures. Amended by Article 129 of Law 62/2003 on fiscal, administrative, and social measures. Law 11/2005 of 22 June 2005 amending Law 10/2001 of 5 July 2001 on the National Hydrological Plan. Royal Decree-Law 4/2007, of 13 April, amending the revised text of the Water Law. Royal Decree 2090/2008, of 22 December, approving the Regulations for the partial development of Law 26/2007, of 23 October, on Environmental Responsibility.
PUBLIC WATER DOMAIN	Regulation of the Public Hydraulic Domain (RDPH), approved by Royal Decree 849/86, of 11 April 1986, which implements the Preliminary Titles, I, IV, V, VI, and VIII of the Water Law. Modified by RD 995/2000, of 2 June, which establishes quality objectives for certain pollutants. Modified by RD 606/2003, of 23 May, which modifies RD 849/1986, of 11 April, which approves the Regulations of the Public Hydraulic Domain, which develops the Preliminary, I, IV, V, VI, and VIII Titles of Law 29/1985, of 2 August, on Water. RD 9/2008, of 11 January, amending the Regulations on the Public Hydraulic Domain, approved by Royal Decree 849/86, of 11 April. Order ARM/1312/2009, of 20 May, which regulates the systems for the effective control of the volumes of water used by the water exploitations of the public hydraulic domain, of the returns to the public hydraulic domain, and of the discharges to the same.
PLANNING	Law 10/2001 of 5 July 2001 on the National Hydrological Plan. Law 11/2005 of 22 June 2005 amending Law 10/2001 of 5 June on the National Hydrological Plan Royal Decree-Law 2/2004 of 18 June 2004 amending Law 10/2001 of 5 July 2001 on the National Hydrological Plan Regulation of the Public Administration of Water and Hydrological Planning, approved by Royal Decree 927/88, of 29 July, implementing Titles II and III of the Water Law.

	RD 907/2007, of 6 July, approving the Hydrological Planning Regulations. RD 125/2007, of 2 February, establishing the territorial scope of the hydrographic demarcations. RD 126/2007, of 2 February, regulating the composition, operation, and powers of the committees of competent authorities of the river basin districts with inter-community basins.

Source: Demográfico, s.f.

In addition to these three areas, there is extensive legislation on water quality objectives (drinking water production, bathing water, and protection of fish biodiversity), discharges, nitrates from agriculture, hazardous substances, and damage assessment.

For water management planning, Directive 2000/60/EC imposed on Member States the obligation to delimit the territorial scope of river basin districts (RBDs). In Spain, the competences to dictate legislation, and manage the planning and concession of water resources and uses correspond to the State when the river basin is intercommunity (exceeds the territory of an Autonomous Community). However, it is the responsibility of the Autonomous Communities when the waters flow only through their territories (intra-community basin).

On the other hand, the Statute of Autonomy of Andalusia itself attributes to the Autonomous Community the exclusive competence over waters that flow only through Andalusia and over hydraulic resources and exploitation, as well as over groundwater when its exploitation does not affect another territory (Andalucía, s.f.).

Decree 357/2009 of 20 October 2009 establishes the territorial scope of the River Basin District of the intra-community basins located in Andalusia. The following figure (figure 1) shows the different river basin districts of Andalusia.

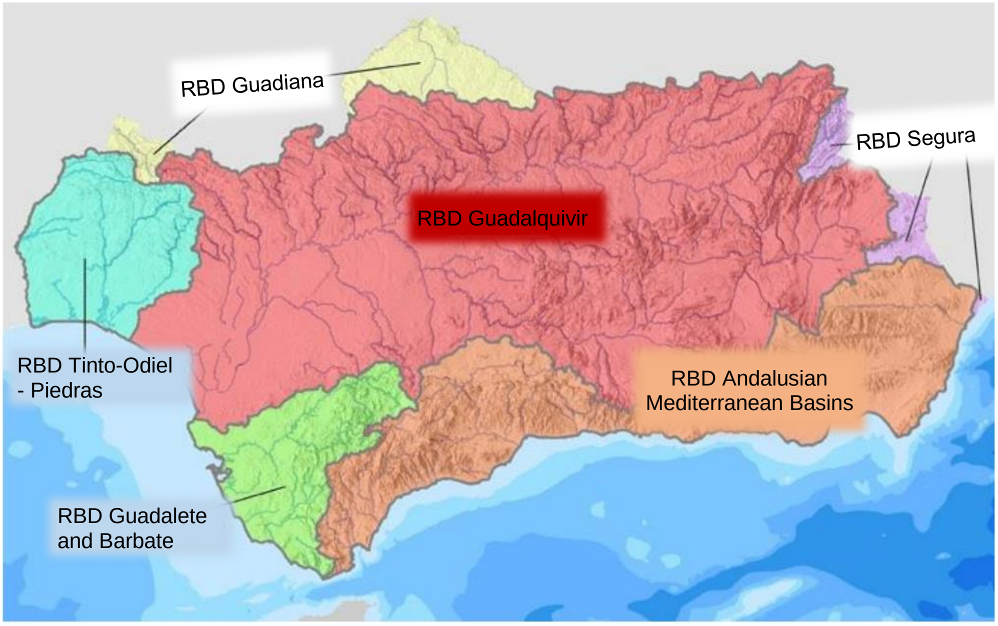

Figure 1 - River Basin Districts in Andalusia. Source: CMAOT, Junta de Andalucía (2016)

Table 2 shows the surface areas of the river basins of Andalusia in terms of: total surface area (km^2) of the basin, surface area in Andalusia (km^2), percentage of the basin represented in Andalusia and the percentage that the basin occupies of Andalusia.

Table 2 - Surface area of the hydrographic River Basin Districts in Andalusia

RIVER BASIN DISTRICTS	TOTAL SURFACE (km^2)	ANDALUSIAN SURFACE (km^2)	RBD IN ANDALUSIA (%)	RBD REPRESENTATION (%)
Guadalquivir	57,527	51,900	90.22	59.02
Andalusian Mediterranean Basins	17,944	17,944	100.00	20.40
Tinto-Odiel-Piedras	4,729	4,729	100.00	5.38
Guadalete-Barbate	5,969	5,969	100.00	6.79
Guadiana	55,528	5,618	10.12	6.39
Segura	18,870	1,780	9.43	2.02
Total	160,567	87,940	54.77	100.00

Source: IMA, 2013

In Andalusia, due to the complexity of its competences (intra-community, inter-community, and international basins), there are two management models depending on the institution responsible. The first model includes the River Basin Authorities of the Guadiana and Guadalquivir rivers, while the second model includes the smaller basins that are managed by the Regional Department of Environment and Regional Planning.

