BioINSouth

Supporting regional environmental sustainability assessment for the BIO-based sectors to improve INnovation, INdustries and INclusivity in SOUTH Europe

Deliverable 4.5

Biodiversity and ecosystems integrity

Bio-based Industries Consortium

Circular Bio-based Europe Joint Undertaking

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Supporting regional environmental sustainability assessment for the BIO-based sectors to improve INnovation, INdustries and INclusivity in SOUTH Europe

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D4.5 Biodiversity and ecosystems integrity

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Table of abbreviations

Abbreviation	Meaning
AFOLU	Agriculture, Forestry and Other Land Use
ARIES	Artificial Intelligence for Ecosystem Services
BCG	Boston Consulting Group
BHI	Biodiversity Habitat Index
BII	Biodiversity Intactness Index
B-INTACT	Biodiversity Intactness Index Tool
CBD	Convention of Biological Diversity
EBVs	Essential Biodiversity Variables
ESDV	Ecosystem Service Valuation Database
EX-ACT	Environmental eXternalities ACcounting Tool
FAO	Food and Agriculture Organization
GBIF	Global Biodiversity Information Facility
GEOBON	Group on Earth Observations Biodiversity Observation Network
GERI	Global Ecosystem Restoration Index
GIS	Geographic Information System
GDP	Gross Domestic Product
GLOBIO	Global Biodiversity Model
GPI	Genuine Progress Indicator
HFP	Human Footprint Index
IBAs	Important Bird and Biodiversity Areas
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Areas
KML	Keyhole Markup Language
KOM	Kick Off Meeting
LPI	Living Planet Index
LULUC	Land Uses and Land-use Changes
MARG	Multi- Actor Regional Groups
MOL	Map of Life
MSA	Mean Species Abundance
OECD	Organization for Economic Co-operation and Development
PBL	Netherlands Environmental Assessment Agency
SDGs	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
STAR	Species Threat Abatement Restoration
UN	United Nations
UNEP-WCMC	United Nations Environment Programme World Conservation Monitoring Centre
USD	United States dollar
WDPA	World Database on Protected Areas
WWF	World Wildlife Fund
ZSL	Zoological Society of London

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Executive Summary

The BioINSouth project contributes to the CBE-JU Strategic Research and Innovation Agenda (SRIA) by developing guidelines and tools to improve sustainability and promote circularity of bio-based industries in Mediterranean European regions. This aligns with the CBE-JU's objectives of accelerating innovation, improving market deployment, and ensuring high environmental performance in bio-based industrial systems.

The key objective of the BioINSouth project is to support decision-makers in Mediterranean European regions to incorporate ecological limits into their regional bioeconomy strategies and roadmaps. The project specifically targets regions that are currently lagging, with a focus on increasing regional competitiveness and innovation capacity, by fostering collaboration among stakeholders, including policymakers, SMEs, and civil society, inspired by the good practice of the BIOEAST Initiative as a good example of collaborative regional networks for exchanging experiences, knowledge, and best practices.

This document presents the deliverable D4.5 and addresses the identification and evaluation of a suitable tool to assess the impact of the bioeconomy on biodiversity and ecosystem services, in line with the objectives of the BioINSouth project. Considering that policymakers and non-specialized personnel are the principal stakeholders, the selection process focused on usability and accessibility, preferring tools that require minimal technical expertise. The target was to ensure that the solution selected would have the capacity to effectively support decision-making processes regarding sustainable bioeconomy strategies.

Therefore, a readily utilisable set of tools was selected and intensively examined. To further assure its use, the deliverable also includes developing a comprehensive user guideline, with the aim to facilitate adoption and frequent utilization by different groups of stakeholders.
This work provides the foundation for incorporating biodiversity and ecosystem service considerations in the examination of biobased value chains to help achieve the aim of enabling smart, sustainability-driven policy and business decisions.

1 Introduction

1.1 Bioeconomy, biodiversity and ecosystem services

The European Union's policy agenda prioritizes the transition to a sustainable and circular bioeconomy as a response to growing climate and biodiversity crises. As outlined in the European Green Deal (European Commission, 2019), achieving climate neutrality and sustainable resource consumption requires a paradigm shift in producing, governing, and valorising biological resources. Simultaneously, the EU Biodiversity Strategy 2030 (European Commission, 2020) highlights the need to restore degraded ecosystems and prevent biodiversity loss. In this context, bioeconomy, biodiversity, and ecosystem services are intrinsically interconnected.

Bioeconomy relies on biological resources and processes to generate food, materials, and energy, but long-term sustainability depends on maintaining biodiversity and the stability of natural ecosystems. The Global Bioeconomy Summit (2018) has established the bioeconomy as an innovative strategy that enables the achievement of the Sustainable Development Goals (SDGs) (D'amato et al., 2020).

Biodiversity plays a key role in the bioeconomy by enabling the development of innovative pharmaceutical, cosmetic, and food products, as well as for the discovery of new molecules that are essential for biotechnological innovation. A biodiversity-based bioeconomy will thus need to be complemented with sound scientific research and bioprospecting to create new product, service, idea, and technology development (D'amato et al., 2020). Such strategies can further enhance biodiversity-associated services, particularly ecosystem services.

Ecosystem services are the benefits that people derive from nature and encompass the many processes that sustain life on Earth. They are commonly grouped into four main categories (MEA, 2005):

i. Provisioning services, such as food, freshwater, and raw materials;
ii. Regulating services, including climate regulation, water purification, and biological pest control;
iii. Cultural services, such as recreation, spiritual enrichment, and aesthetic enjoyment;
iv. Supporting services, like nutrient cycling and soil formation, which are necessary for the functioning of all other services.

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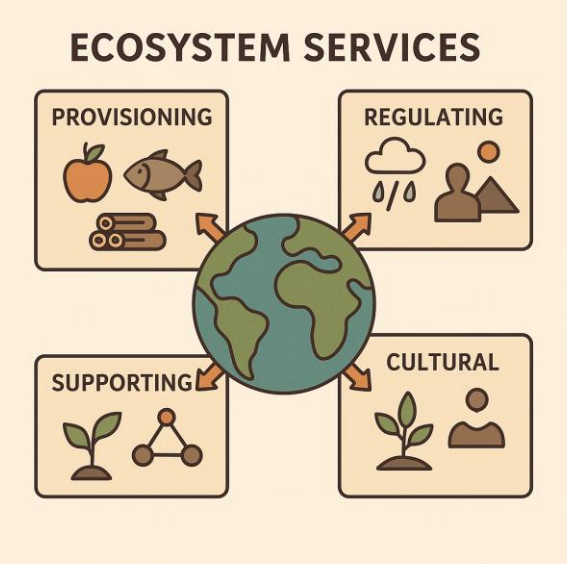
Figure 1. Ecosystem services



Despite being highly relevant, the links between biodiversity, ecosystem services, and the bioeconomy are often overlooked in policy discussions and are only now being addressed in research on sustainability governance. Current policy frameworks often assume that the bioeconomy is intrinsically sustainable. As a result, essential trade-offs and risks—such as biodiversity loss through large-scale monoculture-based biomass or biofuel production—are not considered (de Queiroz-Stein & Siegel, 2023).

Biodiversity decline is primarily driven by habitat destruction caused by agriculture and forestry, which account for 66% of global biodiversity loss, followed by greenhouse gas emissions (34%). In the agricultural context, monocultures are one of the main drivers of biodiversity loss. For instance, the extensive cultivation of olive trees in Spain as a monoculture, while economically beneficial, has contributed to a significant loss of biodiversity. If ongoing trends of degradation persist, the global economy could lose up to USD 2.7 trillion annually by 2030, due to impacts on pollination, fisheries, and forest resources. According to IPBES (2019), the five main drivers of loss of biodiversity are:

- Land use change
- Overexploitation of natural resources
- Pollution
- Invasive alien species
- Climate change

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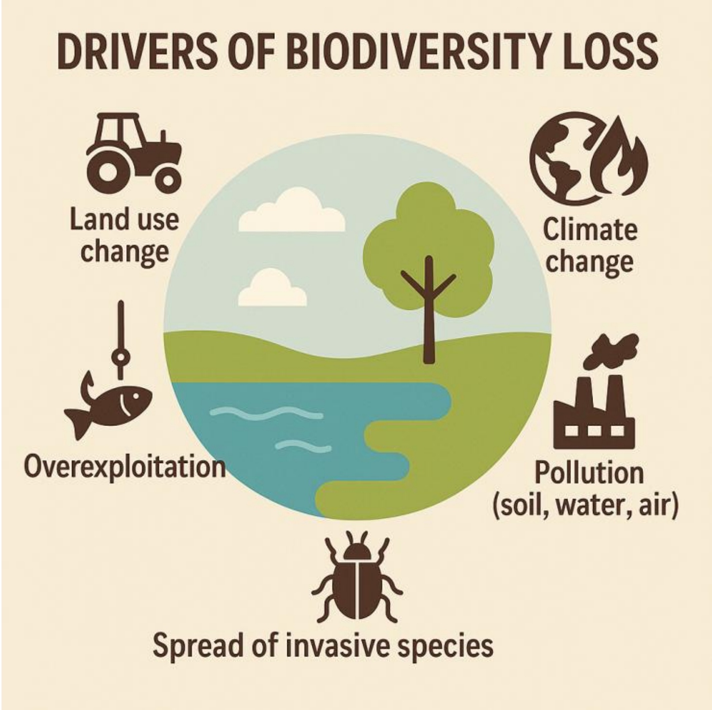
Figure 2. Drivers of biodiversity loss



If well designed and implemented, bioeconomy-based solutions hold the potential to address these drivers in a comprehensive and systemic way. Specifically, the principles underlying bioeconomy-based solutions act directly on pollution and the overexploitation of natural resources, and also indirectly on climate change and the risks of species extinction.

The integration of bioeconomy, biodiversity, and ecosystem services is not merely beneficial—it is essential. This integration ensures resilience and sustainability across economic and ecological systems. Investments in knowledge generation, environmental monitoring, soil science, and biotechnological innovation are the only viable path toward building an economy that is both productive and ecologically responsible. **Restoring balance between human development and nature is not a choice—it is a prerequisite for a sustainable future.**

Therefore, it is crucial to provide accessible and practical tools for policymakers and stakeholders, enabling informed and responsible decision-making that protects biodiversity and secures vital ecosystem services.

1.2 GDP, biodiversity and ecosystem services

Gross Domestic Product (GDP) is the most common economic indicator worldwide to measure the growth and welfare of a nation. Nevertheless, even though it is highly applied, GDP has great limitations in quantifying the sustainability of economic activities, especially concerning environmental effects, the health of ecosystems, and future natural resource availability (Stiglitz, Sen & Fitoussi, 2009).

One of the most critical limitations of GDP is that it does not account for biodiversity loss or ecosystem degradation, even though these are fundamental to both life and the economy. Natural ecosystems provide a wide array of goods and services that underpin the functioning of human societies — from climate regulation to crop pollination, from water purification to soil fertility. These are collectively referred to as ecosystem services. Over the past two decades, the concept of ecosystem services has gained prominence as a powerful framework for interpreting and communicating the socio-economic value of biodiversity and natural capital. By making visible both the tangible and intangible benefits nature provides, this framework has proven essential in shaping sustainable resource management strategies and conservation policies (TEEB, 2010). Safeguarding ecosystem services is therefore not only crucial to ensuring ecological resilience and human well-being, but also represents a core pillar of long-term economic stability (IPBES, 2019).

Biodiversity generates significant economic value in the form of ecosystem services, which—estimates BCG—are greater than $150 trillion every year, roughly twice the worth of worldwide GDP (Kurth et al. 2021). Despite their immense economic value, ecosystem services are not captured in traditional GDP metrics , which only include market transactions (Actis et al., 2025).

This disconnection produces self-evident economic paradoxes: for instance, deforestation may lead to a temporary increase in GDP resulting from the harvesting of trees and the clearing of land for agriculture, while at the same time inducing an irreparable loss of habitats, species, and ecosystem services that are of enormous importance for large industries such as agriculture, fisheries, and tourism. Briefly, what stimulates economic growth in the short-term can destabilize natural capital in the long term (Dasgupta, 2021).

Numerous international studies, including the UK's HM Treasury's Dasgupta Review, have highlighted the necessity for economic systems to urgently integrate biodiversity and natural capital into mainstreaming. According to this, GDP should be complemented—or partially replaced—by more comprehensive indicators that reflect the value of natural capital, defined as the sum of resources and services provided by nature (Dasgupta, 2021; UN SEEA, 2021).

In the current context, where global environmental crises that accelerated biodiversity loss and climate change have become a reality, it is essential to update the very definition of growth. Structurally, economies depend on ecosystems behaving normally: in the absence of productive land, clean water, pollinators, and a stable atmosphere, even highly developed production systems become excessively vulnerable (IPBES, 2019). The complex balance and interplay between genes, species, and ecosystems produce services that are essential to the functioning of society and the modern economy and therefore generate enormous economic value.

Due to this, several international organizations—e.g., FAO, IPBES, the World Bank, and the OECD—are promoting other approaches to ecological accounting. These include the System of Environmental-Economic Accounting (SEEA) of the United Nations, and complementary indicator construction to GDP, such as the Green GDP, the Genuine Progress Indicator (GPI), and Natural Capital Accounting (UN, 2021; OECD, 2020).

In conclusion, environmental health, ecosystem services, and biodiversity are not beyond the economy but its underlying foundation. It would be a mistake- or at least a deficiency — to attribute the impact of biotechnological solutions to GDP alone because this indicator fails to account for such vital resources as environmental quality and biodiversity. Furthermore, continuing to measure prosperity solely by GDP means neglecting the invisible costs of un-sustainability. One of today’s challenges is to embed nature into economic, political, and social decision-making, not perceiving it as an open-ended resource, but as critical capital to be preserved, renewed, and invested.

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1.3 Databases and Indices for biodiversity and ecosystem services

For the study of biodiversity and ecosystem services, numerous databases and indices are available. With the aim of identifying the most suitable tool to assess the impact of biobased companies on biodiversity and ecosystem services, the most used indices and databases have been reviewed.

1.3.1 Databases

1.3.1.1 IUCN Red List

The IUCN Red List is a critical indicator of the health of the world's biodiversity. Far more than a list of species and their status, it is a powerful tool to inform and catalyze action for biodiversity conservation and policy change, critical to protecting the natural resources we need to survive. It provides information about range, population size, habitat and ecology, use and/or trade, threats, and conservation actions that will help inform necessary conservation decisions.

Link: https://www.iucnredlist.org

1.3.1.2 GEOBON Essential Biodiversity Variables (EBVs)

GEOBON's Essential Biodiversity Variables (EBVs) are a standardized framework for monitoring biodiversity across space and time. Organized into six main categories (genetics, species, traits, communities, ecosystems), EBVs act as intermediate metrics that support the development of biodiversity indicators for policy and decision-making. They integrate multiple data sources and help ensure consistency and comparability in biodiversity assessments globally.

Link: https://geobon.org/

1.3.1.3 Map of Life (MOL)

Map of Life (MOL) is a global platform designed to support biodiversity monitoring by providing detailed information on the distribution of species across the planet. It integrates data from museums, citizen science, remote sensing, and ecological models to generate high-resolution species distribution maps. MOL helps identify species richness, endemism, and conservation priorities, making it a valuable tool for tracking biodiversity trends, assessing ecosystem status, and informing decision-making at regional and global scales.

