Biodiversity Core Indicator
Comprehensive Guidance

IFAD
Investing in rural people

The Comprehensive Guidance document on IFAD's Biodiversity Core Indicator was prepared by IFAD's Environment, Gender and Social Inclusion Division (ECG) and the Operational Policy and Results Division (OPR). The document provides detailed guidance on the choice, methodological approach and practical application of IFAD's new biodiversity core indicator 3.2.4: 'Biodiversity improvements at ecosystem-level'.

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Acknowledgements

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Acronyms

ABC-Map	Adaptation, Biodiversity and Carbon Mapping Tool
AFOLU	Agriculture, Forestry and Other Land Use
AIB	Area of Intact Biodiversity
ALIGN	Aligning accounting approaches for nature
ANC	Average Natural Capital
AOI	Area of Intervention
BFC	Biodiversity Footprint Calculator
BFM	Biodiversity Footprint Methodology
CASP+	Community-based Agricultural Support Project Plus
CBD	Convention on Biological Diversity
CCI	Climate Change Initiative
CI	Core Indicator
COI	Core Outcome Indicators
ESVD	Ecosystem Services Valuation Database
FAO	Food and Agriculture Organization of the United Nations
GBS	Global Biodiversity Score®
GHGs	Greenhouse Gases
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
MSA	Mean Species Abundance
NbS	Nature-based Solutions
PBF	Product Biodiversity Footprint
PRIDE	Programme for Rural Irrigation Development
RECAF	Reduced Emissions through Climate Smart Agroforestry
REDD+	Reducing Emissions from Deforestation and forest Degradation
SDGs	Sustainable Development Goals
SECAP	Social, Environmental and Climate Assessment Procedures
STAR	Species Threat Abatement and Restoration metric
tCO_2e	Tonnes of CO_2-equivalent
TEEB	the Economics of Ecosystems and Biodiversity study

Executive summary

IFAD aligns with the Convention on Biological Diversity (CBD, 1992) and defines biological diversity, or biodiversity, as the "variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems." In so doing, IFAD recognizes that biodiversity is a complex, multi-level concept for which there is no single unit of measurement (or indicator). The complexity of biodiversity indicators is reflected in the current negotiations of the Post-2020 Global Biodiversity Framework. In the most recent report of the expert workshop on the monitoring framework for the Post-2020 Global Biodiversity Framework (CBD, 2021a), a total of 22 headline indicators are proposed, mainly because there is currently no single metric, tool or platform that addresses biodiversity holistically. This has direct implications on the choice of the biodiversity core indicator, as science-based biodiversity indicators for IFAD should highlight the scope and magnitude of, and measure progress towards improvements in biodiversity by covering most of the four biodiversity dimensions, namely (i) species, (ii) habitats, (iii) ecosystem services, and (iv) genetic diversity.

This Comprehensive Guidance Document explains IFAD's new biodiversity core (outcome) indicator 3.2.4. 'Biodiversity improvements at ecosystem-level', which measures improvements via two sub-indicators: (i) Area of Intact Biodiversity in ha (biodiversity intactness); and (ii) Average Natural Capital in USD/ha (ecosystem service flows). This directly addresses the habitat and ecosystem services dimensions.

The IFAD biodiversity core indicator will be incorporated into IFAD's existing CI framework and will become mandatory for new project designs with nature-based solutions (NbS) finance starting from 2023. Projects may, however, already adopt the biodiversity core indicator on a voluntary basis.

Biodiversity core indicator
Ecosystem-based indicator

Indicator

CI 3.1.5: Area of Intact Biodiversity (AIB) in ha
CI 3.1.6: Average Natural Capital per ha (ANC) in USD/ha

Type of core indicator

Core Output Indicator (COI)

Measurement

Remote sensing via the Adaptation, Biodiversity and Carbon Mapping Tool (ABC-Map)

Reporting frequency

COI survey at Baseline, Mid-Term and Completion

Data collection

Land-based activities in ha can easily be derived from project logframe (aligned with information required for carbon-balance assessment)

Biodiversity improvements

Either the AIB or the ANC shows a positive change with the implementation of a project, while the other one is at least held constant