At regional level, the Andalusian Water Law 9/2010 incorporates several tools to guarantee the participation of users and society as a whole in water management. To this end, several collegiate bodies for participation, coordination, and information have been created for advisory and control purposes (Chica Ruiz, Arcila Garrido, Pérez Cayeiro, & Salle, 2017):

- The Andalusian Water Department, where all stakeholders involved in water planning and management are represented.
- The Andalusian Water Observatory, which is a collegiate body of consultative function.
- Citizen juries, a research technique used in Andalusia to know the opinion of the citizens on the management of a specific problem, in this case, water management.
- In the case of the River Basin Authorities, information on water management in each basin is structured through various computer platforms:
    - SIA: Sistema Integrado de Información del Agua (Integrated Water Information System).
    - SNCZI: Sistema Nacional de Cartografía de Zonas Inundables (National Flood Zones Cartography System (Inventory of Dams and Reservoirs)).
    - SIRSEIH: Sistema de Información de Redes de Seguimiento del Estado e Información Hidrológica (Information System of Hydrological Status and Information Monitoring Networks).
    - SAIH: Sistema Automático de Información Hidrológica (Automatic Hydrological Information System).
    - In the case of Andalusia, there is a portal called HIDRA: A management tool that allows consultation of all the information associated with the river sections of the Andalusian water network.

- Part of the information is still integrated into the Andalusian Environmental Information Network (Red de Información Ambiental de Andalucía, (REDIAM)).

Due to the hydrographic extension of the Andalusian region, the present study is limited to the Guadalquivir Hydrographic Demarcation, whose information is detailed and updated in the hydrological plan for the third cycle (2022-2027).

1.2 Soil resources management profile

There are a variety of governmental initiatives focused on soil management, including the "National Action Programme against Desertification". In addition, there is the "National Inventory of Soil Erosion", which facilitates the detection, quantification, and cartographic representation of the most important erosion processes in the national territory, as well as their evolution over time. In Andalusia, the Regional Department of the Environment has statistical reports in which it is possible to estimates soil loss by province and its trend over time.

The SIOSE project (Spanish Land Use Information System), part of the Andalusian Environmental Information Network (REDIAM), has two basic levels: National and Autonomous. At the regional level, SIOSE Andalusia meets the need for a land use and occupation information system that is unique for the public administration and useful for land management. The first reference cartography corresponds to the year 2005 (Junta de Andalucía. Consejería de Sostenibilidad, s.f.) and is currently updated with data corresponding to 2020.

The Regional Department of Sustainability, Environment, and Blue Economy is in charge of carrying out the responsibilities of the Autonomous Community of Andalusia has regarding the environment and sustainable development, as well as the sustainable use, management, and conservation of marine resources. It is in charge of the natural and forestry environment, as well as the management of contaminated soils (among other activities).

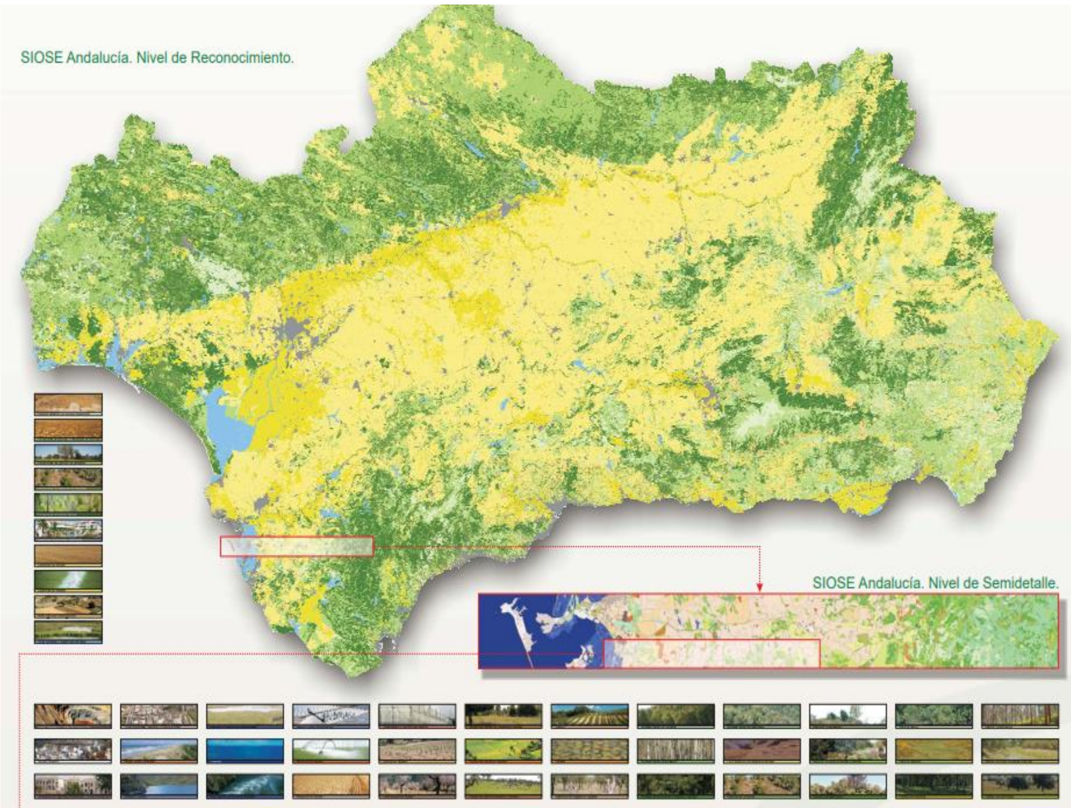

Figure 2 - SIOSE in Andalusia. Source: Romero et al. (s.f.)

1.3 Biodiversity management profile

In September 2011, the Andalusian Strategy for Integrated Biodiversity Management was approved in Andalusia by the Government Department Agreement, which was framed within the scope of the agreements approved during the 10th Conference of the Parties to the United Nations Convention on Biological Diversity, the EU Strategy on Biodiversity until 2020 and the State Strategic Plan for Natural Heritage and Biodiversity. It became a basic instrument for the correct coordination of the Administration of the Junta de Andalucía in the application of the objectives and guidelines established in the EU Birds Directive (Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds) and the EU Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). It remained in force until 27/12/20 and now the Governing Department has approved the formulation of the Andalusian Biodiversity Strategy Horizon 2030 (EAB, 2030) with which it intends to (Andalucía, Estrategia Andaluza de Biodiversidad Horizonte 2030, 2023):

- Promote the conservation and sustainable use of biological diversity in Andalusia.
- Improving Andalusian habitats.
- Focus on the human factor, in accordance with global, European, national, and regional strategic planning.
- Update the Andalusian framework strategy to adapt it to the current context and adapt its objectives, actions, and programmes to 2030 Horizon.