Link: https://mol.org/

1.3.1.4 The Global Biodiversity Information Facility (GBIF)

The Global Biodiversity Information Facility (GBIF) is an international open-data infrastructure that provides access to one of the world's largest collections of biodiversity occurrence data. It aggregates georeferenced records of species from museums, research institutions, citizen science programs, and monitoring networks. GBIF supports biodiversity research, conservation planning, species distribution modelling, and policy development by enabling users to visualize, download, and analyze species data at global and regional scales. Its standardized and interoperable format makes it a key resource for both scientific and decision-support applications related to biodiversity and ecosystem services.

Link: https://www.gbif.org/

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1.3.1.5 Bird Life

BirdLife International maintains a global database on the distribution, population status, and threats to bird species, recognized as a key authority for birds' conservation. It provides spatial data on Important Bird and Biodiversity Areas (IBAs), species extinction risk assessments (used in the IUCN Red List), and migratory routes. This resource is essential for identifying priority conservation areas, informing environmental impact assessments, and supporting biodiversity indicators relevant to policy frameworks like the CBD and SDGs. The limitation of this database is that it considers only one category of species.

Link: https://www.birdlife.org/

1.3.1.6 Ecosystem Service Valuation Database (ESVD)

The Ecosystem Service Valuation Database (ESVD) is an open-access repository that compiles economic values of ecosystem services from peer-reviewed literature. Managed by the Foundation for Sustainable Development, it provides standardized information on provisioning, regulating, and cultural services across ecosystems globally. The ESVD is used to quantify the societal and economic relevance of biodiversity, support cost-benefit analyses, and inform natural capital accounting and policy decisions.

Link: https://www.esvd.info

1.3.1.7 Key Biodiversity Areas map database

The Key Biodiversity Areas (KBA) database offers geospatial and descriptive data on sites that are critical for the global persistence of biodiversity. Managed by the KBA Partnership (including IUCN and BirdLife), this resource identifies areas that meet strict criteria for species vulnerability, ecological integrity, and irreplaceability. The database supports site-based conservation planning, environmental safeguards, and monitoring efforts under international biodiversity commitments.

Link: https://www.keybiodiversityareas.org/kba-data

1.3.1.8 World Database on Protected Areas

The World Database on Protected Areas (WDPA), managed by UNEP-WCMC and IUCN, is the most comprehensive global dataset on terrestrial and marine protected areas. It provides spatial boundaries, designation types, and management information for official protected areas worldwide. WDPA is widely used for tracking progress toward international conservation targets, such as the Kunming-Montreal Global Biodiversity Framework and SDG 15. It also supports environmental modelling, gap analyses, and decision-making in conservation planning.

Link: https://www.protectedplanet.net/en/thematic-areas/wdpa?tab=WDPA

1.3.1.9 Vertlife

Vertlife is a comprehensive and dynamic data platform designed to support research in biodiversity, ecology, and evolutionary biology. It integrates phylogenetic, ecological, and geographical information across a wide range of species, allowing scientists and researchers to explore patterns of species distribution, evolutionary history, and trait diversity.

Link: https://vertlife.org/

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1.3.2 Indices

1.3.2.1 Mean Species Abundance (MSA)

The Mean Species Abundance (MSA) index is a model-based indicator that estimates the average abundance of originally occurring species in a given ecosystem, relative to their abundance in an undisturbed, reference state. It ranges from 0 (no original species remaining) to 1 (no disturbance). MSA is used to quantify the impact of land use, infrastructure, and pollution on biodiversity and is widely applied in global models such as GLOBIO to assess biodiversity loss over time.

1.3.2.2 Human Footprint Index (HFP)

The Human Footprint Index (HFP) measures the cumulative impact of direct human pressures on the environment, including built infrastructure, population density, land transformation, and access routes (e.g., roads, railways). The index provides a spatial representation of anthropogenic pressure, helping to identify intact areas and hotspots of human disturbance, which are crucial for biodiversity conservation planning.

1.3.2.3 Biodiversity Habitat Index (BHI)

The Biodiversity Habitat Index (BHI) estimates the reduction in the ability of natural ecosystems to support biodiversity due to habitat loss, degradation, and fragmentation. It is based on species distribution data and habitat suitability models, and it is developed under the auspices of the Biodiversity Indicators Partnership. BHI supports global biodiversity assessments, such as the IPBES Global Assessment and CBD reporting.

1.3.2.4 Biodiversity Intactness Index (BII)

The Biodiversity Intactness Index (BII) reflects the average abundance of native species in a given area relative to their abundance in minimally impacted ecosystems. It considers multiple pressures, including land use, fragmentation, and human population density. BII is commonly used to evaluate overall ecosystem integrity and to support scenario analyses at global, regional, and national levels.

1.3.2.5 Living Planet Index (LPI)

The Living Planet Index (LPI), developed by WWF and ZSL, is a measure of the state of the world's biological diversity based on population trends of vertebrate species from terrestrial, freshwater and marine habitats. The LPI was adopted by the Convention of Biological Diversity (CBD) as an indicator of progress towards its 2011-2020 targets and it is now an indicator in the post-2020 Kunming-Montreal Global Biodiversity Framework.

1.3.2.6 Global Ecosystem Restoration Index (GERI)

The Global Ecosystem Restoration Index (GERI) is a composite indicator that evaluates progress in the restoration of degraded ecosystems. It combines remote sensing data, land use information, and restoration activities to provide spatially explicit insights on restoration outcomes. GERI supports the implementation and monitoring of global initiatives such as the UN Decade on Ecosystem Restoration and the Kunming-Montreal Global Biodiversity Framework.

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1.4 Software and tools for biodiversity and ecosystem services study

A literature review was conducted to identify the main tools and software used to assess human impacts on biodiversity and ecosystem services. Below is a list and description of the tools and software that were selected as the most suitable.

1.4.1 B-INTACT (Biodiversity Intactness Index Tool)

B-INTACT quantifies the biodiversity impact of various investments at project and policy-level using globally recognized environmental assessment, aiming to provide a thorough biodiversity assessment of project-level activities in the Agriculture, Forestry and Other Land Use (AFOLU) sector, taking on both a quantitative and a qualitative approach.

Link: https://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/b-intact/en/

1.4.2 GLOBIO (Global Biodiversity Model)

GLOBIO is a model used to assess the impact of human activities on biodiversity at the global level. It can estimate biodiversity loss in response to various drivers such as land use, climate change, and pollution.

Link: https://www.globio.info/

1.4.3 STAR: Species Threat Abatement and Recovery

The Species Threat Abatement Restoration (STAR) metric uses IUCN Red List of Threatened Species data to estimate the potential reduction in species extinction risk that could be achieved at a site, across a corporate footprint, or within a country. It can also be used to set local or global species extinction risk targets, and measure progress towards those targets.

Link: https://www.ibat-alliance.org/

1.4.4 InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs)

InVEST is a suite of models that quantifies ecosystem services and their economic value. Its modules include biodiversity, carbon sequestration, water quality, and habitat quality.

Link: https://naturalcapitalproject.stanford.edu/software/invest

1.4.5 ARIES (Artificial Intelligence for Ecosystem Services)

ARIES uses artificial intelligence to model ecosystem services and biodiversity, with a focus on how land-use change and other human activities affect these services.

Link: https://aries.integratedmodelling.org/

1.4.6 ArcGIS

ArcGIS is a geographic information system (GIS) platform used by professionals and organizations to analyze and manage geographic data. Built by Esri (the global market leader company in geographic information system software, location intelligence, and mapping), ArcGIS integrates and connects data

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through the context of geography providing a set of capabilities, apps, and tools for creating, managing, analyzing, mapping, and sharing all types of data.

Link: https://www.arcgis.com/index.html

1.4.7 Earthmap

EarthMap is a free, web-based application developed by FAO, designed to provide easy access to global environmental, climatic, and land-use data. While originally developed to support climate and land degradation monitoring, EarthMap offers several features relevant to biodiversity assessment. Its intuitive interface makes it especially valuable for non-technical stakeholders seeking to integrate spatial data into biodiversity monitoring and nature-based planning strategies.

Link: https://earthmap.org/login

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2 B-INTACT tool (Biodiversity Intactness Index Tool)

Following a critical study of all the tools described above, an analysis was conducted based on several parameters concerning accessibility, ease of use, universality, as well as the main contexts of use. B-INTACT tool was selected as the most appropriate for the specific objectives of this project.

B-INTACT was chosen for several reasons. Most significantly, it is an open-access tool, which enables it to be downloaded and utilized without the payment of subscription or license fees. This is particularly significant in the context of publicly funded projects that aim to promote transparency, replicability, and stakeholder engagement. In addition, B-INTACT relies on open and freely available databases, which do not require specialized infrastructure or proprietary data to be effective.

Functionally, the tool was designed to support biodiversity assessments at project level, with a particular reference to the AFOLU sector activities (Agriculture, Forestry and Other Land Use). This makes it highly appropriate to the thematic focus of this deliverable, where the goal is to assess the possible impacts of biobased value chains and activities on ecosystems and biodiversity. Its relevance is further enhanced by the fact that it acts as a complementary tool to Deliverable 4.4, which concentrates on LULUC.

One of the best features of B-INTACT is that can provide both quantitative and qualitative outputs, offering not just spatially explicit assessments of biodiversity loss estimates, but also a set of policy-oriented indicators. Among these, the measurement of the "*lost social value of biodiversity*" reflects both ecological and socio-economic dimensions of biodiversity loss. Such outputs are particularly valuable for policy and decision-making purposes because they offer tangible measures that can be utilized for informing sustainable land-use planning, environmental risk analysis, and conservation policies for biodiversity.

Another key aspect is the user-friendly interface of the tool, making it accessible to a large range of users, from policymakers to practitioners and stakeholders with minimal technical or modelling skills. While some level of familiarity with biodiversity data and geospatial inputs is necessary, B-INTACT is specifically designed to minimize technical barriers and facilitate wider application.

However, the tool still requires some level of knowledge regarding its structure and data needs. For this reason, one of the key tasks in this deliverable has been the development of a *user guideline* (Chapter 3). The aim of this document is to guide users' step by step through the initial preparation of input data, model running, and results interpretation. It aims to allow users to conduct robust and informed biodiversity impact assessment in accordance with the project's goals.

Briefly, the selection of B-INTACT was a combination of technical robustness, thematic relevance, open use, and user-centred design. These features make it a useful and effective tool to support biodiversity impact assessments in the spirit of sustainable bioeconomy development. Moreover, it directly aligns with the overall objectives of the project to provide environmentally information for policymaker.

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3 B-INTACT guideline

3.1 Definition of the tool

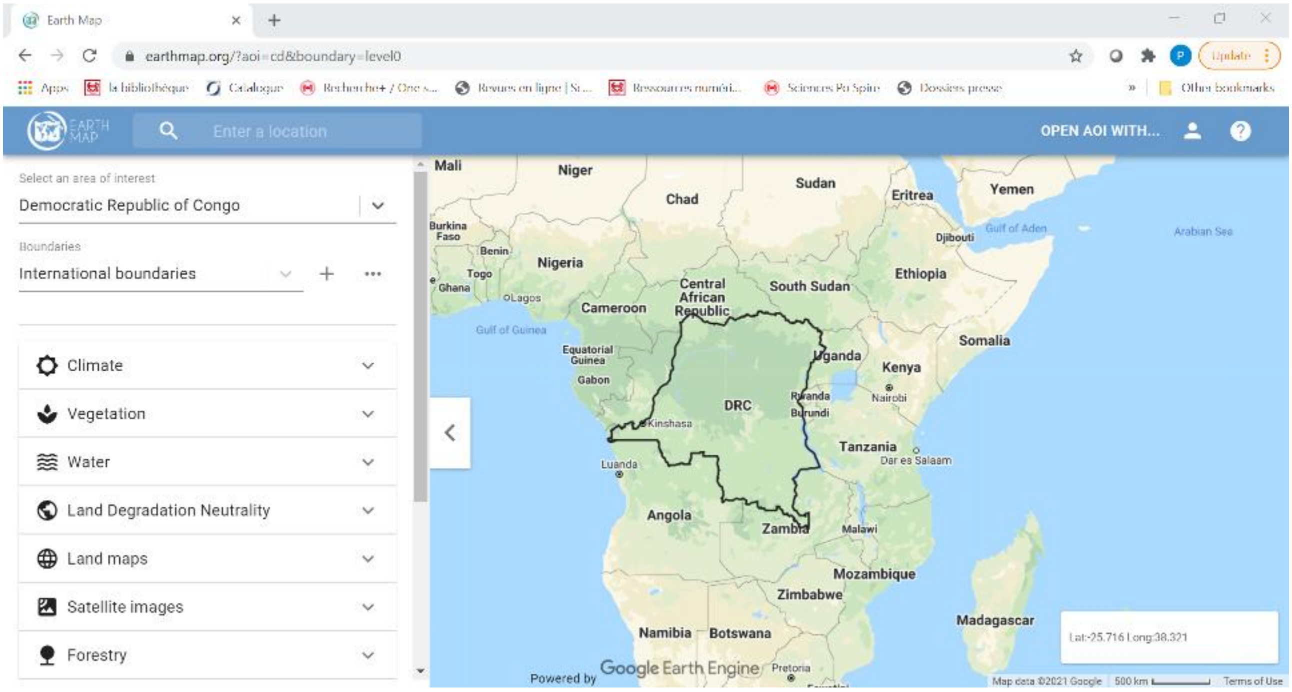
The Biodiversity Integrated Assessment and Computation Tool (B-INTACT; FAO, 2021) allows the assessment of the impact of (agricultural) anthropogenic activities on biodiversity by using existing databases and geo-referenced maps that account for the ecological value and sensitivity of biodiversity within project sites. The tool was developed by the EX-ACT team from the Food and Agriculture Organization (FAO) of the United Nations, and it is designed for a broad range of users, ranging from policy decision-makers to international financial institutions.

B-INTACT includes both quantitative and qualitative approaches. The quantitative approach relies on the mean species abundance (MSA) metric, which quantifies the mean abundance of original species in disturbed conditions relative to their abundance in an undisturbed habitat. The MSA is calculated by considering several anthropogenic impacts on biodiversity, such as land use changes, the presence of infrastructures, habitat fragmentation, and human encroachment. The qualitative approach considers non-quantifiable impacts assessed through a qualitative survey about the biodiversity sensitivity to the project, biodiversity management activities, and agrobiodiversity practices implemented by the project.

The tool is available at https://exact.apps.fao.org/ upon registration with an email address.

The B-INTACT computation is also available within the EarthMap application (Morales et al., 2023) by accessing the platform earthmap.org (Fig.3; see PART 3.4 of the B-INTACT guidelines for more details; https://doi.org/10.4060/cb3393en).

Figure 3. EarthMap application. Figure taken from the B-INTACT guidelines (FAO, 2021).



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3.2 Organization of the tool and input data required

B-INTACT is presented as an excel file organized in six different sheets: Start page, Biodiversity assessment, Qualitative assessment, Biodiversity Results, Help, Definitions.

To start the biodiversity assessment, few inputs are required by the user:

- E-mail address to access the EarthMap platform;
- Basic information of the project: country, climate, moisture regime, elevation, and number and type of patches within the project site according to the IPCC land use classes (refer to paragraph 2.1.1 and table 3 of the B-INTACT guidelines). All these data are available within the EarthMap application by filtering the related layers for a selected area of interest within the platform or an uploaded area of interest (see next point);
- Spatial data (e.g., shapefile or KML) of the project site to be used in the EarthMap application (not mandatory);
- Proposal of the amount invested (in USD) for biodiversity management activities and agrobiodiversity practices, if implemented (only for the qualitative approach).