Habitat and Ecosystem dimensions

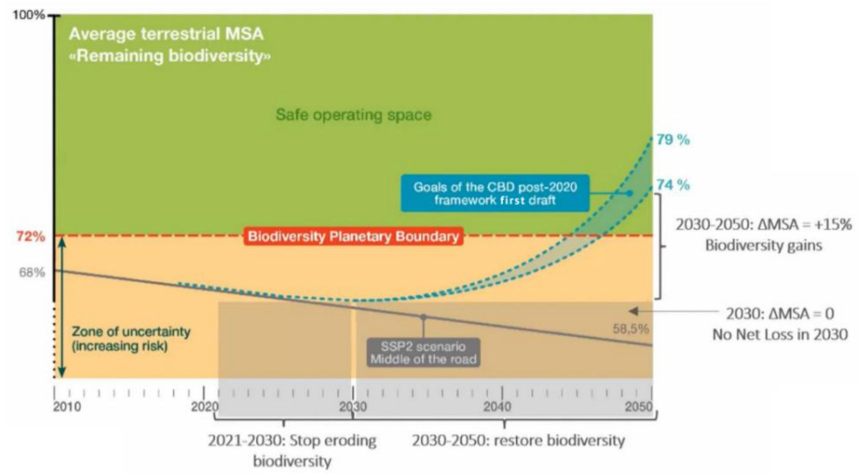
The AIB (via the underlying Mean Species Abundance metric) measures to which extent a habitat is intact. The ANC (via the underlying Ecosystem Service Valuation Database) measures ecosystem service flows per year for different ecosystems. Both ABC-Map metrics cover, respectively, the habitat and ecosystem dimensions. The innovative remote sensing component of the ecosystem-based core indicator has the advantage of being a relatively cheap and rapid method of acquiring up-to-date information over large geographical areas.

Introduction

(i) Context

Biodiversity underpins all life on land and below water and provides a wealth of benefits to society. The world's poor, particularly in rural areas, depend on biological resources for as much as 90 per cent of their needs, including food, fuel, medicine, shelter and transportation (CBD, 2020a). And yet, anthropogenic pressures such as land, water and sea use change, direct exploitation of organisms, climate change, pollution and invasive species are undermining the planet's biodiversity (IPBES, 2019). By 2010, global biodiversity had declined by around 32 per cent in terms of mean species abundance (MSA), compared to an undisturbed natural state (Van der Esch et al., 2017, GBS, 2021). While most of these losses have occurred in developed countries, future losses are expected to be occurring in developing countries, in line with land-use expansions and more intensive land management. Past and ongoing rapid declines in biodiversity "mean that most international societal and environmental goals, such as those embodied in the Aichi Biodiversity Targets and the 2030 Agenda for Sustainable Development, will not be achieved based on current trajectories" (IPBES, 2019). That is why, Parties to the Convention on Biological Diversity are currently negotiating a new, Post-2020 Global Biodiversity Framework. In its first draft (CBD, 2021a), the framework is built around a theory of change which "recognizes that urgent policy action globally, regionally and nationally is required to transform economic, social and financial models so that the trends that have exacerbated biodiversity loss will stabilize in the next 10 years (by 2030) and allow for the recovery of natural ecosystems in the following 20 years, with net improvements by 2050 to achieve the Convention's vision of 'living in harmony with nature by 2050." The Post-2020 Global Biodiversity Framework has four long-term Goals for 2050 related to the 2050 Vision for Biodiversity. Through Goal A, the first draft calls for (i) a stabilization of net losses by 2030; and (ii) an increase of at least 15 per cent in the area, connectivity and integrity of natural ecosystems by 2050. Figure 1 shows a scheme that visualizes the current biodiversity trends (grey line), and the way how biodiversity can be put on a path to recovery (blue dotted line) to achieve the Convention's vision of "living in harmony with nature by 2050" (i.e. to reach a safe operating space) using the MSA metric.

Figure 1.
MSA metric and the Goals of the Post-2020 Global Biodiversity Framework.



Source: CDC Biodiversité 2022.

IFAD recognizes that biodiversity loss is having disproportionate adverse effects on rural people, as they depend on biodiversity for their livelihoods, food and nutritional security. This is reflected in IFAD's operations, which aim to foster social, environmental and climate sustainability to address environmental degradation.