The Natura 2000 Network covers 2.67 million hectares in Andalusia (under the competence of the Junta de Andalucía), of which 2.59 million are land surface and 0.07 million marine (Estrategia Energética de Andalucía 2030, 2022), and is one of the richest and most diverse networks in the EU. For its management and conservation, it is fully included in the Network of Protected Natural Spaces of Andalusia (RENPA), by Decree 95/2003, of 8 April.

The Natura 2000 Network is integrated by 197 protected areas: 63 Special Protection Areas for Birds (SPAs) and 190 Sites of Community Interest (SCI), of which 176 are declared Special Areas of Conservation (SAC) (Espacios protegidos por la Red Natura 2000, s.f.).

In the Andalusian Community, the declaration of SACs or SPAs is by decree of the Governing Department of the Andalusian Regional Government, following the process of declaration of the Natura 2000 Network of protected areas.

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

2.1 Water data and indicators

To carry out the evaluation of the capacity of surface water and groundwater bodies potentially relevant to the region of Andalusia, the data collected in the Third River Basin Management Plan (2022-2027) of the Guadalquivir River Basin District (RBD) have been reviewed. The hydrological planning of the RBD is reviewed and updated every six years. This six-year cycle is regulated at different levels by National and Community regulations which constitute a basic and common procedure for all the Member States of the EU. The River Basin Management Plans (RBMPs) of the third cycle were approved by RD 35/2023 of 24 January, approving the revision of the RBMPs of the Western Cantabria, Guadalquivir, Ceuta, Melilla, Segura, and Jucar RBDs, and of the Spanish territory of the Eastern Cantabria, Miño-Sil, Duero, Tajo, Guadiana and Ebro RBDs.

2.1.1 Description of the data / definition of the indicators employed

The data reviewed for this section of the report include the analysis of the ecological, potential ecological, and chemical status of surface water bodies, as well as the quantitative and chemical status of groundwater bodies in the Guadalquivir River Basin District, in which Andalusia represents more than 90% of the surface area. These data give indications on water quality classifying it as "good" or "worse than good". On the other hand, data on significant pressures and significant impacts on the water bodies of the RBD are used to indicate the level of certain types of pressures and impacts on the aquatic ecosystems of the regions according to the number and percentage of water bodies subjected to them.

The acquired data line up with the Guadalquivir Hydrological Plan (Revision for the Third Cycle: 2022–2027). Access was made to the information included in the Guadalquivir Hydrographic Confederation (CHG) database of the Ministry for Ecological Transition and the Demographic Challenge.

The data are summarized in Table 3, which shows the overall status of the surface water bodies of the Guadalquivir RBD, and Table 4, which summarizes the evaluation of the status of the groundwater bodies.

Table 3 - Overall status of Surface water bodies. Guadalquivir River Basin District (Ministerio para la Transición Ecológica y Reto Demográfico, 2023).

OVERALL ASSESSMENT OF THE STATE							
STATE*		Good	%Good	no data	worse than good	% worse than good	Total body of water
Natural rivers	ES	194	67%		96	33%	290
	CS	278	96%		12	4%	290
	GLOBAL	192	66%		98	34%	290
Highly modified and artificial rivers assimilable to rivers	EP	28	52%		26	48%	54
	CS	47	87%		7	13%	54
	GLOBAL	26	48%		28	52%	54
RIVER-TYPE WATER BODIES	ES or EP	222	65%		122	35%	344
	CS	325	94%		19	6%	344
	GLOBAL	218	63%		126	37%	344
Natural lakes	ES	14	45%		17	55%	31
	CS	31	100%		0	0%	31
	GLOBAL	14	45%		17	55%	31
Heavily modified and artificial lakes	EP	1	20%	1	3	60%	5
	CS	4	80%	1	0	0%	5
	GLOBAL	1	20%	1	3	60%	5
Bodies of water highly modified or artificial by the presence of dams (reservoirs)	EP	47	80%		12	20%	59
	CS	59	100%		0%	0%	59
	GLOBAL	47	80%		12	20%	59
LAKE-TYPE WATER BODIES	ES or EP	62	65%	1	32	34%	95
	CS	94	97%	1	0	0	95
	GLOBAL	62	65%	1	32	34%	95
Natural coastal water bodies	ES	1	33%		2	67%	3
	CS	3	100%		0	0%	3
	GLOBAL	1	33%		2	67%	3
Coastal water bodies heavily modified by ports	ES	0	0%		0	0%	0
	CS	0	0%		0	0%	0
	GLOBAL	0	0%		0	0%	0
COASTAL WATER BODIES	ES or EP	1	33%		2	67%	3
	CS	3	100%		0	0%	3
	GLOBAL	1	33%		2	67%	3
TRANSITIONAL WATER BODIES	ES	1	8%		12	92%	13
	CS	12	92%		1	8%	13
	GLOBAL	1	8%		12	92%	13
State of surface water bodies.		**282**	62%	**1**	**172**	38%	455

Table 4 - Overall Status of the groundwater bodies. Guadalquivir River Basin District (Ministerio para la Transición Ecológica y Reto Demográfico, 2023).

State	Bodies in Good Condition		Bodies in Bad Condition	
	No.	%	No.	%
Quantitative State	54	63%	32	37%
Chemical state	62	72%	24	28%
Global State	**41**	**48%**	**45**	**52%**

<u>Summary - Surface water bodies.</u>

The total number of surface water bodies in the Guadalquivir RBD is 455. Of these, the percentage of surface water bodies that reach a good (or higher) status is 62%. The number of surface water bodies whose status is unknown is only 0.22%. Of the total number of rivers and lakes in the RBD, 65% achieve good ecological status or higher as well as 95% achieve good chemical status or higher. Both these figures are above the EU average. Combining the two results and following the thresholds proposed by Anzaldúa et al. (2022), the rivers and lakes in the RBD are thus in the "Moderate Concern" category.

Determining the effects of human activity on water status through the analysis of pressures and impacts enables one to verify that the WFD is being implemented correctly. Regarding the Point Source Pressures that affect these bodies, the most recurrent ones are associated with urban wastewater, with 23%. The most widespread diffuse pressures are those related to agriculture, which affect 35.6% of the water bodies in the RBD. It should be noted that agriculture acts as a source of pressure in most of them:

- Types of pressures for water extraction and flow diversion: Agriculture (31.10%)

- Types of pressures due to physical alteration of the river channel, bank, or margins: Agriculture (16.52%)

- Types of morphological pressures by dams, weirs, and dikes: Others (37.58%)

Finally, most significant impacts on surface water bodies are those related to chemical contamination and acidification.