3.3 Start page

In the start page (Fig. 4), the user can provide the basic information on the country, climate, moisture regime, elevation, and number of patches within the project site for both the “without-project” scenario (or baseline) and the “with-project scenario”. In particular, a patch is defined as a connected plot of land characterized by a single type of land use (e.g., forest zone vs annual cropland; see section 3.4 for more details on land use classes).

Figure 4. B-INTACT start page. Figure taken from the B-INTACT guidelines (FAO, 2021).

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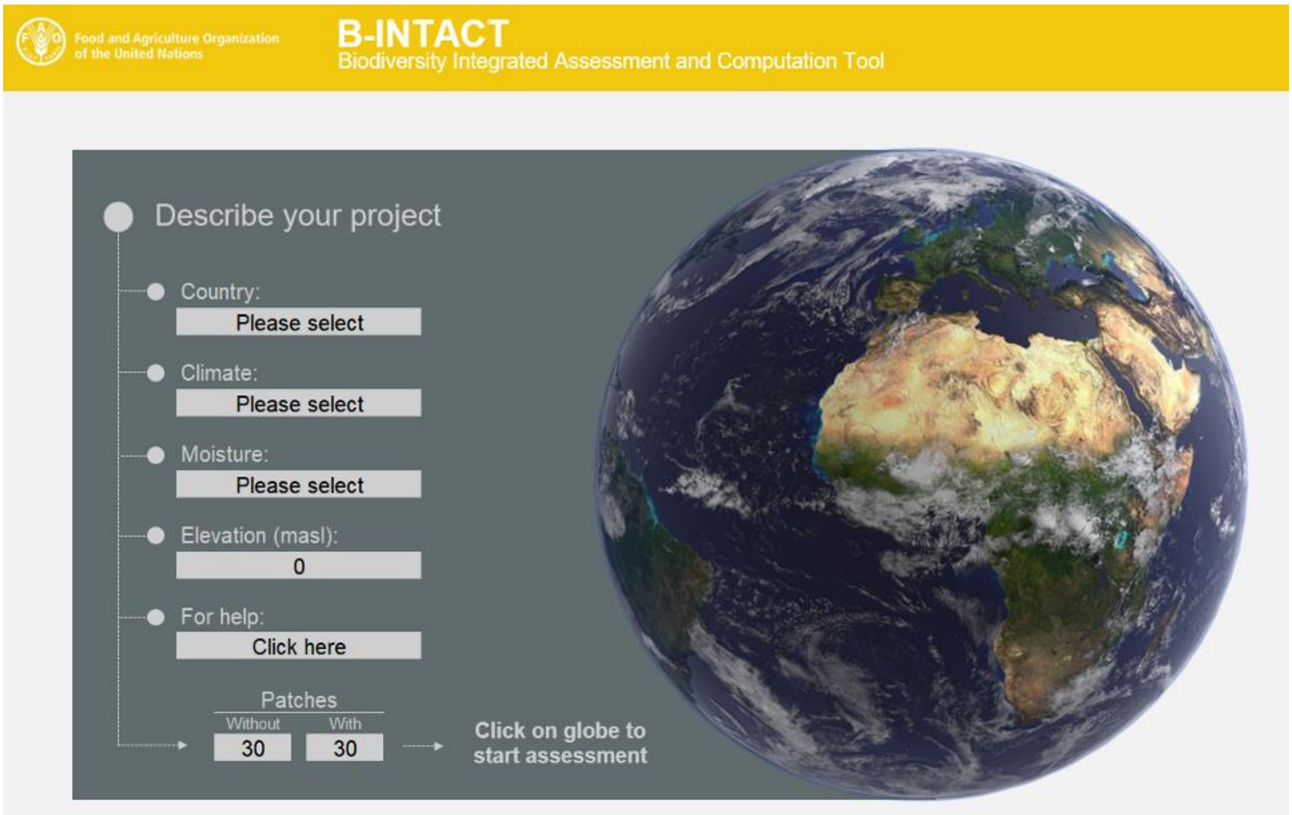

The country, climate, and moisture can be filled through a drop-down menu; if the last two are unknown, the 'Help' button will redirect the user to a help section with the climatic zones. Alternatively, the user can obtain the climatic information from the EarthMap platform by selecting the country of interest and filtering the layer which refer to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (namely 'IPCC Climatic Zones' within the section 'Climate'; Fig.5).

Figure 5. Example of the Lazio region for the visualization of the IPCC Climatic Zones layer in EarthMap (source: EarthMap screenshot).

Once the user has entered all the basic information on the Start page, the biodiversity assessment may be filled out on the next page.

3.4 Step-by-step guide for the quantitative (Biodiversity) assessment

3.4.1 The mean species abundance (MSA) metric

The quantitative assessment within B-INTACT is based on the mean species abundance (MSA) metric, which is an indicator of the ecosystem's intactness expressed as the mean abundance of original species in disturbed conditions relative to their abundance in an undisturbed habitat. The MSA ranges between 0% to 100%, where 0% represents a destroyed ecosystem with no species left, and 100% represents an undisturbed ecosystem with all original species.

The MSA is calculated by considering several anthropogenic impacts on biodiversity on a patch level, such as land use changes, the presence of infrastructures, and habitat fragmentation. Each anthropogenic impact is calculated per patch and expressed in MSA values. The aggregate MSA value of the patches is thus given by multiplying the anthropogenic impacts for each patch and then derived from the area-weighted mean of the patch-level MSA values. To obtain the final MSA, the aggregate MSA value is multiplied by the project area-level MSA values from human encroachment impacts.

3.4.2 Anthropogenic pressures for MSA calculation

3.4.2.1 Pressure 1: Land Use

Land use of the patches is the starting point of the quantitative assessment. Here, the user will find as many rows as the number of patches defined in the Start page with and without project. Therefore, the user is required to select from a dropdown list the land use type of each patch, and to fill out the land area of each patch in hectares (ha) (Fig. 6). The sum of the land area of both the without and with project scenarios needs to be same, otherwise a "Check areas!" warning will appear.

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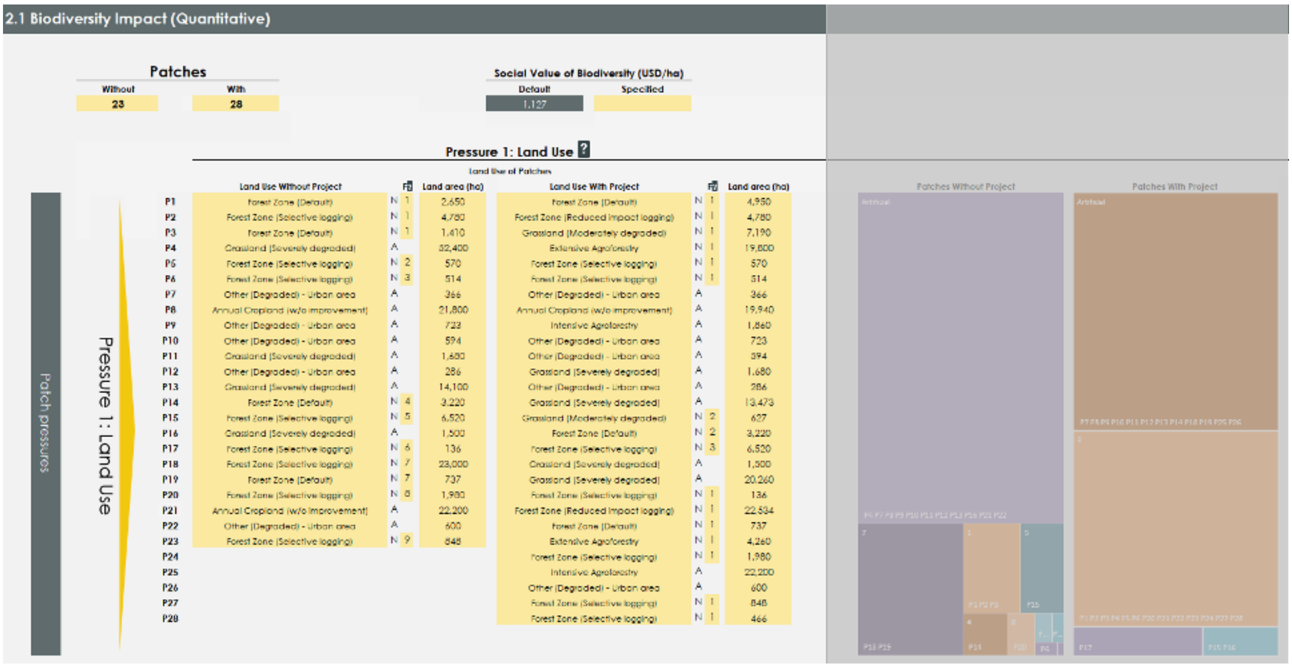
Figure 6. Visualization of land use pressure section within B-INTACT. Figure edited from the B-INTACT guidelines (FAO, 2021).

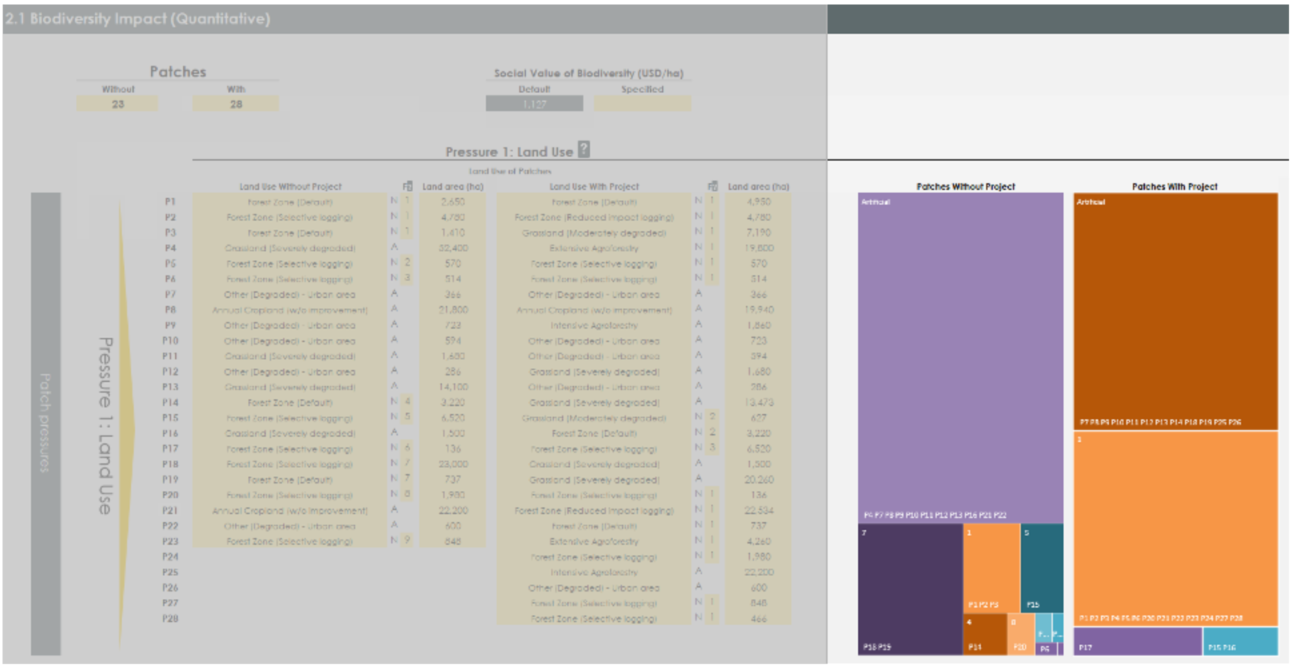


The land use classes are defined according to IPCC land use classes, and definitions of each class can be found in the 'Definitions' sheet within B-INTACT as well as in Table 3 of the B-INTACT guidelines. If the land use types and land area of each patch of the project site is unknown, the user can use the EarthMap platform by selecting the area of interest and querying the proper layer (Fig.7). The MSA value given by the land use pressure (MSA_{LU}) is automatically filled based on the cause-effect relationships between land use and MSA identified under the GLOBIO model (Alkemade et al., 2009) developed by the Netherlands Environmental Assessment Agency (PBL) (values reported in Table 3 of the B-INTACT guidelines).

Figure 7. Example of the Lazio region for the visualization of the IPCC land use layer in EarthMap (source: EarthMap screenshot).

Once the user has specified the land use types, each patch is automatically classified into non-fragmented natural areas versus artificial areas (see ‘Definitions’ sheet) and a rectangular pie chart shows the fragmentation groups with and without project (Fig.8).

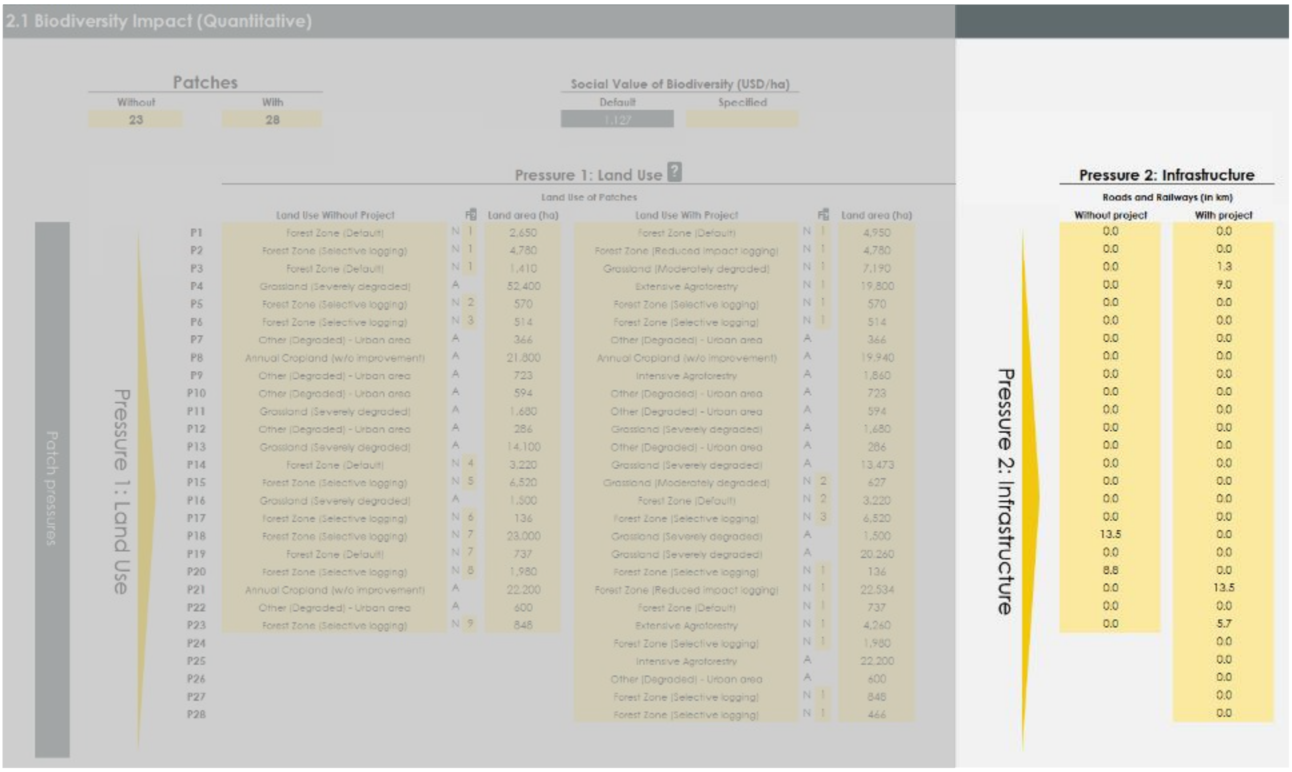
Figure 8. Rectangular pie chart showing the fragmentation groups with and without project based on land use types. Figure edited from the B-INTACT guidelines (FAO, 2021).