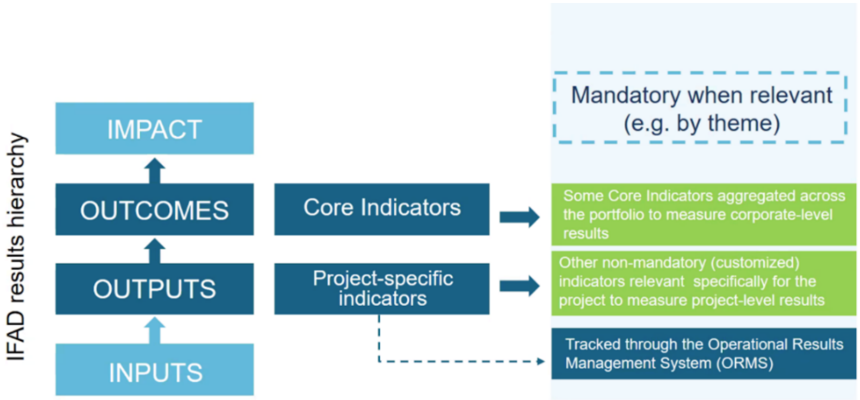
Alongside its updated Social, Environmental and Climate Change Assessment Procedures (SECAP), IFAD recently approved its new Biodiversity Strategy 2022-2025 to facilitate a more systematic, organized and generalized integration of the conservation, sustainable use and promotion of biodiversity in IFAD operations. The goal of the new strategy is to enhance IFAD's ability to support countries to protect, restore and promote biodiversity and its sustainable use in rural systems, ensuring multiple benefits for both nature and the livelihoods of rural people. The Strategy aims to improve monitoring of the impacts of its projects and programmes on biodiversity, as well as of the multiple benefits from biodiversity for the livelihoods of rural people. One important part of the Biodiversity Strategy implementation is the **identification of a core indicator.**

The present Biodiversity Core Indicator Guidelines provide the narrative and guidance for applying the selected core indicator.

(ii) Existing IFAD core indicator framework

IFAD's current core indicator (CI) framework is comprised of a total of 45 indicators (3 outreach indicators, 20 output indicators and 22 outcome indicators) and offers a comprehensive and coherent approach for improving project monitoring and fostering the use of evidence in portfolio management (IFAD, 2021). The CIs are mapped to the strategic objectives and areas of thematic focus of IFAD's Strategic Framework 2016-2025, and are aligned with the Sustainable Development Goals (SDGs) defined in the 2030 Agenda. A core aspect of the CIs is that they are easily integrated into project logframes and can be aggregated across projects and countries to facilitate corporate reporting. CIs are mandatory whenever relevant to the project Theory of Change, and can be complemented by project-specific indicators. The mandatory indicators for all projects are all the three outreach indicators and the two stakeholder feedback indicators (output and outcome). CIs do not aim to capture the richness and vastness of IFAD's interventions. Indeed, in any given project, CIs may be complemented by project-specific output, outcome and impact indicators to measure specific results that may not be adequately captured by the CIs. Figure 2 shows the core indicator and results chain of IFAD.

Figure 2.
Core indicators and results chain.



Source: IFAD, 2021.

The CIs at outcome level are called core outcome indicators (COI). The COI measurement guidelines (https://www.ifad.org/en/coitraining/) provide a methodological framework that can be used by project teams to collect COI data and thus measure attributable changes in CIs through dedicated surveys. The COI measurement guidelines are not only a useful tool for evaluation, but also help projects monitor their progress. They also allow IFAD to assess changes occurring at the outcome level due to the project intervention and help projects obtain early evidence of progress towards objectives, assessing whether or not the project is on the right track.

The IFAD biodiversity core indicator will be incorporated into IFAD's existing CI framework and **will become mandatory for new project designs that include nature-based solutions (NbS) climate finance from 2023 onwards**. Projects may, however, adopt the biodiversity core indicator on a voluntary basis.

With the above in mind, the underlying goal for IFAD's Biodiversity Core Indicator is to be simple, smart, robust, measurable and globally applicable - limiting hence the extra burden to projects to a strict minimum.

(iii) A new Biodiversity Core Indicator for IFAD

IFAD aligns with the Convention on Biological Diversity (CBD, 1992) and defines biological diversity, or biodiversity, as the "variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems."

In so doing, IFAD recognizes the complexity and multiple layers of biodiversity. While biodiversity and climate action share a lot of similarities, one fundamental difference between the two is that global goals can be translated into a single unit of measurement in the field of climate change. For climate change mitigation activities, different greenhouse gases (GHGs) can be aggregated into so-called tonnes of CO_2-equivalent (or tCO_2e). The advantage of this unit is that a one-tonne reduction of CO_2-equivalent emissions has the same impact regardless of where the activities are located. A science-based target for biodiversity is more complicated than the target for carbon emissions for two main reasons (European Commission, 2021):

1. Biodiversity has multiple facets – species, ecosystems, ecosystem services, genes for example – and so cannot be expressed by a single measure such as tCO2e. (see
2. *Figure* 3).
3. Biodiversity is location-specific, so a given impact (e.g. loss of 1 ha of an ecosystem) in one part of the world is not equivalent to a similar impact in another (see
4. Figure *4*).