Summary - Groundwater bodies

The total number of groundwater bodies in the Guadalquivir RBD is 86. Of these, the percentage of groundwater bodies reaching good (or higher) status is 48%. The number of groundwater bodies whose status is unknown is 0%. Of the total number of groundwater bodies in the RBD, 63% are in good quantitative status, while 72% are in good chemical status. Both these figures fall below the EU average. Combining the two results and following the thresholds proposed by Anzaldúa et al. (2022), the groundwater bodies in the RBD are thus in the “High Concern” category.

Regarding the Point Source Pressures that affect these bodies, the most are classified under the "other" category, with 22%. The most widespread diffuse pressures are those related to agriculture, which affects 30.23% of the groundwater bodies in the RBD. Of the other pressures, agriculture acts as a source of pressure on others:

- Types of pressures for water extraction: Agriculture: 36.05%

Finally, the most significant impacts on groundwater bodies are those related to piezometric drawdown by abstraction, and nutrient pollution.

2.1.2 Methodology applied

The status of surface water bodies is determined by the worst value of its ecological status/potential or chemical status. Only when the ecological status/potential is good or very good or maximum and the chemical status is good, the overall status of the surface water bodies is assessed as "good or better". In any other case, it will be "worse than good".

Regarding groundwater bodies, the status of a groundwater body is determined by the worst value of its quantitative or chemical status. The achievement of good status in groundwater bodies requires the achievement of good quantitative status and good chemical status.

The assessment criteria are those indicated in the corresponding regulatory standards and in the Instruction of the Secretary of State for the Environment (October 14, 2020) and in the methodological guides adopted by the aforementioned instruction, where possible, "Guide for the assessment of the status of surface and groundwater" and the "Guide to the process of identification and designation of heavily modified and artificial water bodies river category." The autonomous community analyzed transitional and coastal water bodies (Ministerio para la Transición Ecológica y Reto Demográfico, 2023).

2.1.3 Data uncertainties

In order to determine the current state of surface water bodies, data from the years 2015 to 2018 have been used. According to the information in the Third Hydrological Plan of the Guadalquivir River Basin District, the quality control network has not had updated data since 2018, which raises the possibility of a deficiency in the updating of data.

To define the elements that will form part of the inventory, there is a complexity in defining general thresholds for selecting the pressures to be inventoried in order to obtain the cumulative diagnoses explaining their effects on the water bodies. For this purpose, the Water Framework Directive requires the Member States to collect and conserve information on the type and magnitude of the significant anthropogenic pressures to which the water bodies may be exposed (Ministerio para la Transición Ecológica y Reto Demográfico, 2023).

2.1.4 Methodological uncertainties

The proposed methodology for the water section in this application of sustainability screening is simple, accessible, and updated. However, it could be improved by adding higher resolution data in some areas. As previously mentioned, the established thresholds, in this case, are based on the EU-wide proportions of water bodies that do not achieve good status or whose conditions are unknown. Furthermore, the straightforward calculations and the use of data on significant pressures and impacts without additional calculations, compared in relative terms within the RBD, minimize the potential for imprecision or uncertainty.

2.2 Soil data and indicators

2.2.1 Description of the data / definition of the indicators employed

The chosen markers to assess soil depletion susceptibility are primarily linked to water-induced soil erosion. To determine the impact of rain erosion in Andalusia, the analysis considers the following factors:

1. NUTS (Nomenclature of Territorial Statistical Units).
2. Province
3. Erosion intervals (Degree of intensity of rain erosion).
4. Erosion values (Percentage (%))

The Joint Research Centre (JRC) provides updated information on the risk of secondary salinisation, mean erosion (T/ha per year), and the number of soil degradation processes.

Secondary salinization is the result of non-optimal or inappropriate irrigation, which causes an increase in soil salt concentration. This can occur due to the use of poor quality irrigation water with excessive salt content or excessive irrigation leading to a rising groundwater table. It is more prevalent in hot climates with low rainfall, where water evaporates easily, leaving salts in the soil. This layer displays the presence of irrigation in climatic areas where evaporation exceeds precipitation, in order to estimate the risk of soil salinization. Its purpose is to identify areas within the EU where secondary salinization is likely to occur. It is important to note that areas identified as being at risk of soil salinization are not necessarily affected by salinization.

On the other hand, the Junta de Andalucía promotes information through various programs, including the Thematic sub-programme of the olive grove sector. This program provides valuable information, such as the risks of soil erosion in olive groves, which is a significant and widespread environmental concern. The loss of surface horizons, which are rich in nutrients and organic matter, can negatively impact the productive capacity of soils. This can limit their ability to produce biomass, whether for productive purposes or as a support for the natural environment, which is the first link in the food chain. Finally, Soil organic matter is a crucial factor to consider for soil fertility and conservation, as stated in the Annual Report of Agriculture, Fisheries, and Food Indicators 2021 by the Ministry of Agriculture, Fisheries, and Food (Ministerio de Agricultura, 2022).

Soil organic matter is a crucial factor in maintaining soil fertility and conservation. The concentration of organic matter is highest on the surface and decreases with depth. The effects of low soil organic matter levels are:

1. Low soil fertility and decreased plant nutrient uptake.
2. Soil structure is affected, reducing water holding capacity and increasing susceptibility to compaction.
3. Increased surface water run-off can lead to erosion and reduced biodiversity. Susceptibility to acidic or alkaline conditions.

The most commonly used agri-environmental indicator to calculate the environmental pressures on agricultural systems from fertiliser nutrients is called gross nutrient balance.

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 EUSO aims to become the main provider of reference data and knowledge at EU level for all soil-related issues. Their platform provides access to the:

- EUSO Soil Health Dashboard
- EUSO Soil Policy Dashboard (under construction).

The EUSO Soil Health Dashboard contains information such as (Commission, s.f.):

- Number of soil degradation processes
- Soil degradation indicators:
    - Soil erosion
    - Soil pollution
    - Soil nutrients
    - Loss of soil organic carbon
    - Loss of soil biodiversity
    - Soil compaction
    - Soil salinization
    - Loss of organic soils
    - Soil consumption

Additional information is provided by the Ministry of Agriculture, Fisheries and Food and the Junta de Andalusia. The following sources have mainly been consulted:

- Annual report on Agriculture, Fisheries, and Food Indicators 2021
- Thematic sub-programme of the olive grove sector (Ministerio de Agricultura, Subprograma Temático del sector del olivar 2014-2020). Provides information on Soil erosion in olive groves
- REDIAM
- Andalusian Environmental Statistics Viewer

These last two tools provide information on rainfall erosion in Andalusia, land use, vegetation, and estimation of soil losses in the Andalusian region.