3.4.2.2 Pressure 2: Infrastructure

Biodiversity disturbance from infrastructure is assumed to be induced by 1 km^2 around infrastructural elements, such as roads and railways. The user is required to fill out the total km of newly built roads and railways in each patch for both without and with project scenarios (Fig.9). The MSA value given by the impact of infrastructures (MSA_I) is automatically filled based on a meta-analysis from Benítez-López et al., 2010 (applied formula in the B-INTACT guidelines).

Figure 9. Visualization of the infrastructure pressure section within B-INTACT. Figure edited from the B-INTACT guidelines (FAO, 2021).



3.4.2.3 Pressure 3: Fragmentation

Biodiversity impact from habitat fragmentation is assumed to be induced by roads, cropland, and urban areas. Once the patches of both with and without project scenarios are aggregated in non-fragmented natural areas vs artificial areas according to the land use type previously defined (see Table 5 in the B-INTACT guidelines), the tool automatically provides the number of hectares of each non-fragmented natural areas (Fig. 10). The MSA value given by the fragmentation pressure (MSA_F) is automatically filled by size range of non-fragmented area defined in the GLOBIO model (see Table 4 and 6 in the B-INTACT guidelines).

Figure 10. Visualization of the fragmentation pressure section within B-INTACT. Figure edited from the B-INTACT guidelines (FAO, 2021).

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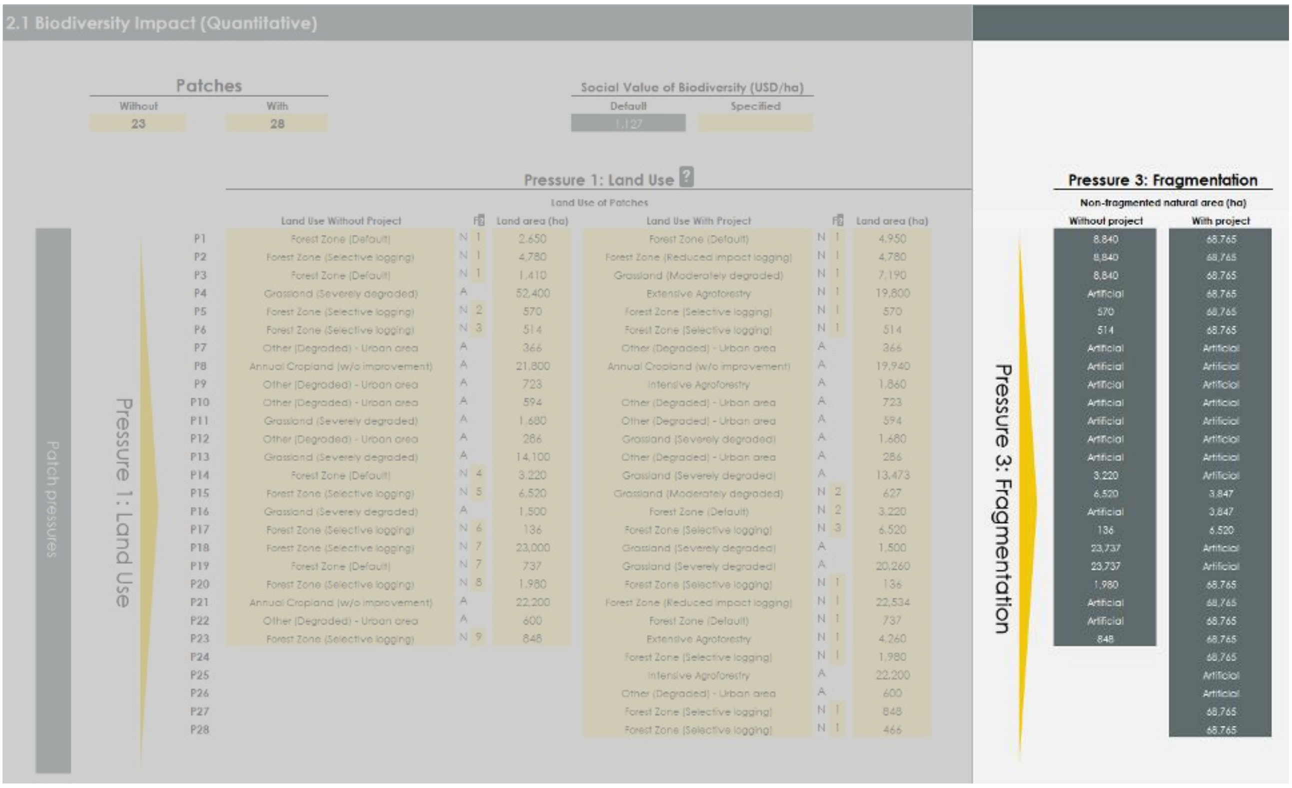


2.1 Biodiversity Impact (Quantitative)

Patches Without	Patches With	Social Value of Biodiversity (USD/ha) Default	Specified
23	28	1,127	

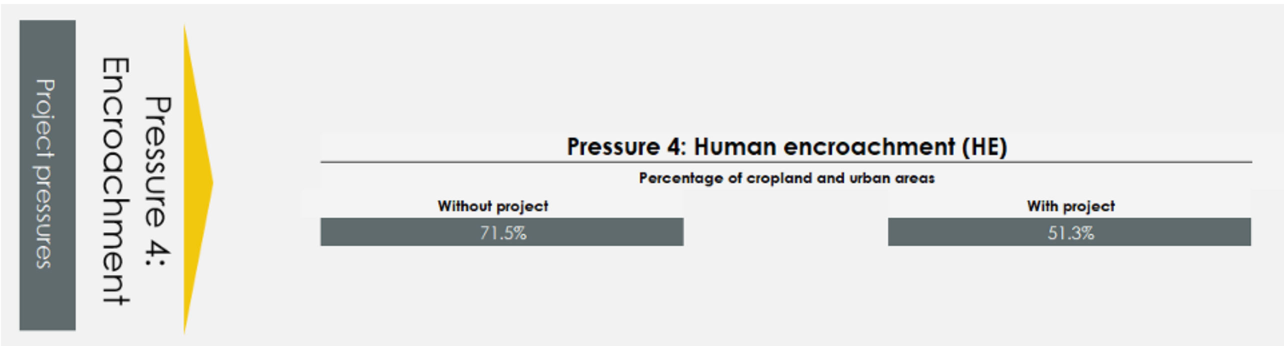
Pressure 1: Land Use / Pressure 3: Fragmentation

Patch	Land Use Without Project		F	Land area (ha)	Land Use With Project		F	Land area (ha)	Non-fragmented natural area (ha) Without project	With project
P1	Forest Zone (Default)	N	1	2,650	Forest Zone (Default)	N	1	4,950	8,840	68,765
P2	Forest Zone (Selective logging)	N	1	4,780	Forest Zone (Reduced impact logging)	N	1	4,780	8,840	68,765
P3	Forest Zone (Default)	N	1	1,410	Grassland (Moderately degraded)	N	1	7,190	8,840	68,765
P4	Grassland (Severely degraded)	A		52,400	Extensive Agroforestry	N	1	19,800	Artificial	68,765
P5	Forest Zone (Selective logging)	N	2	570	Forest Zone (Selective logging)	N	1	570	570	68,765
P6	Forest Zone (Selective logging)	N	3	514	Forest Zone (Selective logging)	N	1	514	514	68,765
P7	Other (Degraded) - Urban area	A		366	Other (Degraded) - Urban area	A		366	Artificial	Artificial
P8	Annual Cropland (w/o improvement)	A		21,800	Annual Cropland (w/o improvement)	A		19,940	Artificial	Artificial
P9	Other (Degraded) - Urban area	A		723	Intensive Agroforestry	A		1,860	Artificial	Artificial
P10	Other (Degraded) - Urban area	A		594	Other (Degraded) - Urban area	A		723	Artificial	Artificial
P11	Grassland (Severely degraded)	A		1,680	Other (Degraded) - Urban area	A		594	Artificial	Artificial
P12	Other (Degraded) - Urban area	A		286	Grassland (Severely degraded)	A		1,680	Artificial	Artificial
P13	Grassland (Severely degraded)	A		14,100	Other (Degraded) - Urban area	A		286	Artificial	Artificial
P14	Forest Zone (Default)	N	4	3,220	Grassland (Severely degraded)	A		13,473	3,220	Artificial
P15	Forest Zone (Selective logging)	N	5	6,520	Grassland (Moderately degraded)	N	2	627	6,520	3,847
P16	Grassland (Severely degraded)	A		1,500	Forest Zone (Default)	N	2	3,220	Artificial	3,847
P17	Forest Zone (Selective logging)	N	6	136	Forest Zone (Selective logging)	N	3	6,520	136	6,520
P18	Forest Zone (Selective logging)	N	7	23,000	Grassland (Severely degraded)	A		1,500	23,737	Artificial
P19	Forest Zone (Default)	N	7	737	Grassland (Severely degraded)	A		20,260	23,737	Artificial
P20	Forest Zone (Selective logging)	N	8	1,980	Forest Zone (Selective logging)	N	1	136	1,980	68,765
P21	Annual Cropland (w/o improvement)	A		22,200	Forest Zone (Reduced impact logging)	N	1	22,534	Artificial	68,765
P22	Other (Degraded) - Urban area	A		600	Forest Zone (Default)	N	1	737	Artificial	68,765
P23	Forest Zone (Selective logging)	N	9	848	Extensive Agroforestry	N	1	4,260	848	68,765
P24					Forest Zone (Selective logging)	N	1	1,980		68,765
P25					Intensive Agroforestry	A		22,200		Artificial
P26					Other (Degraded) - Urban area	A		600		Artificial
P27					Forest Zone (Selective logging)	N	1	848		68,765
P28					Forest Zone (Selective logging)	N	1	466		68,765

3.4.2.4 Pressure 4: Human Encroachment

Biodiversity impact from human encroachment is given by anthropogenic activities in natural areas, such as hunting, food and fuel gathering, recreation, and human settlements. According to the patch areas specified by the user, the MSA value given by the human encroachment pressure (MSA_{HE}) is automatically filled based on the GLOBIO model estimates, calculating the proportion of cropland and/or urban area with and without project scenarios (Fig. 11).

Figure 11. Visualization of the human encroachment pressure section within B-INTACT. Figure taken from the B-INTACT guidelines (FAO, 2021).



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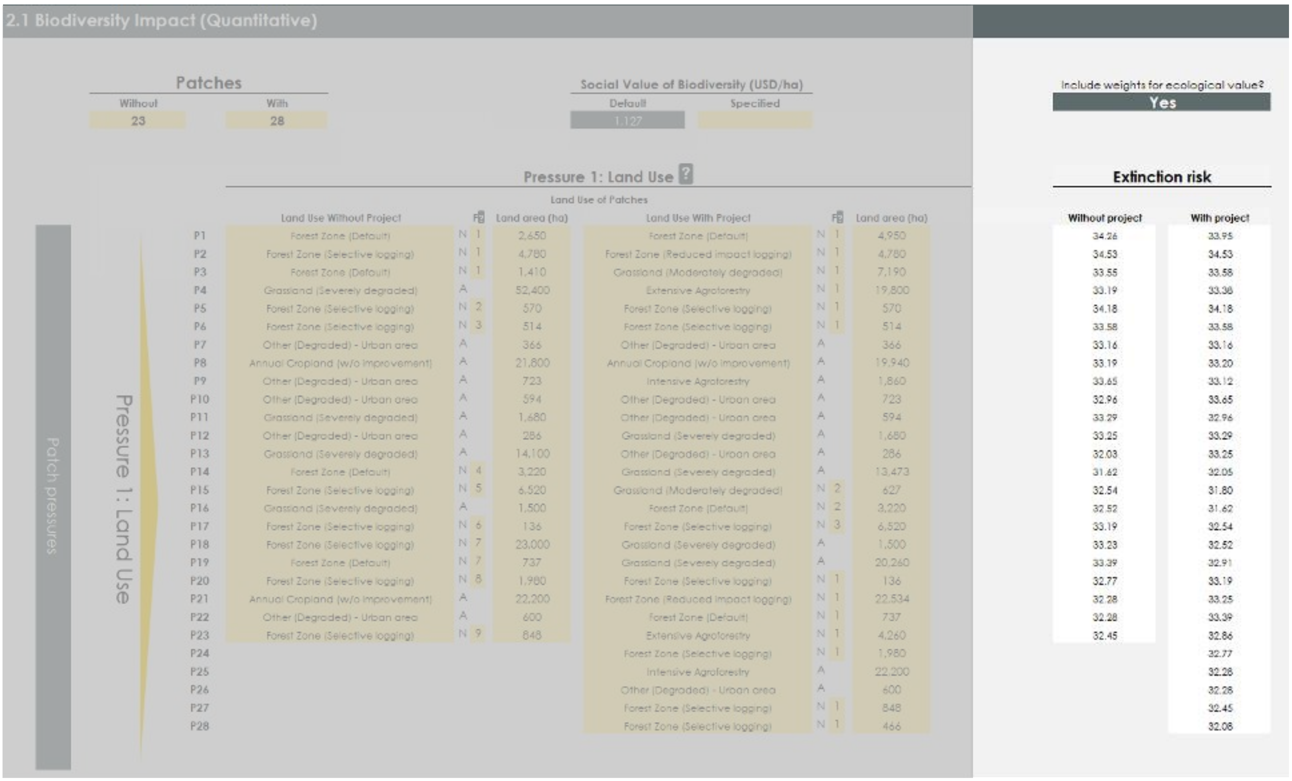
3.4.3 Other elements considered in the B-INTACT evaluation

3.4.3.1 Ecological values

The B-INTACT tool allows the user the option to weight the identified patches based on three geo-spatialized ecological values: the extinction risk of the species, the total biome vulnerability, and the total endemicity. As a first step, the user should select 'Yes' at the section 'Include weights for ecological value'. Then, the user can select from a drop down list the ecological value (Fig. 12), and then fill out the score for each patch according to the World Bank's open-access Terrestrial Biodiversity database incorporated in the EarthMap platform (Fig.13). For this purpose, the user needs to access to the EarthMap platform, select the area of the project (or upload a KLM file), and filter the proper layer according to the ecological value chosen.

Figure 12. Visualization of ecological value with the index of the extinction risk of species. Figure edited from the B-INTACT guidelines (FAO, 2021).