The complexity of biodiversity indicators is also reflected in the current negotiations of the Post-2020 Global Biodiversity Framework. In the most recent report of the expert workshop on the monitoring framework for the Post-2020 Global Biodiversity Framework (CBD, 2021a), a total of 22 headline indicators are proposed, mainly because there is currently no single metric, tool or platform that addresses biodiversity holistically (European Commission, 2021; UNEP-WCMC, 2022).

This has direct implications on the choice of the biodiversity core indicator, as science-based biodiversity indicators for IFAD should highlight the scope and magnitude of, and measure progress towards improvements in biodiversity by covering most of the four biodiversity dimensions, namely (i) species, (ii) habitats, (iii) ecosystem services, and (iv) genetic diversity (CBD, 2021b; European Commission, 2021; UNEP-WCMC, 2022; OECD, 2021).

Figure 3.
Comparing climate and biodiversity: measuring a single unit.

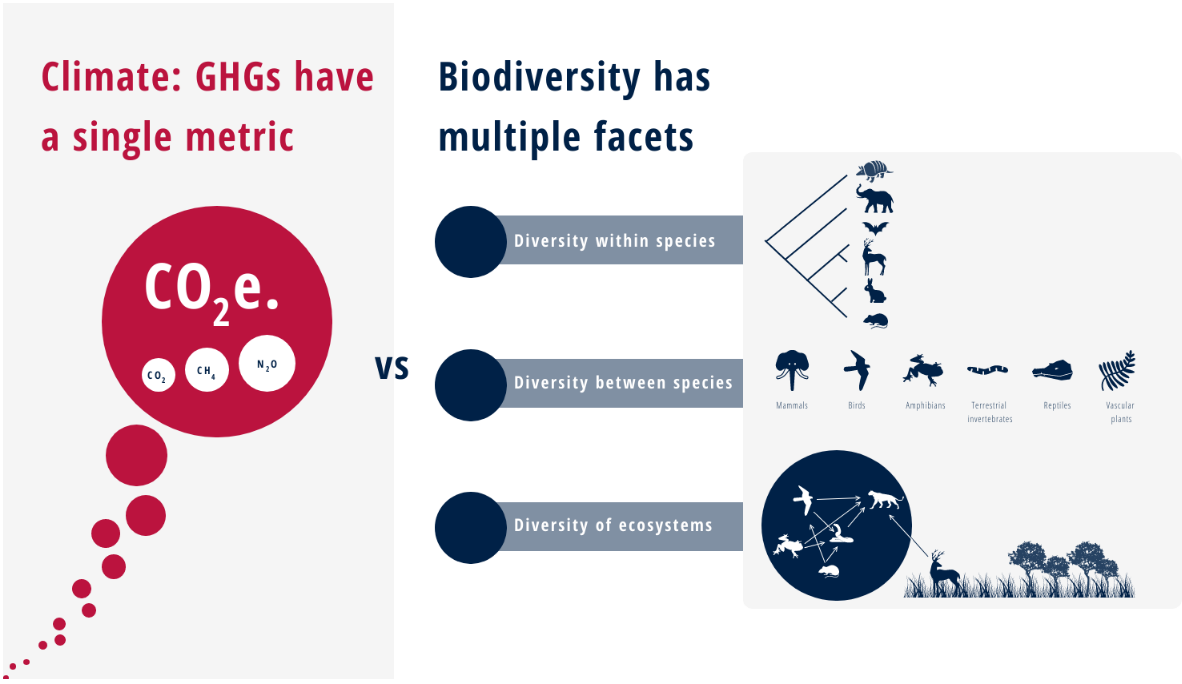
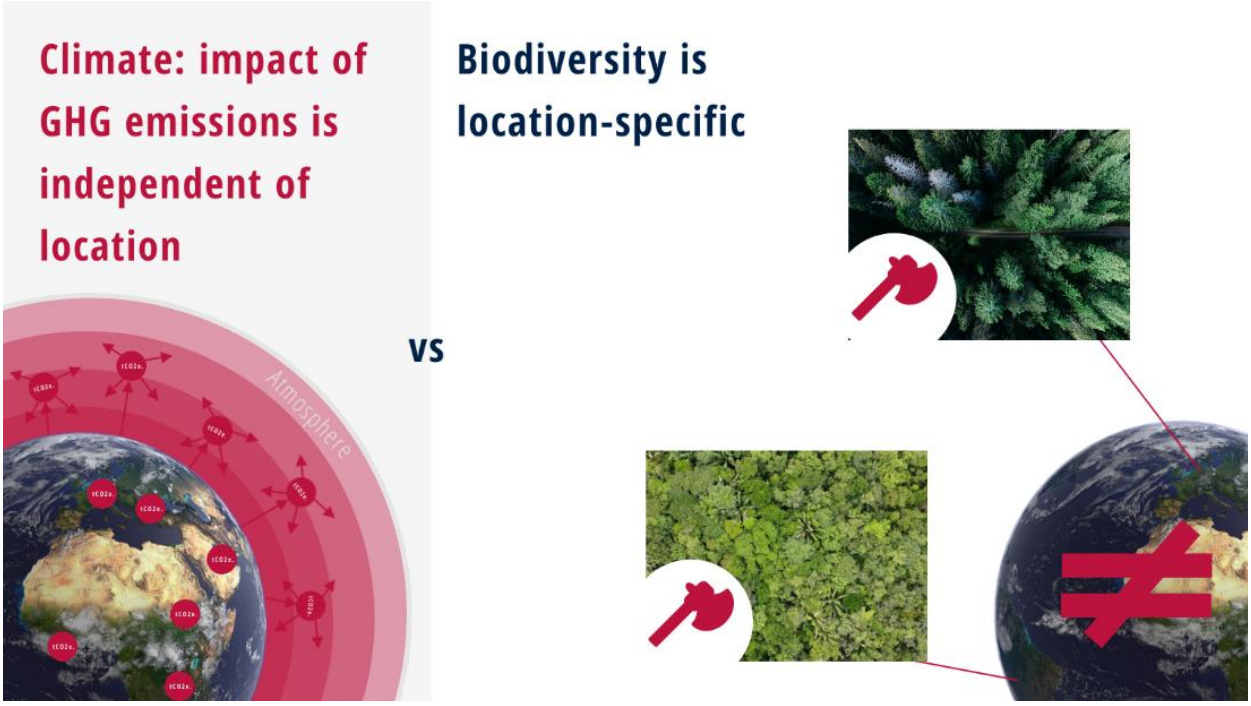