REDIAM offers a geographic information viewer that allows the application of several visualization layers of different themes for the region.

2.2.3 Data uncertainties

The sources used in this section of the study are diverse, including data from the Joint Research Centre (JRC) and the RUSLE model. However, much of the data available from these sources corresponds to the years 2015-2016. To ensure the evaluation criteria are updated and to eliminate any obsolete data, regional sources such as REDIAM, regional reports, and viewers were also used. These sources provided specific data for the olive value chain.

The REDIAM environmental information catalogue is a database of Andalusian environmental information. Each topic is organized in layers produced by the Andalusian Visibility System (SVA), which can be accessed by navigating through the content structure. Metadata files (XML) are used to characterize REDIAM's environmental information. The Catalogue is regularly updated with new data source information. The Andalusia Visibility System is being enhanced by developing various parameters and algorithms that enable detailed analysis of existing and potential geometric visual relationships. The aim is to move away from the conceptual limitations that it has been facing. (Romero Romero, et al., 2016).

2.2.4 Methodological uncertainties

The indicators to measure the different parameters related to the Andalusian soil have been measured taking into consideration the entire Andalusian territory and not only limited to the Guadalquivir River Basin District. The Guadalquivir RBD covers almost 60% of the Andalusian surface area and Andalusia's share in the basin is 90% (Ministerio para la Transición Ecológica y Reto Demográfico, 2023).

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

(1) <u>Critically Endangered (CR):</u> 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) <u>Endangered (EN):</u> Species in this category are facing a high risk of extinction in the wild.
(3) <u>Vulnerable (VU):</u> Species in this category are facing risks of extinction in the wild.
(4) <u>Near Threatened (NT):</u> Species in this category are close to qualifying for, or are likely to qualify for, a threatened category soon.
(5) <u>Least Concern (LC):</u> Species in this category have been evaluated but do not qualify for any other category. They are widespread and abundant in the wild.
(6) <u>Data Deficient (DD):</u> 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) <u>Not Evaluated (NE):</u> A category applied to species that have not yet been evaluated against the criteria.

Data description

Data on the risk category of each species found in the SCALE-UP regions is accessed through the online database of the IUCN Red List website. The IUCN Red List serves as a comprehensive repository of information, offering insights into the present extinction risk faced by assessed animal,

[1] 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).

fungus, and plant species. In 2000, IUCN consolidated assessments from the 1996 IUCN Red List of Threatened Animals and The World List of Threatened Trees, integrating them into the IUCN Red List website with its interactive database, currently encompassing assessments for over 150.300 species. Since 2014, assessors of species have been mandated to furnish supporting details for all submitted assessments. Among the recorded details are the species' (1) IUCN Red List category, (2) distribution map, (3) habitat and ecology, (4) threats and (5) conservation actions. The assessment of these dimensions is elaborated below:

(1) The IUCN Red List category: The IUCN Red List categories (CR, EN, VU, NT, LC, DD, NE) are determined through the evaluation of taxa against five quantitative criteria (a-e), each grounded in biological indicators of population threat:

   a. Population Size Reduction: This criterion evaluates the past, present, or projected reduction in the size of a taxon's population. It considers the percentage reduction over a specific time frame, with different thresholds indicating different threat levels.
   b. Geographic Range Size and Fragmentation: This criterion assesses the size and fragmentation of a taxon's geographic range. Factors such as few locations, decline, or fluctuations in range size contribute to the evaluation.
   c. Small and Declining Population Size and Fragmentation: This criterion focuses on taxa with small and declining populations, considering factors like population size, fragmentation, fluctuations, or the presence of few subpopulations.
   d. Very Small Population or Very Restricted Distribution: This criterion addresses taxa with extremely small populations or limited distributions. It assesses whether the taxon is at risk due to its small population size or restricted geographic range.
   e. Quantitative Analysis of Extinction Risk: This criterion involves a quantitative analysis, such as Population Viability Analysis, to estimate the extinction risk of a taxon. It considers various factors influencing population dynamics and extinction risk.

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

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

(3) Habitat and Ecology: The IUCN classifies the specific habitats that a species depends on for its survival. These habitats are categorized into three broad systems: terrestrial, marine, and freshwater. A species may inhabit one or more of these systems, and so the possible permutations result in seven categories of natural systems. Beyond these seven system categories, the IUCN offers a more nuanced classification system for habitats, comprising 18 different classes at level 1 (e.g., forest, wetlands, grassland, etc.), and 106 more specific classes listed at level 2 (e.g., Forest – Subtropical/tropical moist lowland, Wetlands (inland) – Permanent inland deltas; Grassland - Temperate) (IUCNa n.d.). For SCALE-UP's sustainability screening, the IUCN classification of the seven systems is sufficient to refine the search while not excluding relevant habitats. The EU Habitats Directive, in contrast, distinguishes 25 habitat types that are

considered threatened and require active and recurring conservation action. The Directive demands member states to take measures to maintain or restore these natural habitats and wild species. If data on these became accessible in the future, it could be used in future iterations of the sustainability screening to supplement the results that using the IUCN classification yields.

(4) Threats: The IUCN database encompasses various general threats that can negatively impact a species. Direct threats denote immediate human activities or processes impacting, currently impacting, or potentially affecting the taxon's status, such as unsustainable fishing, logging, agriculture, and housing developments. Direct threats are synonymous with sources of stress and proximate pressures. Assessors are urged to specify the threats that prompted the taxon's listing at the most granular level feasible within this hierarchical classification of drivers. These threats could be historical, ongoing, or anticipated within a timeframe of three generations or ten years. These generalized threat categories encompass residential and commercial development, agriculture and aquaculture, energy production and mining, transportation and service corridors, biological resource use, human intrusion and disturbances, natural system modifications, invasive and other problematic species, genes and diseases, pollution, geological events, and climate change and severe weather. Beneath each general threat, more specific threats are detailed. Please refer to the IUCN Red List's website[2] for a detailed list of all threats, including explanations.

(5) Conservation Actions: The IUCN database contains conservation action needs for each species, providing detailed information on the current conservation efforts and recommended actions for protecting the taxon. It includes general conservation actions such as research & monitoring, land/water protection, management, and education. Specific conservation actions are listed under each general action, along with a description of the current conservation status and recommended actions to protect the taxon. A hierarchical structure of conservation action categories (see the IUCN Red List's website[3]) indicates the most urgent and significant actions needed for the species, along with definitions, examples, and guidance notes on using the scheme. Assessors are encouraged to be realistic and selective in choosing the most important actions that can be achieved within the next five years, informed by the conservation actions already in place.