	Land Use Without Project			Land area (ha)	Land Use With Project			Land area (ha)	Extinction risk: Without project	Extinction risk: With project
P1	Forest Zone (Default)	N	1	2,650	Forest Zone (Default)	N	1	4,950	34.26	33.95
P2	Forest Zone (Selective logging)	N	1	4,780	Forest Zone (Reduced impact logging)	N	1	4,780	34.53	34.53
P3	Forest Zone (Default)	N	1	1,410	Grassland (Moderately degraded)	N	1	7,190	33.55	33.58
P4	Grassland (Severely degraded)	A		52,400	Extensive Agroforestry	N	1	19,800	33.19	33.38
P5	Forest Zone (Selective logging)	N	2	570	Forest Zone (Selective logging)	N	1	570	34.18	34.18
P6	Forest Zone (Selective logging)	N	3	514	Forest Zone (Selective logging)	N	1	514	33.58	33.58
P7	Other (Degraded) - Urban area	A		366	Other (Degraded) - Urban area	A		366	33.16	33.16
P8	Annual Cropland (w/o improvement)	A		21,800	Annual Cropland (w/o improvement)	A		19,940	33.19	33.20
P9	Other (Degraded) - Urban area	A		723	Intensive Agroforestry	A		1,860	33.65	33.12
P10	Other (Degraded) - Urban area	A		594	Other (Degraded) - Urban area	A		723	32.96	33.65
P11	Grassland (Severely degraded)	A		1,680	Other (Degraded) - Urban area	A		594	33.29	32.96
P12	Other (Degraded) - Urban area	A		286	Grassland (Severely degraded)	A		1,680	33.25	33.29
P13	Grassland (Severely degraded)	A		14,100	Other (Degraded) - Urban area	A		286	32.03	33.25
P14	Forest Zone (Default)	N	4	3,220	Grassland (Severely degraded)	A		13,473	31.62	32.05
P15	Forest Zone (Selective logging)	N	5	6,520	Grassland (Moderately degraded)	N	2	627	32.54	31.80
P16	Grassland (Severely degraded)	A		1,500	Forest Zone (Default)	N	2	3,220	32.52	31.62
P17	Forest Zone (Selective logging)	N	6	136	Forest Zone (Selective logging)	N	3	6,520	33.19	32.54
P18	Forest Zone (Selective logging)	N	7	23,000	Grassland (Severely degraded)	A		1,500	33.23	32.52
P19	Forest Zone (Default)	N	7	737	Grassland (Severely degraded)	A		20,260	33.39	32.91
P20	Forest Zone (Selective logging)	N	8	1,980	Forest Zone (Selective logging)	N	1	136	32.77	33.19
P21	Annual Cropland (w/o improvement)	A		22,200	Forest Zone (Reduced impact logging)	N	1	22,534	32.28	33.25
P22	Other (Degraded) - Urban area	A		600	Forest Zone (Default)	N	1	737	32.28	33.39
P23	Forest Zone (Selective logging)	N	9	848	Extensive Agroforestry	N	1	4,260	32.45	32.86
P24					Forest Zone (Selective logging)	N	1	1,980		32.77
P25					Intensive Agroforestry	A		22,200		32.28
P26					Other (Degraded) - Urban area	A		600		32.28
P27					Forest Zone (Selective logging)	N	1	848		32.45
P28					Forest Zone (Selective logging)	N	1	466		32.08

Figure 13. Example of the extinction risk score from the EarthMap platform. Figure taken from the B-INTACT guidelines (FAO, 2021).

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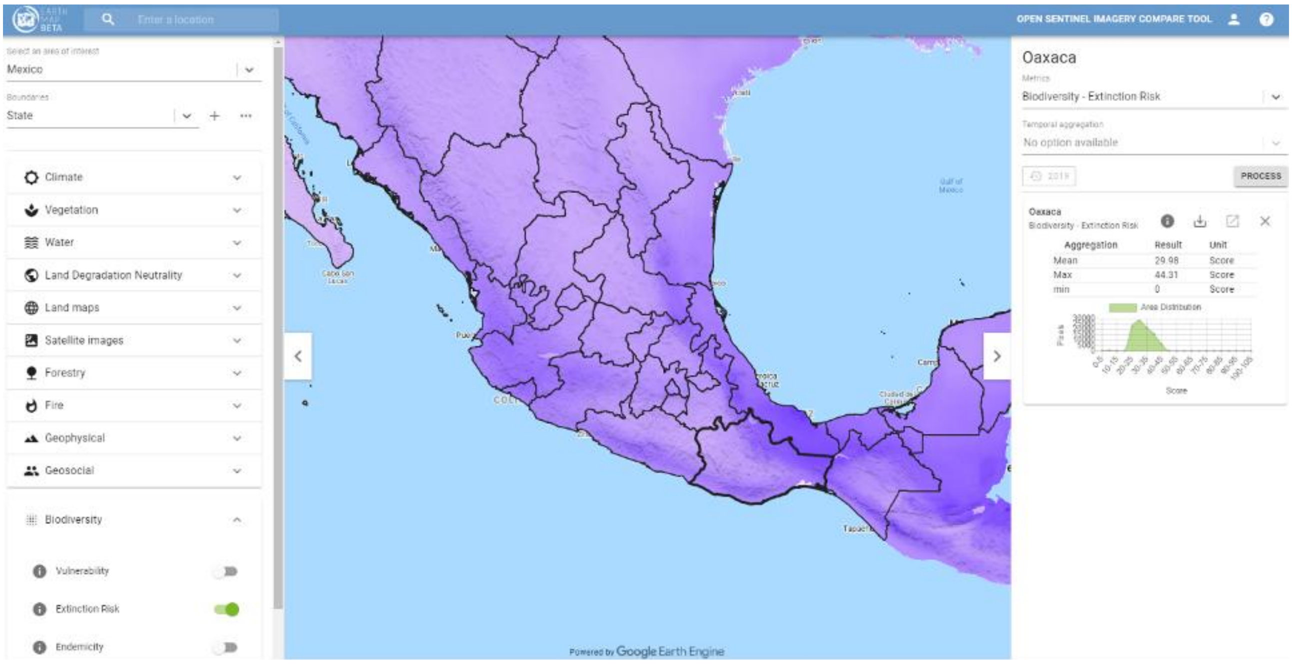

The index of the extinction risk of species ranges from 0 to 60, the total biome vulnerability score ranges from 0 to 100, and the total endemicity score ranges from 0 to 50.

3.4.3.2 Social values

Based on the information given at the Start page, the B-INTACT tool automatically fills out an ecosystem service evaluation, which is expressed as the percentage of ecosystem distribution (% of total areas) and the amount of USD per hectares for each of the patches (Fig. 14). These values are derived from large scale analyses within the Ecosystem Service Valuation Database (ESVD; De Groot et al., 2020; www.es-partnership.org/esvd).

Figure 14. Visualization of ecosystem services evaluation within B-INTACT. Figure taken from the B-INTACT guidelines (FAO, 2021).

		Ecosystem distribution (% of total areas)*			Social Value of Intact Biodiversity (per ha)*					
					W/o P			W/P		
		Forest Type	Tier 1	Tier 2	TIER 1	TIER 2	TIER 3	TIER 1	TIER 2	TIER 3
P1	1	Mediterranean wood-& shrubland	100%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P2	2	Healthland	0%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P3	3	Mangroves	0%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P4	4		0%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P5					USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P6					USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P7		Grassland Type	Tier 1	Tier 2	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P8	1	Temperate grasslands	100%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P9	2	Savanna	0%	100%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P10	3		0%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P11	4		0%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P12					USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P13					USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P14		Other (Nominal) Type1	Tier 1	Tier 2	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P15	1	Inland Un- or Sparsely Vegetated	100%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P16	2	True desert (sand/rock/salt)	0%	100%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P17	3	Semi-desert	0%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P18	4		0%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	
P19	5		0%	0%	USD 1,524	USD 1,524		USD 1,524	USD 1,524	

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3.4.3.3 Policy indicators

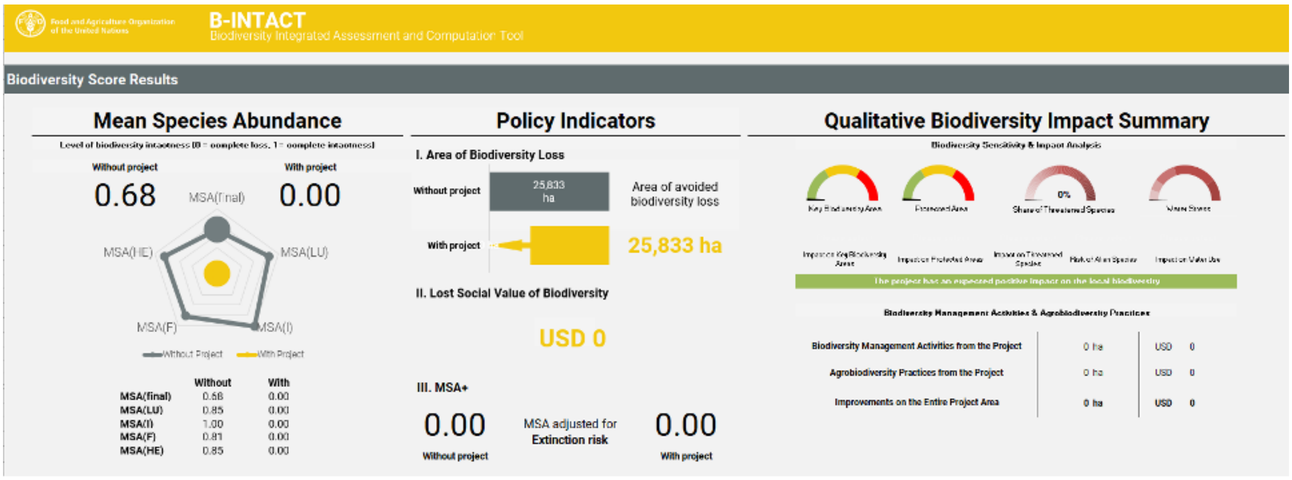
Besides the MSA metric described above, the B-INTACT tool has developed policy indicators to provide a more comprehensible unit for decision makers:

- MSA.ha: it is the total area of biodiversity loss. This indicator provides a surface area equivalent to the MSA scores (see equation 4 in the B-INTACT guidelines);
- SV: it is the added or lost social value of biodiversity due to project implementation. This indicator attributes a monetary value per hectare to the MSA score (see equation 5 in the B-INTACT guidelines);
- MSA+: it is an adjusted MSA indicator for the ecological value of the total project area (see equation 6 in the B-INTACT guidelines). The coefficients for the ecological value of each project activity patch are given by the ecological values described above (see paragraph 3.4.3.1).

3.4.4 Results of the quantitative assessment

The results of the quantitative assessment (MSA and MSA+) are given for each patch and pressure at the far right of the 'Biodiversity Assessment' sheet. However, for a more friendly and summarized interpretation of the results, it is advisable to directly analyse them within the 'Biodiversity Results' sheet (Fig. 15).

Figure 15. Visualization of the Biodiversity Results sheet within B-INTACT. Figure taken from the B-INTACT guidelines (FAO, 2021).



In particular, the results of the quantitative assessment are given in the first and second sections of the 'Biodiversity Results' sheet. In the first section, the aggregate MSA scores along with a table and a chart representing the individual MSA scores of each anthropogenic pressure (land use, infrastructure, fragmentation, and human encroachment) are provided for both with and without the project (Fig. 16).

Figure 16. Visualization of section 1 of the Biodiversity Results sheet. Figure taken from the B-INTACT guidelines (FAO, 2021).

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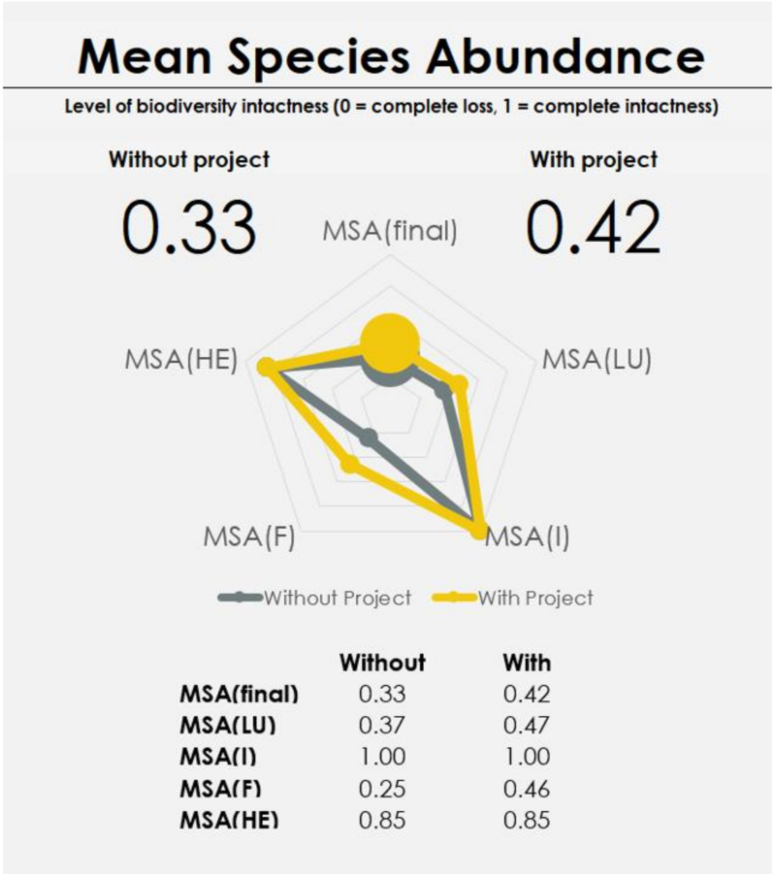
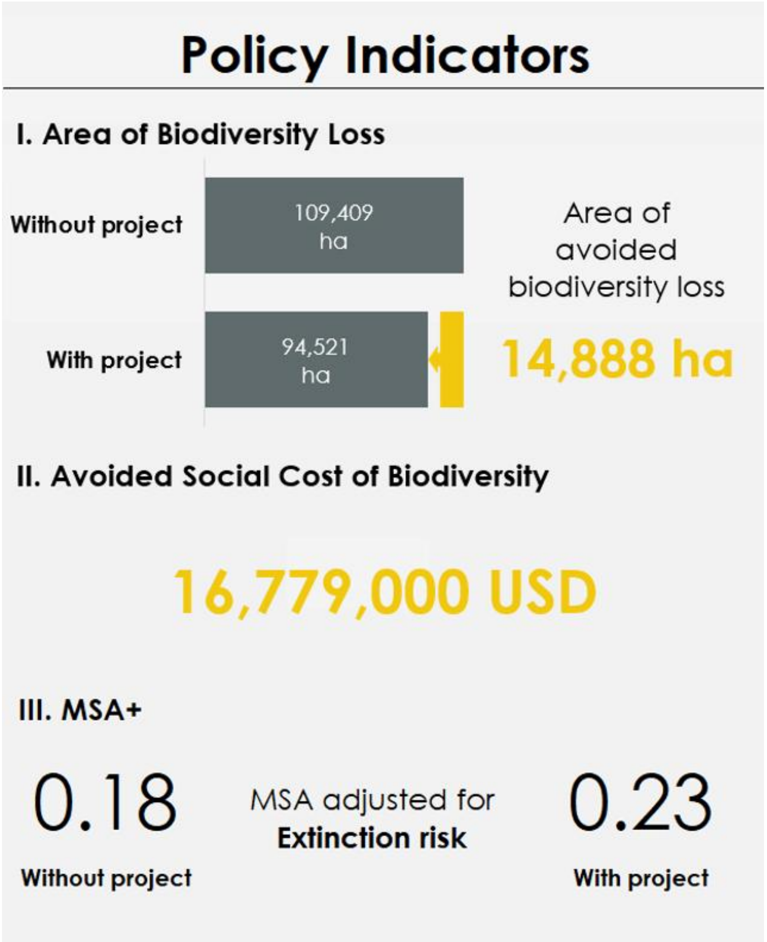


These results reflect the level of biodiversity intactness without and with the project for the duration of the project, measured as MSA score ranging from 0 (complete species loss) to 1 (complete species intactness).

The second section of the 'Biodiversity Results' sheet provides the policy indicators results (Fig. 17; paragraph 3.4.3.3).

Figure 17. Visualization of section 2 of the Biodiversity Results sheet. Figure taken from the B-INTACT guidelines (FAO, 2021).