Figure 4.
Comparing climate and biodiversity: location specificity.



(iv) An IFAD core outcome indicator

As stated above, the Convention on Biological Diversity covers biodiversity at all levels: ecosystems, species and genetic. There are hence “multiple dimensions” to diversity. The ALIGN (Aligning accounting approaches for nature) project led by UNEP-WCMC and the European Commission (2021) distinguishes four such dimensions, namely: (i) species; (ii) habitats; (iii) ecosystem services; and (iv) genetic diversity.[1]

IFAD's mandate is to invest in rural people and enable inclusive and sustainable transformation of rural areas. This is achieved through financial and technical assistance to agriculture and rural development projects in developing member states. IFAD's Operations have a direct impact on people and ecosystems, and these should hence also be the central entry points of measurement. Consequently, an ecosystem-based biodiversity indicator is proposed for IFAD’s core indicator framework. This ecosystem-based biodiversity Core Outcome Indicator (COI) measures biodiversity improvements via two sub-indicators: (i) the biodiversity intactness; and (ii) ecosystem service flows, which directly address the habitat and ecosystem services dimensions.

The biodiversity core indicator highlights the scope and magnitude of, and measure progress towards improvements in biodiversity.

The section below will provide an overview of the **ecosystem-based core indicator**: (i) existing ecosystem and habitat-based metrics and indicators; (ii) an explanation of the choice and application of the combined sub-indicators, area of intact biodiversity (AIB) and average natural capital per ha (ANC), as the selected ecosystem-based core indicator; (iii) the reporting modalities of the ecosystem-based core indicator, and (iv) five case studies

[1] The ALIGN project led by UNEP-WCMC (2021) and the European Commission found that none of the currently available approaches and metrics cover biodiversity at the genetic level.

to demonstrate how the ecosystem-based core indicator can be applied, using concrete project examples.

Ecosystem-based biodiversity core indicator

(i) Introduction

Ecosystems are defined by the CBD (1992) as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit." Ecosystems (both natural and managed) provide a wealth of benefits to society. These benefits are also referred to as 'ecosystem services' and include provisioning services (e.g. food or water provisioning), regulating services (e.g. carbon sequestration or pollination), cultural services (e.g. recreation, inspiration or cultural identity) and supporting services (e.g. maintenance of life cycles, nutrient cycling). In addition to their intrinsic and other non-monetary values, these services have many welfare effects, which can partly be measured in economic and monetary terms.

Due to the very nature of IFAD investments in small-scale rural production systems in the Agriculture, Forestry and Other Land Use (AFOLU) sector, IFAD has direct and measurable impacts on ecosystems and ecosystem services.