Note: the IUCN Red List and the EU Habitats Directive

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

Both, the EU's Habitats Directive and the IUCN Red List aim to preserve biodiversity, but they employ distinct methods and standards for evaluating conservation status. The Habitats Directive is centered on preserving natural habitats and wild species of flora and fauna within the EU, mandating that member states establish Special Areas of Conservation for habitats and species listed in its annexes. The Directive categorizes conservation status into three groups: favorable, unfavorable-inadequate, and unfavorable-bad. This classification system of habitats and species is based on how far they are from the defined 'favorable' conservation status, not their proximity to extinction (Sundseth 2015).
Conversely, the IUCN Red List is a worldwide evaluation of the conservation status of species, categorizing them according to their extinction risk. The Red List employs a set of five rule-based criteria to assign species to a risk category (see above). However, there are inconsistencies and weak agreement between the conservation status assessments of the Habitats Directive and the IUCN Red List. These inconsistencies can be significant, and correlations can vary greatly between taxonomic groups. Specifically, the Red List assessment tends to be more pessimistic than the Directive's Annex (Moser et.al 2016). Amos (2021), on the other hand, has found strong correlations between the two classifications systems for plants, while recognizing the Red List's quicker reaction to changes in the conservation status.
In summary, while both the Habitats Directive and the IUCN Red List aim to protect and conserve biodiversity, they use different methodologies and criteria to assess conservation status, leading to discrepancies in their assessments. However, they can complement each other in providing a comprehensive view of the conservation status of species and habitats at both the European and global levels (IUCN 2010).

2.3.2 Methodology applied

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

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

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

(3) Species Selection: Limiting of the search results to endangered and critically endangered species to focus on those facing the most severe risks.

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

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

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

2.3.3 Data and methodological uncertainties

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

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

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

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

(4) Outdated data: The IUCN aims to have the category of every species re-evaluated at least every ten years and aims to update the list every two years (IUCNb n.d.). Nevertheless, the data might be outdated, which could lead to inaccuracies in the assessment of biodiversity risks. For this screening carried out for Andalucía, 73 percent of the data were older than 5 years, the most dated being from 2006.

(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

Note: the sections in this chapter were produced based on a review of available and accessible scientific literature on the impacts of bioeconomy activities on water, land and soil, biodiversity, and other environmental dimensions. Quotes associating such activities (or elements thereof) with positive and negative effects on the said environmental dimensions were collected manually from the scientific studies and then fed to ChatGPT4 for structuring and synthesis into flowing text.[4] The resulting text was then thoroughly reviewed and adjusted manually to ensure fidelity with the source documents.

3.1 Bioeconomic activity selected for the screening

Olive cultivation, deeply rooted in regions like Andalusia, is at a crucial juncture, balancing between its rich agricultural heritage and the pressing need for sustainability. Traditionally, this practice was synonymous with biodiversity and eco-friendly farming methods, but recent trends towards intensification have led to worrying environmental consequences. Currently, traditional olive production systems are slightly more common than intensive ones in Spain (51% over 46%, respectively). Benefits

[4] Quotes fed to ChatGPT were previously sorted by topic and kept in quotation marks, including their correct in-text citation. Prompts and feedback were provided to the system to synthesize the information maintaining the style, using the right scientific references, and improving by avoiding repetition, not leaving any of the provided information out, and highlighting agreements, disagreements and complementarities among quotes.

like shorter investment payback periods, underpinned by lower unit production costs and increased productivity, have made intensive cultivation attractive (Pérez, 2023). While intensive cultivation can also incorporate the implementation of soil protection measures (e.g. spreading crop residues on the field), the expanding water footprint driven by the growth in irrigated olive groves, and the potential for nitrate pollution, further complicate the sustainability narrative. As the global demand for olive products rises, the challenge intensifies to adopt sustainable agricultural practices. These practices must harmonize the traditional essence of olive farming with the need to address contemporary environmental concerns, including soil conservation, water management, and biodiversity preservation.

3.2 Potential burden on water resources

The impact of olive cultivation on water resources in areas like Andalusia has become increasingly significant, primarily due to the intensification of agricultural practices.

Non-Point Source Water Pollution: The regular use of agrochemical products in olive systems, primarily herbicides and fertilizers, has deteriorated water quality, leading to increased non-point source water pollution in rivers, dams, and aquifers. This pollution has caused several health concerns, including the prohibition of drinking water from dams surrounded by olive groves, despite the removal of some harmful agrochemical products (Gomez-Limon et.al, 2010). In response, recent changes in Spanish law have incorporated stricter provisions on the types and concentration levels of agrochemical products that can be used.

Water Footprint and Consumption: Between 1997 and 2008, the total water footprint (WF) of agricultural production in the Guadalquivir basin varied significantly due to irregular rainfall patterns. Olive groves consumed the largest proportion of both green (rainfall) and blue (irrigation) water resources, with olive cultivation dominating the upper part of the basin, both under rain-fed and irrigated conditions (Dumont et.al, 2013). The expansion of olive orchards, particularly irrigated systems, has led to an upward trend in total water footprint. The average water footprints for olive oil production in Spain vary depending on the type of system (rainfed or irrigated) and the components of the water footprint (green, blue, grey) (Morgado et.al, 2022).

Overexploitation and Nitrogen Pollution: The intensification of olive cultivation has led to an overexploitation of water resources, especially in the Guadalquivir basin, where most of the water is consumed by irrigated olive farms. This intensification jeopardizes the satisfaction of water demand in the basin and increases the risk of water resource depletion (Gomez-Limon et.al, 2010). Additionally, there is a significant difference in nitrogen inputs between irrigated and rainfed olives, with irrigated olives having nearly three times higher nitrogen inputs. This increase in nitrogen use in irrigated systems could potentially contribute to nitrate pollution, although the overall impact varies across different provinces (Morgado et.al, 2022).

Land Management Practices and Environmental Impacts: The no tillage land management practice (LMP) has been shown to effectively protect olive groves from land degradation and desertification due to better soil and water conservation. This practice results in lower runoff, reduced soil sediment loss, increased water storage in the soil, and lower soil temperatures, contributing to lower costs for olive oil production and protection of sensitive areas from desertification (Kairis et.al, 2013). In a case study the area of Cordoba, olive orchards with higher water-holding capacity soils show less yield sensitivity to decreasing soil depth, underscoring the importance of soil conservation measures to limit off-site erosion damage and maintain water storage capacity for dry seasons (Gomez et.al, 2014).