The first indicator is the area of biodiversity loss (MSA.ha), representing the surface area-equivalent of the MSA metric, therefore measured in hectares of biodiversity loss both without and with the project. This result is provided by both the number of hectares and a bar chart representing the different areas of potential biodiversity loss.

The second indicator is the added social value of biodiversity from the project (SV), representing the monetary value per hectare supplemented from the (avoided) emissions given by the project implementation and investments.

The third indicator is the MSA adjusted for the ecological value (MSA+), given by the inclusion of ecological weights (vulnerability, extinction risk, or endemicity) to the MSA metric.

All the policy indicators may be useful in providing more practical information and results of the biodiversity assessment for decision-makers.

3.5 Step-by-step guide for the qualitative assessment

The qualitative assessment within B-INTACT aims to provide an analysis of non-quantifiable impacts on biodiversity from the project implementation through a qualitative survey complementary to the quantitative assessment.

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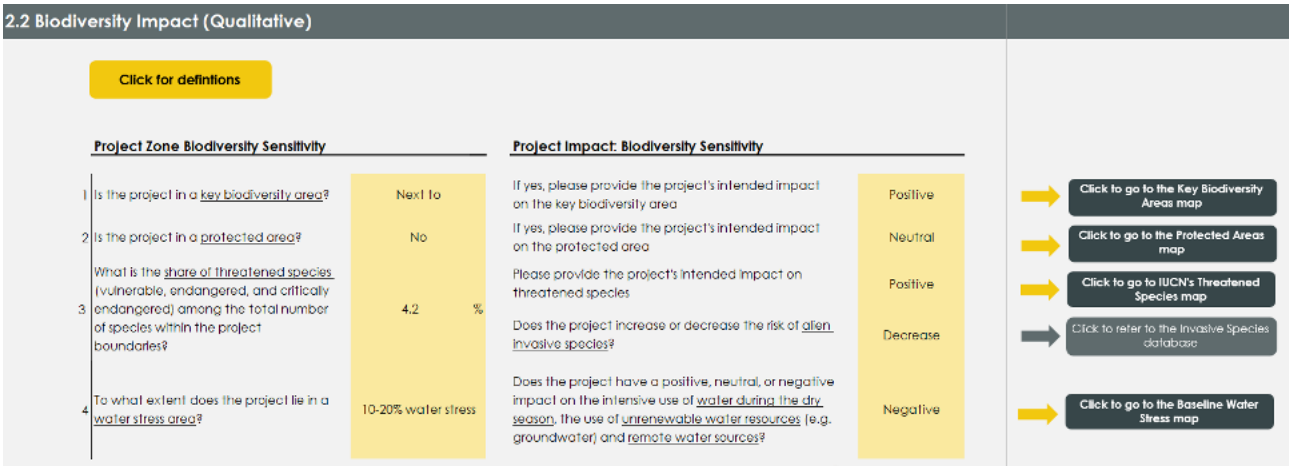
The qualitative assessment is divided into four sections: the first two sections deal with the biodiversity sensitivity level of the project zone and the intended impact on it; the third section concerns biodiversity management activities, and the fourth section covers agrobiodiversity practices.

3.5.1 Biodiversity sensitivity: section 1 (project zone) and section 2 (project impact)

These sections aim to define the status quo sensitivity of in situ biodiversity by considering the presence of key biodiversity areas and protected areas within the project size, the presence of threatened species, and the level of water stress within the project site (Fig. 18).

Figure 18. Visualization of sections 1 and 2 of the qualitative assessment. Figure taken from the B-INTACT guidelines (FAO, 2021).



The user is asked to first reply to the project zone questions (four questions), and then to provide the project's intended impact on each project zone by using geo-spatialized data in databases referenced in the B-INTACT tool.

3.5.1.1 Question 1: Presence of key biodiversity areas (KBA)

The user can select from a drop-down menu the options 'yes/no/next to', and then choose the project's intended impact between 'Positive/Negative/Neutral', if the answer is 'yes' or 'next to'. To assess if the project zone is within a KBA, the user can explore the Key Biodiversity Areas map database (https://www.keybiodiversityareas.org/sites/search; Fig. 19).

Figure 19. Visualization of the Key Biodiversity Areas database (source: website screenshot).

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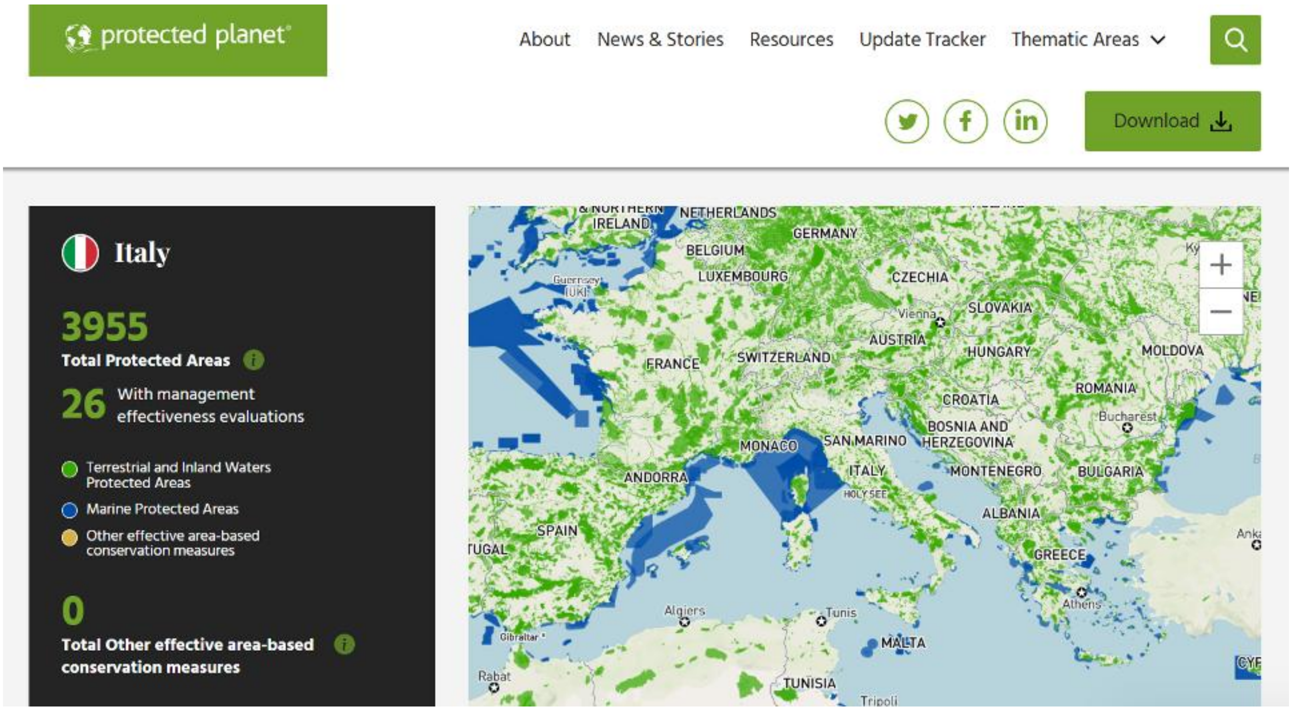

3.5.1.2 Question 2: Presence of Protected Areas (PAs)

As above, the user can select from a drop-down menu the options ‘yes/no/next to’, and then choose the project’s intended impact between ‘Positive/Negative/Neutral’, if the answer is ‘yes’ or ‘next to’. To answer this question, the user can visit the Protected Areas map within the World Database on Protected Areas (WDPA; https://www.protectedplanet.net/en) referenced within the tool (Fig. 20).

Figure 20. Visualization of the World Database on Protected Areas (source: website screenshot).

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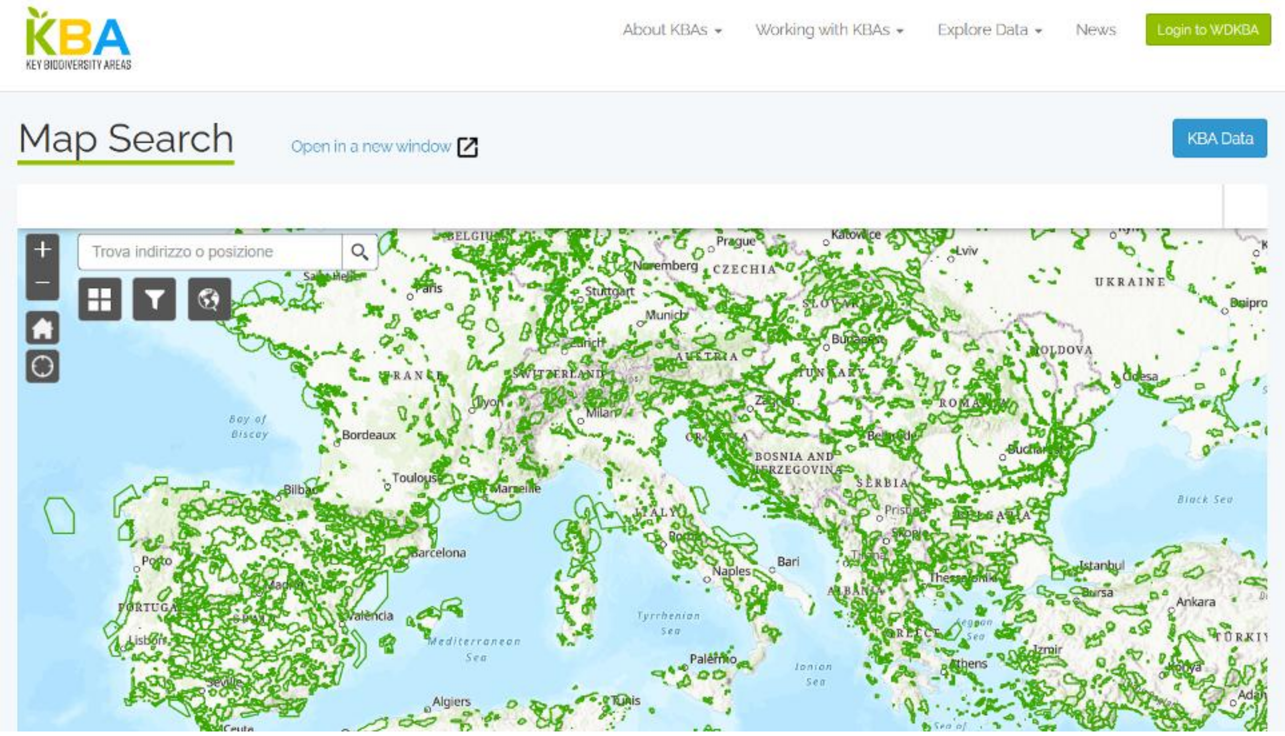

3.5.1.3 Question 3: Presence of threatened species

The user is asked to define the percentage of threatened species (species falling under "vulnerable," "endangered", and "critically endangered") among the total number of species identified within the project boundaries. To answer this question, the user can visit the IUCN's Red List website (IUCN, 2025; https://www.iucnredlist.org/; Fig. 21) to know how the species within the project site are classified by drawing a polygon of the area of the project. The database is directly referenced within the B-INTACT tool.

Figure 21. Visualization of the IUCN's Red List database (source: website screenshot).

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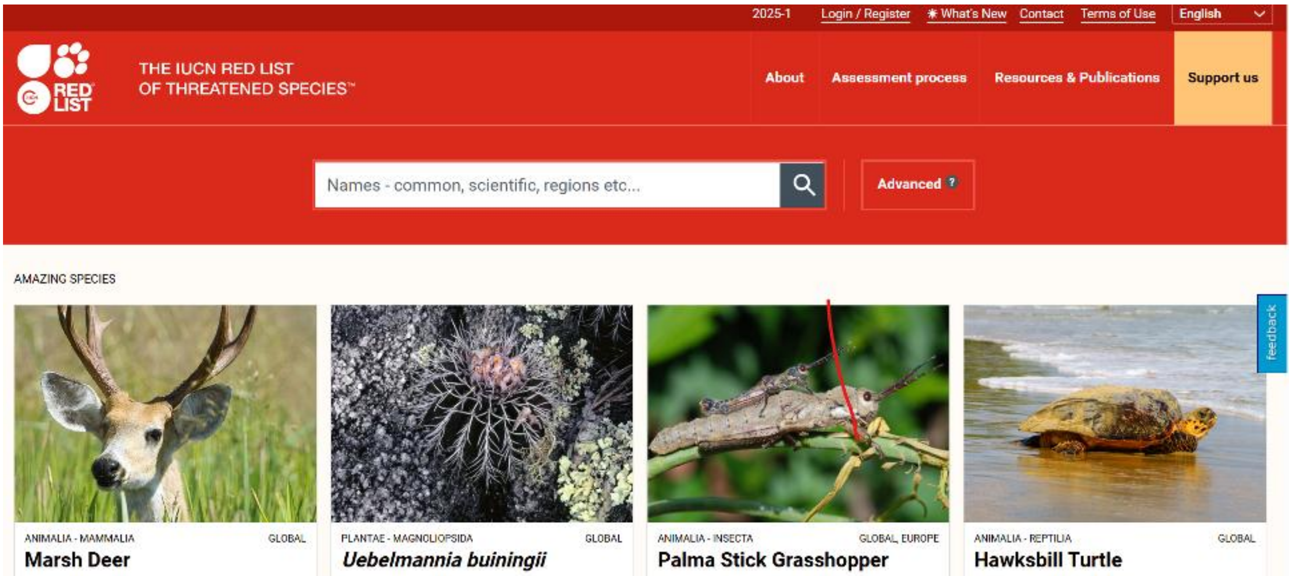
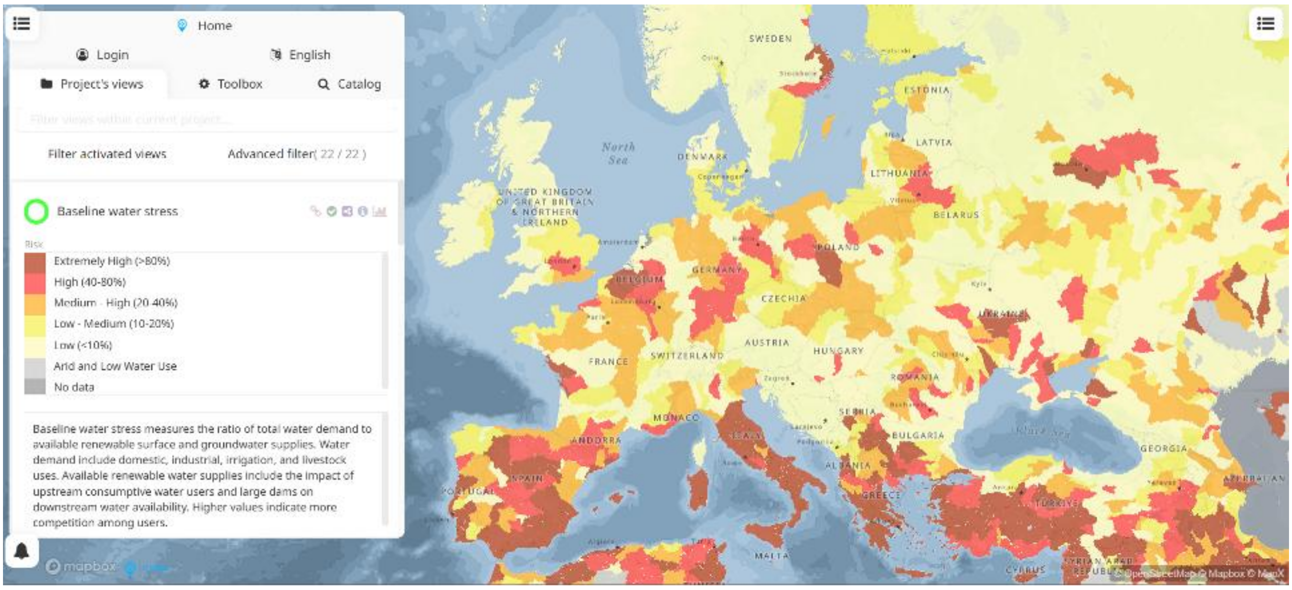


After defining the percentage of threatened species, the user is asked to reply to two sub-questions: the first regards the project's intended impact on threatened species ('Positive/Negative/Neutral'); the second one concerns the risk of introducing alien invasive species ('Decrease/Increase/Neutral'). To answer the second sub-question, the user can visit the Global Register of Introduced and Invasive Species (Pagad et al., 2022), which is available here: https://griis.org/. In the "download" section, the user can either download the data or view the map of invasive species.