To measure compliance with science-based targets on ecosystems and ecosystem services, the ALIGN project (European Commission, 2021) recommends that measurement approaches need to be combined and should cover the following:

(i) Both habitats/species and ecosystem services
(ii) All material pressures to biodiversity
(iii) Both impacts and dependencies
(iv) Terrestrial, freshwater and marine biodiversity as far as relevant for the organization
(v) Alignment with accounting approaches

This section summarizes the most relevant indicators for biodiversity assessments at ecosystem-level. Seven potentially promising tools for measuring biodiversity at the ecosystem-level were assessed for their applicability to IFAD projects, and are discussed below. These tools are: (i) the Adaptation, Biodiversity and Carbon Mapping Tool; (ii) the Global Biodiversity Score®; (iii) the LIFE Key; (iv) Product Biodiversity Footprint (PBF); (v) Species Threat Abatement and Restoration metric; (vi) Biodiversity Footprint Methodology (BFM) and Calculator (BFC); and (vii) ReCiPe2016.

Annex 1 provides a more detailed review of tools and metrics to measure biodiversity at ecosystem-level.

(ii) Literature review on biodiversity measurement approaches

The Adaptation, Biodiversity and Carbon Mapping Tool

The Adaptation, Biodiversity and Carbon Mapping (ABC-Map) Tool, developed by FAO[2] in collaboration with the French Development Agency and Germany's Ministry for Food and Agriculture, is a new geospatial app built on Google Earth Engine that holistically assesses the environmental impact of National Policies and Plans (NDC, NAPs, etc.) and investments in the AFOLU sector using satellite imagery. The tool thereby aligns with the objectives of the three Rio Conventions (United Nations Framework Convention on Climate Change, the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification).

ABC-Map covers three main sections, each of which offers the user a range of indicators for both the baseline and project situation:

1. Adaptation (including a climatic and geophysical profile with e.g. information on the temperature and precipitation evolution over the past 40 years).
2. Biodiversity (including indicators like the MSA, land use evolution in protected and key biodiversity areas, and the natural capital).
3. Carbon (including the evolution of the carbon stock, carbon-balance and social value of carbon).

For the purpose of the IFAD biodiversity core indicator, only the biodiversity tool section is considered relevant. ABC-Map provides two complementary biodiversity impact assessment metrics, namely the MSA and the natural capital assessment. ABC-Map covers both the habitat and ecosystem dimensions of biodiversity.

Mean species abundance

Mean species abundance (MSA) is a biodiversity metric developed by GLOBIO, which expresses the mean abundance of original species in a disturbed habitat compared to their abundance in an undisturbed habitat, measuring to which extent an ecosystem is intact. It can be used as an indicator. The MSA is endorsed by the international scientific community, used by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC) in their reports and one of the most widely used indicators in biodiversity accounting (European Commission, 2021).

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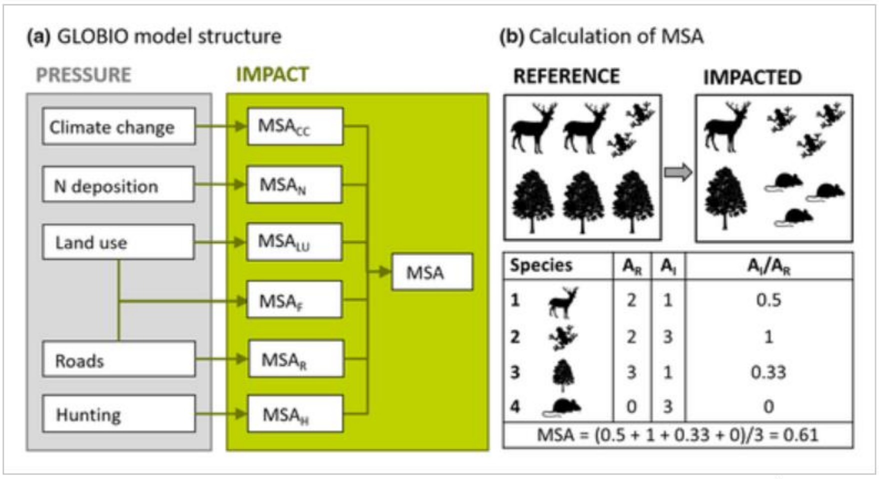
[2] FAO also developed the Biodiversity Integrated Assessment and Computation Tool (B-INTACT), which is an excel-based tool to estimate biodiversity impacts at project-level in the AFOLU sector and can be seen as the first generation of FAO's biodiversity impact assessment tools. As both B-INTACT and ABC-Map were developed by the same technical biodiversity experts, ABC-Map can be considered as the second generation of FAO's biodiversity impact assessment tools, which directly addresses the shortcomings of B-INTACT as a very time and resource intensive tool. In 2021, IFAD undertook a pilot test phase of B-INTACT and concluded that the tool was not fit for use for IFAD's investment projects mainly due to size limitations of possible intervention areas (B-INTACT is limited to 2,000 patches – which correspond to a maximum area of 18,000 ha with a 300m spatial resolution) and the need for expert knowledge and technical backstopping from FAO to undertake a biodiversity impact assessment. ABC-Map uses Google Earth Engine's full computational power to provide users with straightforward, spatially explicit impact assessments on climate change adaptation, biodiversity and carbon fluxes, which can be applied over very large areas (allowing even for small country assessments).