Supply Chain Water Footprint: The largest portion of the water footprint for bottled olive oil lies in the olive production process itself, with other supply chain components like the bottle, cap, and label contributing less than 0.5% to the product's water footprint. This finding is consistent with previous studies, highlighting the significant environmental impact of the olive production process (Morgado et.al, 2022).

3.3 Potential burden on land resources

Olive cultivation has profound impacts on soil resources, which are crucial for sustainable agricultural practices and environmental conservation.

Soil Erosion and Land Degradation: The expansion of olive groves into areas with unfavorable conditions (e.g., steep slopes, torrential rains) has exacerbated soil erosion. The agricultural and fishery regional ministry reports significant proportions of olive farms experiencing moderate to very high soil erosion (Gomez-Limon et.al, 2010). Olive cultivation, particularly under bare soil management practices such as continuous tillage (CT) or no tillage with bare soil (NT), has been associated with unsustainable erosion rates. Studies using indicators like olive mounds or radionuclide content have confirmed these observations (Gomez et.al, 2014). However, the implementation of cover crops significantly reduces erosion rates, often to tolerable levels, typically defined as 10 to 12 t ha^{-1} $year^{-1}$ (Gomez et.al, 2014). In contrast, soil management practices at the catchment scale, especially in regions like Southern Spain, show high erosion rates, negatively impacting water quality due to offsite contamination (Gomez et.al, 2014). Additionally, model predictions in Andalusia indicate prevalent unsustainable erosion rates, highlighting the need for finely-tuned soil management and potentially the abandonment of olive cultivation in favor of natural reversion to forests in severely sloping and degraded areas (Gomez et.al, 2014).

Soil Organic Carbon and Structure: Olive orchards managed with bare soil exhibit lower phosphorus, organic matter content, and aggregate stability compared to those with cover crops. Controlled experiments reveal a direct correlation between soil management techniques and topsoil properties, with higher erosion rates and poorer soil quality indicators under bare soil management (Gomez et.al, 2014). Moreover, there has been a significant reduction in organic matter and aggregate stability in olive orchards relative to natural areas, indicating a trend towards soil degradation (Gomez et.al, 2014).

Water Storage: Different soil management practices have varying impacts on water storage. In areas like the Guadalquivir river valley, represented by the Cordoba scenario, soil depths over 60 cm appear sufficient to maintain water storage for dry seasons, supporting stable yields. However, in more mountainous areas with shallow soil profiles, like the Obejo case, a much deeper soil profile is needed for adequate water storage, as water infiltrates below the olive root zone (Gomez et.al, 2014). Hence, maintaining soil depth is crucial, particularly in areas where irrigation is not feasible, and alternative soil management strategies are needed to maintain productivity.

Impact of Different Land Management Practices: No tillage land management practices (LMPs), especially those without herbicide use, are found to be effective in protecting olive groves from land degradation and desertification. These practices lead to reduced runoff, negligible soil sediment loss, greater water storage, and lower soil temperatures, which are beneficial for organic matter preservation and plant growth (Kairis et.al, 2013). In contrast, tillage practices contribute significantly to land degradation, evidenced by greater soil displacement and sediment losses (Kairis et.al, 2013).

Overall, olive cultivation has a significant impact on soil resources, with the potential for both negative effects, such as increased erosion and land degradation, and positive outcomes, such as improved water storage and soil structure, depending on the management practices employed. Sustainable management practices, particularly the use of cover crops and no tillage techniques, are crucial for mitigating these impacts and ensuring the long-term viability of olive cultivation.

3.4 Potential burden on biodiversity

The transformation of traditional olive groves in Andalusia into more modern, intensive agricultural systems has significantly impacted biodiversity, particularly in terms of farmland bird populations.

From High Biodiversity to Diminished Ecological Richness: Traditionally, Andalusian olive groves were characterized by high biodiversity, made possible by low-intensity farming practices, including minimal use of agrochemicals, the presence of old olive trees, and semi-natural herbaceous vegetation. These groves were part of diverse land-use areas, contributing to their ecological richness (Beaufoy and Cooper, 2009). However, recent shifts towards modernization, characterized by enlargement and intensification of olive farming, have led to a significant reduction in biodiversity. The modernization process involves the establishment of large, single-crop systems, intensive use of fertilizers, pesticides, machinery, and farms with uncovered soil (Gomez-Limon et.al, 2010).

Impact on Biodiversity and Farmland Birds: The high biodiversity of traditional olive groves in the 1980s, including various insects, birds, reptiles, and mammals, has been adversely affected by the intensification of olive farming. Changes such as the disappearance of vegetable cover, water pollution, insecticide use, and soil erosion have led to a reduction in both the number and diversity of animal species in these systems (Gomez-Limon et.al, 2010). Specifically, land cover transitions to irrigated olive plantations from 1990 to 2017 had a profoundly negative impact on open farmland birds, more so than any other observed land use change in the region (Morgado et.al, 2022).

Comparative Impacts of Land Use Changes: Land use dynamics leading to the installation of irrigated olive groves scored worst in terms of impacts on open farmland birds compared to other land use transitions. This negative impact is attributed to the conversion of biodiversity-rich areas, such as rainfed cereal cultivation and smaller, multifunctional rainfed olive groves, into irrigated olive plantations. These areas were previously part of rotational systems with diverse habitats crucial for farmland bird species. The transition towards irrigated olives, often replacing these biodiversity-rich areas, has resulted in simplified bird communities dominated by generalist granivores and a significant loss in bird diversity (Morgado et.al, 2022).

Conservation Recommendations: Given these findings, the importance of maintaining and reinforcing restrictions on olive grove expansion within protected areas, particularly those designated for open farmland bird conservation, is highlighted. These areas, often part of the Natura 2000 network, are vital for the preservation of farmland bird populations (Morgado et.al, 2022).

Overall, the shift from traditional, low-intensity olive farming to modern, intensive practices in Andalusia has led to a significant decline in biodiversity, particularly affecting farmland bird populations. The replacement of diverse land-use systems with intensive, irrigated olive groves has been the primary driver of this decline, underscoring the need for conservation efforts to protect remaining biodiversity-rich landscapes.

Agriculture and olive cultivation can significantly impact species, habitats, and biodiversity. These impacts include changes in soil composition, water usage, habitat modification, chemical runoff, microclimate alterations, reduced biodiversity, disrupted pollination and seed dispersal, introduction of non-native species, and threats to specialized species. Each of these factors plays a crucial role in the survival and health of ecosystems and the species within them.