3.5.1.4 Question 4: Water stress level

The user is asked to select from a drop-down menu the percentage of water stress level within the project area. To answer this question, the user can visit the Baseline Water Stress map (Fig. 22), which is directly referenced within the B-INTACT tool.

Figure 22. Visualization of the Baseline Water Stress map (source: website screenshot).



After defining the percentage of water stress level, the user is asked to assess if the project has a positive, neutral, or negative impact on the intensive use of water during the dry season, the use of unrenewable water resources (e.g. groundwater), and remote water sources (Fig. 22).

3.5.2 Biodiversity Management Activities and Agrobiodiversity Practices: sections 3 and 4

These sections of the qualitative assessment cover questions on biodiversity management activities and agrobiodiversity practices that may or may not be covered by the project. The activities identified within the tool are related to several land use categories listed in Table 7 of the B-INTACT guidelines (pages 22-24). In these sections, the user can provide the applicability of the specific activity or practice, the amount invested in USD, and the 'with project' patches that are impacted by the proposed activity and practice.

3.5.2.1 Biodiversity Management Activities questions

The biodiversity management activities section includes three questions (Fig. 23) covering the implementation of biodiversity buffer activities ensuring landscape connectivity, activities that reduce and/or prevent human-wildlife conflicts, and the reinforcement of forest governance along with a reduction of illegal logging.

Figure 23. Visualization of the questions within the biodiversity management activities section. Figure taken from the B-INTACT guidelines (FAO, 2021).

	Project Impact: Biodiversity Management Activities		Amount Invested (USD)	Patches impacted (Please select all)																												
				P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
5	Does the project promote biodiversity buffers that increase landscape connectivity such as shelter belts, windbreaks, field herbaceous borders, etc.?	Yes	11,246,444		N	Y	Y	Y	N	N		N	Y			N		N	Y	N	N	N	N	N	Y	N	Y	N	Y		N	N
6	Does the project promote measures to reduce and/or prevent human-wildlife conflict?	No	Please insert																													
7	Does the project reinforce forest governance and address illegal logging?	Yes	11,246,444		Y	Y			Y	Y										Y	N			N	Y	Y		Y			Y	N

For all questions, the user is asked to declare if the project promotes the above-mentioned biodiversity management activities, and the total amount invested (in USD) in them. Additionally, the user can select which 'with project' patches are impacted by the implemented activities.

3.5.2.2 Agrobiodiversity Practices questions

The questions of the agrobiodiversity practices section (Fig. 24) cover concepts related to the interactions among the diversity of crops, the environment, and the management practices used by farmers. In particular, the user is asked to declare if the project promotes crop diversification and intercropping practices, the use of traditional crops, the implementation of integrated pest management (IPM), and mixed farming systems, etc. (see pages 22-28 of the B-INTACT guidelines for more details on these questions).

Figure 24. Visualization of the questions within the agrobiodiversity practices section. Figure taken from the B-INTACT guidelines (FAO, 2021).

	Project Impact: Agrobiodiversity Practices		Amount Invested (USD)
8	Does the project promote crop diversification, intercropping, and/or crop rotation practices?	Yes	11,246,444
9	Does the project promote varietal diversity of crops, the utilization of traditional crops, and/or indigenous livestock breeds?	Yes	11,246,444
10	Does the project promote Integrated pest management (IPM)?	No	Please Insert
11	Does the project promote conservation agriculture?	No	Please insert
12	Does the project promote mixed farming systems and/or mixed home gardens?	Yes	11,246,444
13	Does the project promote water harvesting and/or soil moisture retention methods?	Yes	11,246,444
14	Does the project promote field margins (e.g. planting flower strips along field borders)?	No	Please insert
15	Does the project support in situ conservation of crop wild relatives (e.g. protection of natural or semi-natural areas where crop wild relatives grow)?	No	Please Insert
16	Does the project support on-farm conservation of genetic resources (e.g. community seed banks) and/or the development of the local seed Industry (e.g. promote the use of farm-saved seeds, support informal seed systems)?	Yes	11,246,444

	Patches Impacted (Please select all)																												
	P	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
8					Y				N	Y														Y		Y			
9				N	Y				N	Y			N		N	N			N	N				Y		Y			
10																													
11																													
12					Y				N	Y														Y		Y			
13		N	N	N	Y	N	N		N	Y			N		N	N	N	N	N	N	N	N	N	Y	N	Y		N	N
14																													
15																													
16		N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	Y	N	N	N

As in section 3, after declaring the implementation or not of these practices, the user is asked to specify the total amount invested (in USD) and, eventually, which 'with project' patches are impacted by the implemented practices.

3.5.3 Results of the qualitative assessment

The results of the qualitative assessment are provided in the third section of the 'Biodiversity Results' sheet (Fig. 25).

Figure 25. Visualization of section 3 of the Biodiversity Results sheet. Figure taken from the B-INTACT guidelines (FAO, 2021).

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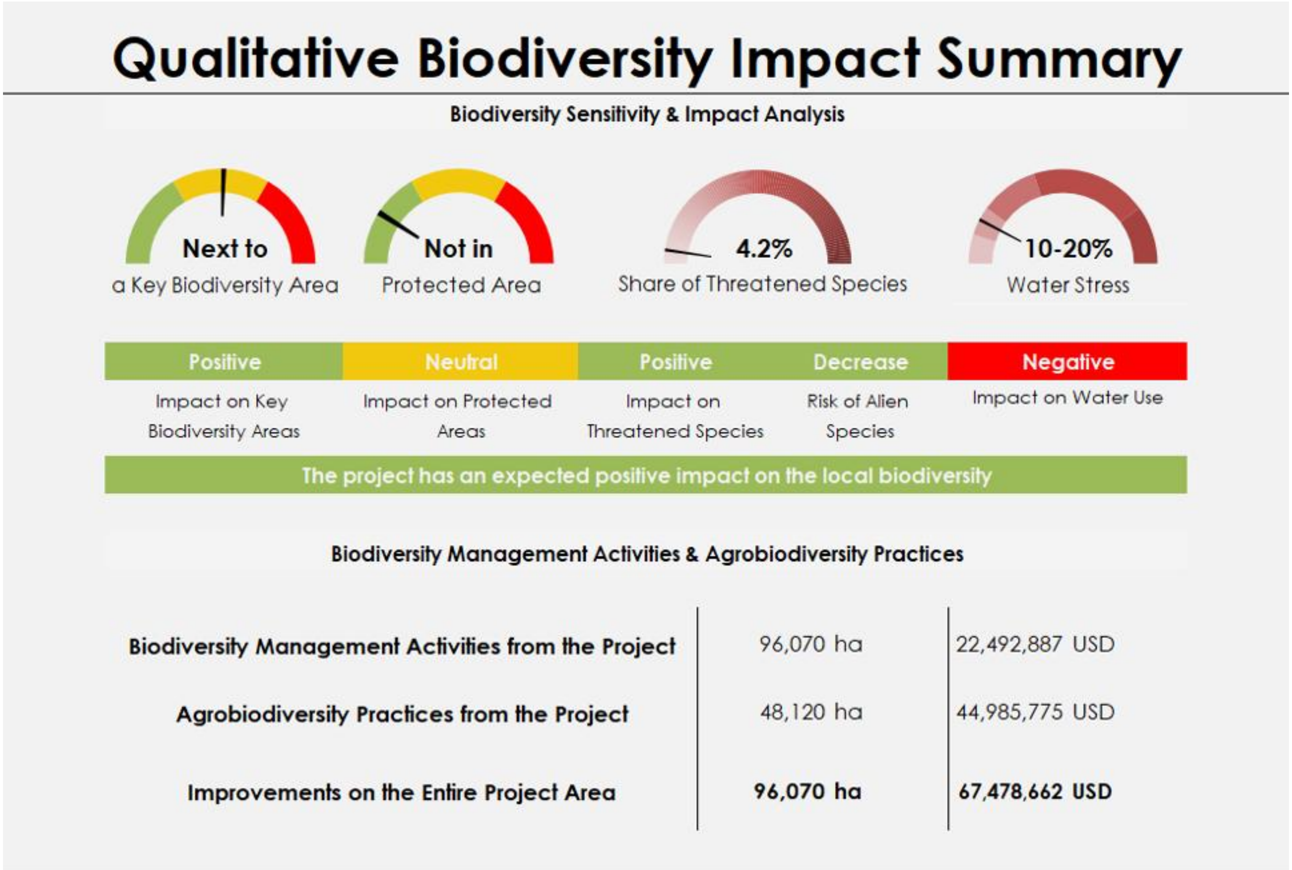

In the first row are represented four charts (speedometers) representing the level of biodiversity sensitivity within the project area (sections 1 and 2) through a colour legend, where red indicates a negative impact, green a positive impact, and yellow a neutral one. Below the charts, an overall expected impact on local biodiversity is given by a sentence, also color-coded as above.

The results on the implementation of biodiversity management activities and agrobiodiversity practices from the project (sections 3 and 4) are presented below, providing a summary of the total number of hectares that are impacted by these activities, and the amount invested.

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4 BioINSouth MARGs Interview

4.1 Structure of the survey

In the context of the activities under Work Package 4.5, a survey was developed and distributed to the MARGs in order to collect information on perceived interconnections between the bio-based industry, biodiversity and ecosystem services. The objective was to understand the degree of awareness, perceived impacts, and future expectations of biodiversity and ecosystem services from regional actors participating in or influenced by the bioeconomy. The questionnaire was structured under five thematic blocks:

4.1.1 Awareness of biodiversity in the bio-based sector

This section aimed to assess the general level of understanding and awareness of biodiversity among respondents, and to investigate to what degree the bio-based industry itself is perceived as having knowledge of issues and challenges of biodiversity.

4.1.2 Perceived Impact of the bio-based sector on biodiversity

Interviewees were asked to provide their views on how different activities and value chains in the bio-based sector affect biodiversity, positively or negatively, at regional or local scales.

4.1.3 Existing measures to protect biodiversity

The purpose of this questions was to identify the nature of practices, measures, and conservation activities currently being adopted or promoted by stakeholders in the bio-based sector towards conserving and enhancing biodiversity.

4.1.4 Future outlook: sector growth and biodiversity safeguards (5–10 Years)

Interviewees were encouraged to reflect on the growth of the bio-based industry over the next 5 to 10 years, and how that growth could be balanced against biodiversity and ecosystem service conservation.

4.1.5 Future challenges and the role of innovation

The final section of the survey asked respondents to rate their views of the most important issues the bioeconomy will face in terms of sustainability, and the role that innovation and technological progress can play in limiting negative environmental impacts and optimizing biodiversity benefits.

The survey combined closed-ended questions (multiple-choice) with open-ended fields, to allow for both quantitative aggregation and qualitative interpretation of responses.

4.2 Results of the survey

The number of participants in the survey was relatively small, with responses from various sectors, including a majority from universities and research institutions, as well as from the private sector, the public sector and NGO. Despite the limited sample size, the responses provide valuable insights into the correlation between biodiversity and bio-based sector in Campania.

Below are shown some of the responses and a general evaluation of the results.

-Awareness of biodiversity in the bio-based sector

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The responses indicate that, overall, participants demonstrate a moderate to good level of awareness regarding biodiversity and its relevance to sustainability. However, a clear gap emerges in the perception of the bio-based sector's awareness: the majority of respondents believe that companies operating within the bioeconomy are not sufficiently informed about the potential impacts of their activities on biodiversity.

This suggests a need for greater knowledge transfer, training, and integration of biodiversity considerations into the strategic planning and operational frameworks of bio-based businesses.

Figure 26. Question 26

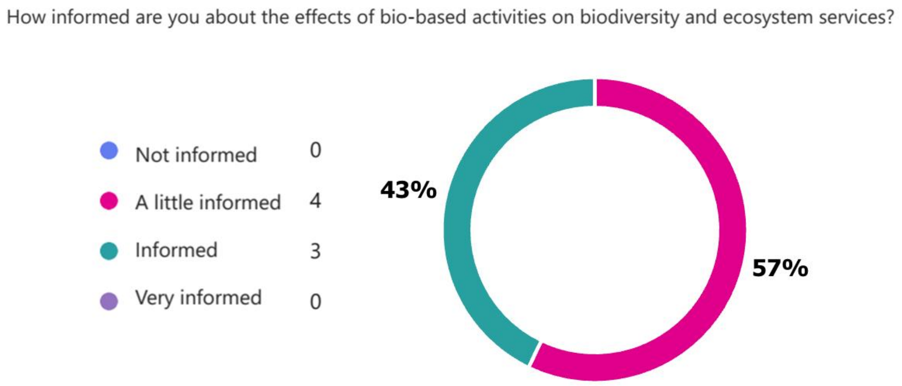
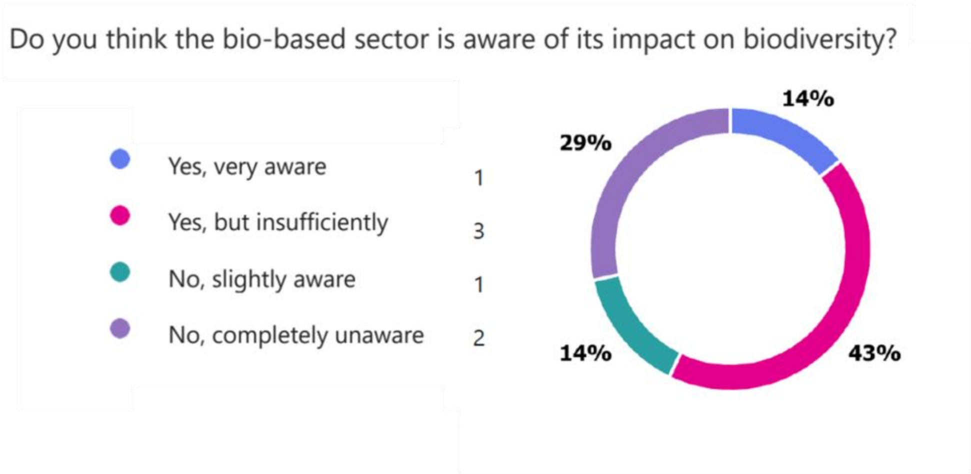


Figure 27. Question 30



-Perceived Impact of the bio-based sector on biodiversity

Overall, stakeholders reported a generally positive perception of the bio-based sector's impact on biodiversity. Several responses mentioned that bio-based practices can lead to an increase in biodiversity.