The MSA metric can be seen as a function of six anthropogenic pressures: land use, road disturbance (also referred to as infrastructure), habitat fragmentation, hunting (also referred to as human encroachment), atmospheric nitrogen deposition and climate change. GLOBIO makes use of extensive terrestrial biodiversity databases (such as the IMAGE model) to establish quantitative pressure-impact relationships (Alkemade et al., 2009). A total of six major taxonomic groups are covered by GLOBIO: mammals, birds, reptiles, amphibians, terrestrial invertebrates and vascular plants. The GLOBIO model structure and calculation of the MSA are illustrated in Figure 5.

Figure 5.
GLOBIO model structure and calculation of MSA values.



Source: Alkemade et al. 2009.

ABC-Map slightly adapts the GLOBIO model structure to exclude the climate change and nitrogen deposition pressures. As the impact of greenhouse gas emissions on climate change is not limited to a restricted (project or investment) area, nor to a specific period, climate change is better addressed via the social value of carbon (which is an estimate of economic costs of emitting an additional tonne of CO2e.). While nitrogen deposition is an important pressure on biodiversity, globally, it is the consequence of global emissions of oxidized nitrogen from fossil fuel combustion, and reduced N from agricultural sources. Not only will it be difficult to obtain project or investment-specific data, but the critical load of atmospheric nitrogen deposition might not be directly linked to the project's or intervention's activities.

Limitations

The MSA metric does, however, have important limitations as it does not take into account the ecological value of project sites. For example, both a forest and desert are considered as completely intact land uses and have an MSA value of 1. In addition, the MSA metric fails to cover the marine environment (which is, however, also less relevant to IFAD, as most investment activities are on land, or in coastal areas). To compensate for the ineptitude of the MSA metric in factoring in this ecological value, and to cover the marine environment, ABC-Map provides an additional natural capital indicator (see natural capital, below).

Natural capital

The Convention on Biological Diversity defines natural capital as "the world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of […] ecosystem services, which make human life possible" (CBD, 2021). In other words, natural capital can be seen as the sum of all ecosystem services for a given period.

One of the leading and most comprehensive studies on the economic importance of ecosystem services has been the Economics of Ecosystems and Biodiversity (TEEB) study (de Groot et al. 2021). Within the context of this study, a database on monetary values of ecosystem services was developed by the Foundation for Sustainable Development and published in 2010 (de Groot et al. 2010). The rationale for developing this database was to provide information on the economic benefits of biodiversity conservation and the costs of loss of biodiversity. After the release of the TEEB Valuation Database, the authors continued to develop the database under the name "Ecosystem Services Valuation Database" (ESVD) (de Groot et al. 2012)[3]. With financial support from DEFRA (UK) in 2019, FAO in 2020, the Dutch Ministry LNV in 2020-2021 and again FAO in 2021 via the contribution to the State of the World's Forests, the content and structure of ESVD was significantly updated and expanded to contain over 6 700 value records distributed across all biomes, services and geographic regions. The many publications[4] used in ESVD cover a large number of ecosystems, types of landscapes, different definitions of services, different areas, different levels of scale, time and complexity and different valuation methods.

ABC-Map uses the ESVD ecosystem service values and links these to geospatial land cover data (mainly from the European Space Agency). All land uses are thereby reclassified to match the ecosystems and their corresponding monetary ecosystem service values (in 2020Int.$) of ESVD. The sum of all ecosystem service value pixels corresponds to the natural capital value for a given year and area. As most land cover products provide data for several years, this allows for a time-series of the natural capital. As compared to the MSA metric, ecosystems do have different aggregate ecosystem service values, e.g. while a tropical forest has a value of US$4,072, a desert only has a value of US$780.

Limitations

While this natural capital assessment is a very innovative approach to allow for natural capital accounting via geospatial data, it is important to note that there are also limitations stemming from both the land cover products and ESVD data. The more a land cover product misclassifies the actual land uses, the more the final natural capital assessment will be distorted. With regards to ESVD, one limitation is that the data of ESVD is not globally representative and the current sample of values reflects the availability of valuation studies, the interests of the funding organization, and the thematic expertise of the researchers involved. An additional limitation is that ESVD does not account for different degradation levels of ecosystems.