1. **Impact on Soil Composition**: Many species mentioned thrive in specific soil types, like calcareous, sandy, or dolomitic soils. Agricultural practices, including olive cultivation, can alter soil composition through erosion, compaction, and changes in pH levels. This alteration can adversely affect species that depend on particular soil types.
2. **Water Use and Quality**: The text frequently references species living in or near water bodies with specific characteristics like high dissolved oxygen, constant temperature, and low nutrient content. Agricultural practices often lead to water extraction, altering flow patterns and temperatures in nearby streams and rivers, impacting species dependent on these water bodies.
3. **Habitat Modification**: Agriculture can lead to habitat loss or fragmentation. Species mentioned are often found in grasslands, scrublands, and mountainous regions, habitats that can be encroached upon by expanding agricultural lands. This fragmentation can limit the range and movement of species, impacting their survival.
4. **Chemical Use**: Pesticides and fertilizers used in agriculture can runoff into nearby habitats, affecting non-target species. Several species in the text, like those pollinated by Lepidoptera and Hymenoptera, could be impacted by these chemicals, affecting their reproductive success.
5. **Climate and Microclimate Alterations**: Agricultural activities can modify local climates and microclimates, impacting species adapted to specific temperature and humidity ranges. This is particularly crucial for species living in mountainous regions or those with narrow ecological ranges.

6. **Biodiversity Reduction**: The preference for monoculture in agriculture, including olive cultivation, reduces biodiversity. This reduction can affect species that rely on a variety of plants for food and habitat, as well as those that are part of a complex ecosystem.
7. **Pollination and Seed Dispersal**: Many plants and insects rely on each other for pollination and seed dispersal. Changes in land use due to agriculture can disrupt these relationships, impacting the reproductive success of both plants and their insect pollinators.
8. **Introduction of Non-native Species**: Agriculture can lead to the introduction of non-native species, which can become invasive and compete with or prey upon native species. This can have a cascading effect on local ecosystems.
9. **Impact on Specialized Species**: Species with highly specialized habitats or diets, like the Iberian Lynx, are particularly vulnerable to changes brought about by agriculture. The alteration of their specific habitats or reduction in prey species due to agricultural expansion can have severe consequences.

4 Screening results and recommendations

4.1 Overview - Andalusia

Resources screened		Ordinal Baseline Rating	Olive cultivation and olive oil production Management Practices	
Category	**Sub-Category**		**Potentially beneficial to the baseline status**	**Potentially detrimental to the baseline status**
Water	**Surface water bodies**		- Extensive olive cultivation - No tillage land management practices with cover crops - Reduced use of water resources and nitrogen in irrigated systems	- Water pollution from agrochemicals (primarily herbicides and fertilizers) - Overexploitation of water resources (for irrigation) - Nitrate pollution (associated with irrigated systems)
	Groundwater bodies			
Land Resources	**-**		- Measures to increasing soil water storage capacity (e.g. maintaining or deepening the soil profile) - Natural reversion to forests in severely sloping and degraded areas	- Continuous tillage and the absence of cover crops - Expansion of olive farms into steep slopes
Biodiversity	**Endangered Species**	**45**	- Traditional, low intensity olive farming practices (with minimal use of agrochemicals, and allowing old olive trees and semi-natural herbaceous vegetation to remain)	- Transformation from diverse land-use systems to intensive olive farming and single-crop systems - Habitat encroachment (e.g. olive grove expansion into protected areas)
	Critically Endangered Species	**17**		

4.2 Recommendations

While the incorporation of high-efficiency irrigation has increased the viability of olive production at scale in water scarce regions, it can also unlock disproportionate expansion of intensive farming operations in response to market demand, if unchecked. In the face of climate change and the increased frequency and intensity of droughts that it is already causing in Spain, as well as the shifts in seasonal conditions upon which environmental management and production planning has been carried out for decades, it is important to increase our understanding of regional system dynamics to avoid –or at least minimize– the negative effects that have been associated with olive production in regions like Andalusia.

Data from the 3rd cycle of EU WFD reporting indicates that the significant pressures and impacts most recurrently observed in the Guadalquivir RBD are associated with agriculture, and more concretely here with water extraction and flow diversion, physical alteration of rivers, and diffuse pollution. To ensure that ecological boundaries within the region are not surpassed, the water demand from irrigated olive production should be carefully balanced with the requirements of other uses, including the environment. This is a longstanding challenge that will clearly continue being at the core of decision-making in Andalusia, and that perhaps will become even more elusive under climate change conditions. At the farm level, the implementation of agricultural practices and measures that allow for increased water retention and lower soil disturbance and erosion risk (like no tillage and cover cropping), and that can enhance the resilience of the system to extended drought and scarcity periods (like better management of groundwater resources), could support the region in dealing with limitations on water resource availability.

While reversion to extensive cultivation practices could potentially mitigate the current pressures on the three environmental dimensions examined in the screening, and while a return to low-density mixed vegetation could strengthen specific degraded areas and slopes at high risk of erosion and biodiversity loss, such a shift seems unrealistic under the current situation of increasing demand and prices of olive products. However, it is at these times where it is most important for policy- and decision makers to frame their current actions within a plan for the mid- and long-term, giving serious consideration to the implications that these present actions may have in the future while still being able to navigate prevailing demands from social and economic systems. An integrated, systemic perspective seems thus fundamental to come as close as possible to a thorough understanding of the multiple challenges at hand, and later on, to formulate adequate responses with the support of local and regional experts and other stakeholders. In the meantime, it will be important to reinforce the preservation of protected areas, not only from a territorial perspective (i.e. from encroachment), but also from a water management one. These changes underscore the need for sustainable water and land management practices to mitigate the adverse effects on water quality and availability, and to ensure the long-term sustainability of olive production as a fundamental pillar of the regional economy of Andalusia.

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Section 1.1

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- Andalusia Environment Report (IMA), 2013
- WATER RESOURCES MANAGEMENT IN ANDALUSIA. ELEMENTS FOR ITS ANALYSIS. (Chica Ruiz, Arcila Garrido, Pérez Cayeiro, & Salle, 2017)
- Environmental Portal of Andalusia.
- Portal of the Ministry for Ecological Transition and Demographic Challenge.

Section 1.2

The main sources consulted have been:

- The EU Soil Observatory dashboard (JRC),
- REDIAM
- EUROSTAT
- RUSLE
- Environmental Portal of Andalusia.
- Portal of the Ministry for Ecological Transition and Demographic Challenge.

Section 1.3

The main sources consulted have been:

- Environmental Portal of Andalusia
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- Andalusian Biodiversity Strategy Horizon 2030.