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However, some respondents also pointed out potential negative effects observed in specific contexts. These include the introduction of non-native species and reduced attention to invasive or ruderal flora. These insights suggest that, while the bio-based sector holds potential to contribute positively to biodiversity, its actual impact can vary depending on local implementation, species interactions, and the management practices adopted.

Figure 28. Question 27

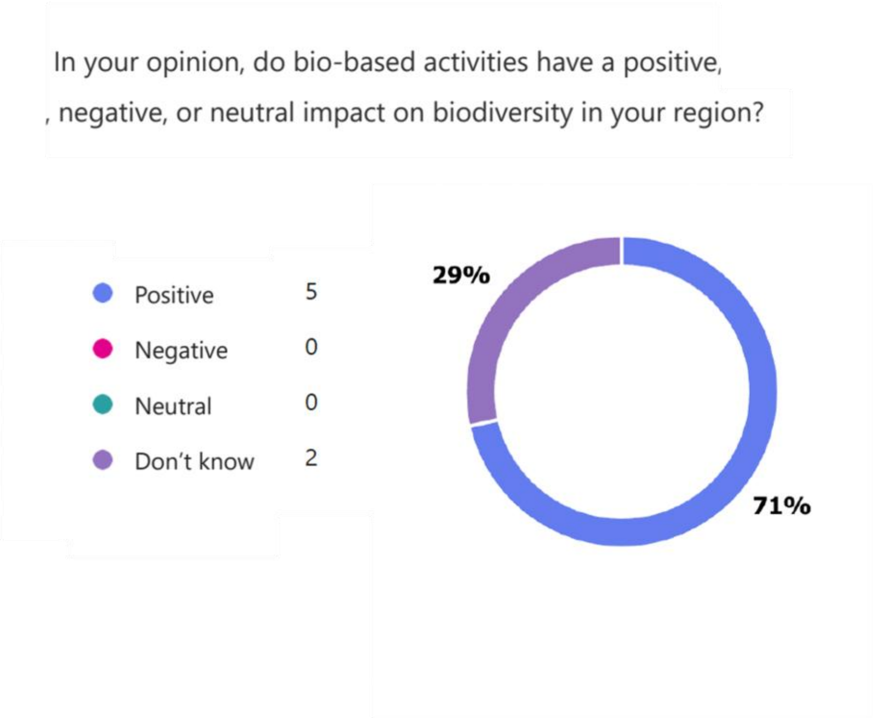

Figure 29. Question 28

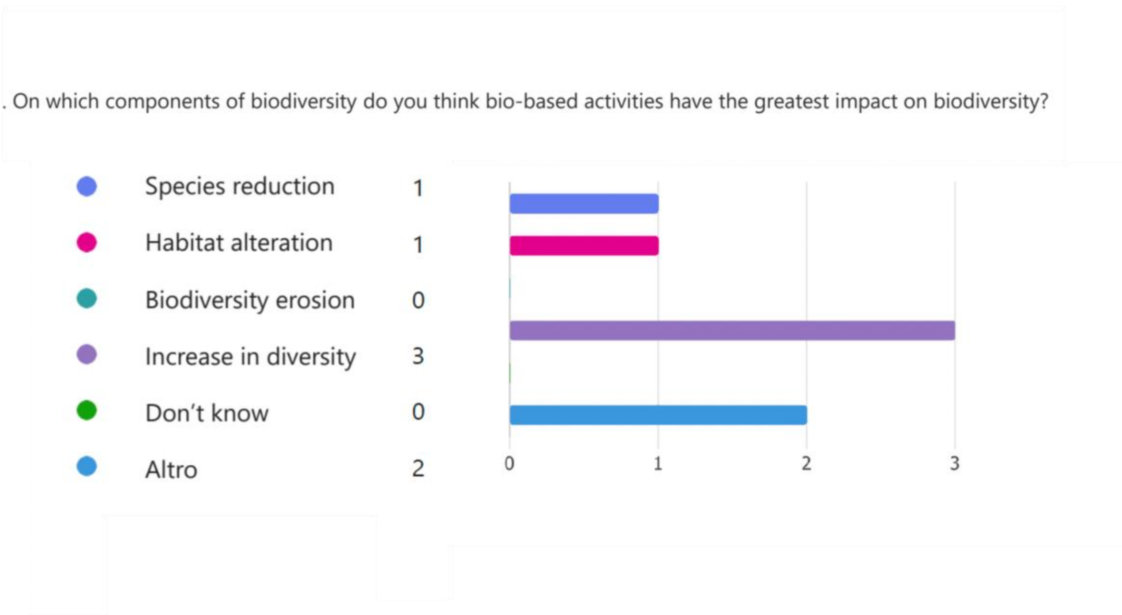

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Figure 30. Question 29

In your experience, have you observed tangible effects of bio-based companies on biodiversity? If yes, can you describe some example s?

6

Replies

"Exploitation of production waste from agricultural products such as tomatoes..."

"Introduction of new species, less attention to infesting flora"

"No"

....

-Existing measures to protect biodiversity

Participants highlighted several practices that are considered relevant or recommended for the protection of biodiversity within the bio-based sector. Among these, water recovery and reuse, as well as the monitoring of local biodiversity, were the most frequently suggested measures.

However, a significant number of respondents were not aware of the existence of regional collaborations between companies and environmental organizations aimed at biodiversity conservation. This indicates a possible lack of communication or visibility regarding local partnerships and coordinated efforts in this field.

Figure 31. Question 38

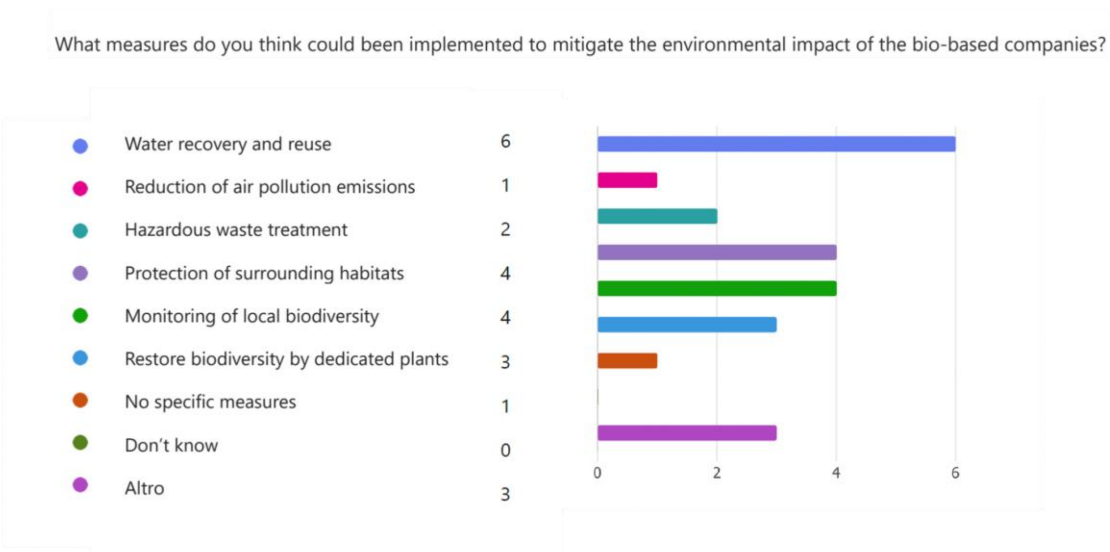

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Figure 32. Question 31

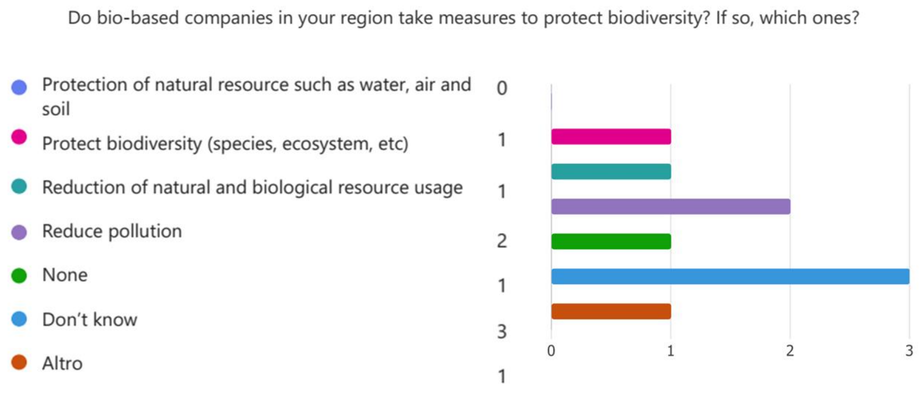
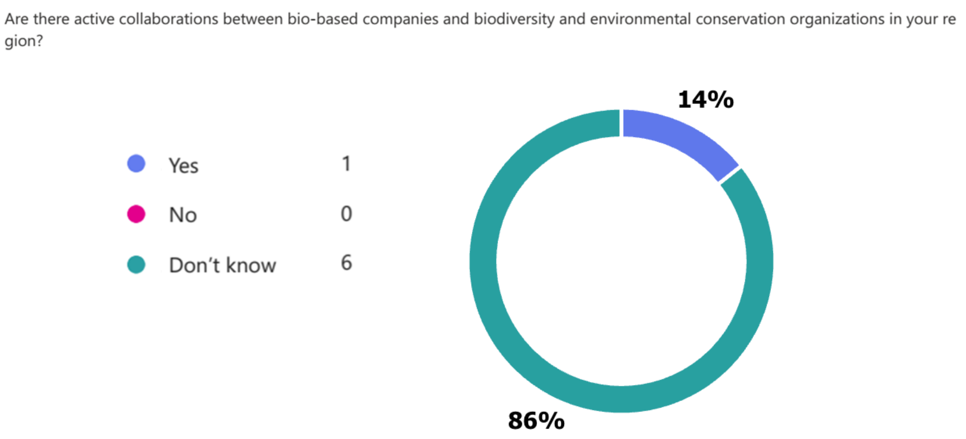


Figure 33. Question 33



-Future outlook: sector growth and biodiversity safeguards (5–10 Years)

Most respondents expressed a positive but cautious outlook, indicating that they believe the bio-based growth with the protection of biodiversity and ecosystem services is achievable. Although no respondent expressed a negative view, the responses suggest that while there is confidence in the sector's potential, there is also recognition of the challenges and efforts required to ensure that future growth does not come at the expense of natural ecosystems.

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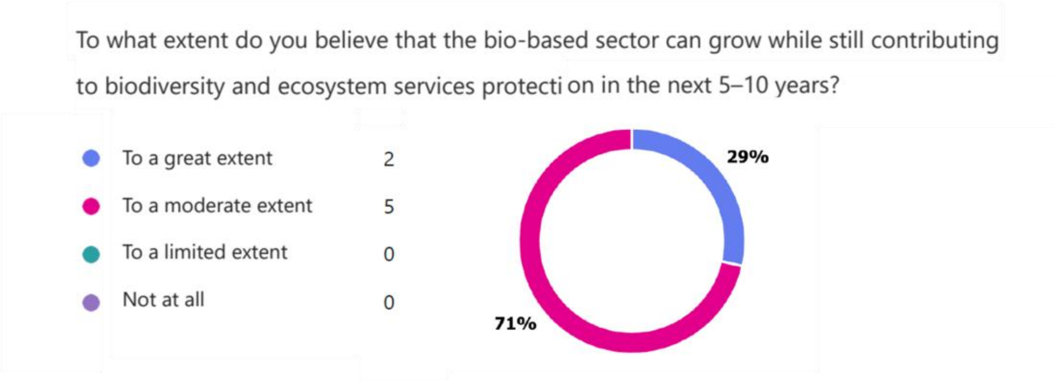
Figure 34. Question 35



-Future challenges and the role of innovation

This final section gathered the views of stakeholders on the main challenges that bio-based companies are expected to face in the coming years, particularly in terms of sustainability and their impact on biodiversity. Respondents highlighted a variety of critical issues and strategic priorities that the sector will need to address.

A respondent stressed the importance of increasing respect for ecosystems and biodiversity across all levels of agricultural, agro-industrial, and industrial production. There was also a call for the optimization of production processes, including the creation of ecological corridors to mitigate the effects of landscape fragmentation. Another key challenge identified concerns the costs and complexity of sustainable production, particularly when it comes to the use and management of green energy in transformation processes. Innovation is seen as a vital enabler for overcoming these challenges, especially through the development and dissemination of new processes and products that minimize environmental impacts. Additional suggestions included the need for continuous monitoring and scientific studies to assess the real effects of bio-based activities on biodiversity, and the integration of bio-based approaches with traditional cropping systems tailored to regional characteristics.

Overall, the responses suggest a shared awareness of the sector's responsibility to balance innovation and growth with ecological integrity, and the critical role that technological advancement and knowledge-sharing will play in supporting this transition.

Figure 35. Question 36

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In your opinion, what will be the main challenges for bio-based companies in terms of sustainability and biodiversity impact in the futur e?

Increase respect for ecosystems and biodiversity by agricultural, agro-industrial, and industrial productions.

Optimize production processes, create ecological corridors.

Issues related to sustainable production and its costs, as well as those related to the use and consumption of energy (green) for production/transformation.

Innovation and development of processes/products and their dissemination.

Studies and monitoring of potential impacts.

Integration with the traditional cropping systems of different areas.

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5 Conclusion

The development of this deliverable reflects the strategic importance of integrating the study of biodiversity and ecosystem services into the evaluation of bio-based industry activities. To this end, the B-INTACT tool has proved to be a very suitable solution to evaluate the effects of companies on biodiversity thanks to its methodological robustness, ease of access, and alignment with project-level sustainability assessment needs.

The selection of B-INTACT was guided by its thematic relevance to the AFOLU sector (Agriculture, Forestry, and Other Land Use), technical soundness, and ease of use. As an open-access tool hosted by FAO, B-INTACT has minimal demands for technical expertise and should be run on publicly available data sets. This is also appropriate for public sector stakeholders and regional planners, which has universal applicability across a wide stakeholder base—a basic requirement of the BioINSouth project.

Furthermore, B-INTACT enables quantitative and qualitative biodiversity impact assessments, offering a balanced approach that combines scientific metrics such as the Mean Species Abundance (MSA) with broader ecological, social, and policy metrics, such as biodiversity loss in hectares and its equivalent social value—metrics that are crucial to convey effectively to non-technical stakeholders and decision-makers.

The guidelines developed in this deliverable ensure that stakeholders can use the tool independently in future phases of the project, particularly in conjunction with the BioINSouth Toolkit under development. The strategy described herein establishes a firm foundation for the integration of biodiversity assessments into more broad sustainability studies of bio-based value chains.

Throughout the project, B-INTACT will be integrated into the BioINSouth Toolkit (Annex I), offering a replicable and harmonized framework for ecological integrity assessment and project scenario simulation, with biodiversity impacts ascertained in a transparent and evidence-based manner. This will facilitate the uptake by regional decision-makers of more sustainable and biodiversity-conscious bioeconomy strategies, in line with the European Green Deal and the EU Biodiversity Strategy for 2030.

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BioINSouth Info Box

The BioINSouth project aims to support decision-makers to incorporate considerations of ecological limits into their regional bioeconomy strategies and roadmaps relevant to circular bio-based activities. We aim to develop guidelines and digital tools, considering the safe and sustainable by design (SSbD) assessment framework, to support the adoption of innovative methodologies to assess environmental impacts in multiple industrial bio-based systems, increasing regional competitiveness and innovation capacity, and contributing to the EU fair & green transition.

Find out more:

Website: https://www.bioinsouth.eu/
LinkedIn: https://www.linkedin.com/company/104361906/
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