As the natural capital values reflect the underlying ecological and socio-economic contexts of diverse (but not necessarily representative) study sites, the monetary amounts should

[3] For more information on the database, see: https://www.esvd.info/.

[4] Comprised of peer reviewed academic articles, book chapters, government reports, NGO reports, dissertations, and theses.

be interpreted with caution. Rather than focusing on the exact monetary amounts, the natural capital metric should be understood as a useful means to measure both magnitude and direction of change of ecosystem service flows.

Global Biodiversity Score®

The Global Biodiversity Score® (GBS) was developed by CDC Biodiversité (France) to provide an overall view of the biodiversity footprint from economic activities. This indicator covers habitats and species, but not ecosystem services or genes. This is measured through MSA based on PBL Netherlands Environmental Assessment Agency's model of five terrestrial pressures (land use, nitrogen deposition, climate change, fragmentation, infrastructure/encroachment) and five aquatic pressures, and their impacts on biodiversity. Impacts are expressed in MSA.km2. This indicator quantifies risks, as well as highlighting opportunities for reducing risks to biodiversity, showing impacts but also the potential biodiversity gains from activities.

Limitations

Assessments are not made at site level, but at company level over the entire value chain. Within this tool, MSA does not cover the risk of extinction of species, nor the degradation of the diversity of genes. Pressures on marine ecosystems are not included. Additionally, GBS requires expert usage as calculations are not available to non-experts currently. Application of GBS requires support by a consultant. Guidance estimates that three days of training is required for evaluators, and assessment requires 40-80 person-days from an external consultant.

LIFE Key

LIFE Key was developed with the goal of guiding and acknowledging businesses organizations that promote effective natural capital conservation actions, contributing to the maintenance of biodiversity and ecosystem services. This tool provides information on a company’s pressure and positive impacts on biodiversity, as well as strategic guidance on the effectiveness of conservation actions and outcomes of natural restoration investments. Specifically, LIFE Key looks at biodiversity pressures from land use changes, water use, pollution and climate change. Therefore, this indicator covers habitats and species, but not genes, and ecosystem services are only covered qualitatively. LIFE Key uses a robust and measurable methodology which is adaptable to any country or region.

Limitations

Information provided by LIFE Key on the severity of pressures on biodiversity is related to national or regional information, and not specific to local biodiversity contexts, therefore has limited applicability to IFAD projects. Additionally, guidance estimates that initial user efforts to implement the methodology is between 10 to 100 person-days.

Product Biodiversity Footprint

The Product Biodiversity Footprint (PBF) was developed by I CARE and Sayari. This tool combines biodiversity studies and company’s data to quantify impacts of a product on biodiversity along its life cycle stages. This indicator examines five pressures: habitat change, pollution, climate change, overexploitation, and invasive alien species. Therefore, PBF covers habitats and species, but not ecosystem services or genes. PBF utilizes open-source data to undertake analysis with geographical specificities.

Limitations

PBF requires the collection of primary data from ecological surveys on site and in the supply chain, on yields, emissions and resource use. Therefore, technical knowledge of ecology and of life cycle assessments is needed. Guidance recommends the use of expert consultants to carry out assessments. Additionally, as PBF is targeted towards businesses and its model relies on a Life Cycle Assessment method, it is not as suitable for IFAD projects.

Species Threat Abatement and Restoration metric

Species Threat Abatement and Restoration (STAR) metric was developed by IUCN to measure the contribution that investments make towards reducing species extinction risk. Therefore, the scope of this metric includes habitats and species, but not ecosystem services or genes. This indicator can enable investors to measure the contribution of investments towards global targets such as the SDGs.

Limitations

STAR collects primary data from remote sensing of land use changes, camera traps to measure species presence, and through targeted interviews with local informants. Field verification of primary data is needed, which is time and resource intensive. Additionally, STAR has data gaps for some taxa of trees, reptiles, freshwater fish and marine species. More importantly, STAR focuses on endangered species, but does not consider other pressures on biodiversity generated by the AFOLU sector. Therefore, it is not as relevant for IFAD projects.

Biodiversity Footprint Methodology and Calculator

The Biodiversity Footprint Methodology (BFM) and Calculator (BFC) quantifies the impact of a product, sector or company on biodiversity. This tool uses a pressure-based methodology for three pressure types: land use; GHG emissions; and nitrogen and phosphorus emissions to water. Impact on biodiversity is calculated for each part of the production chain (raw materials, production process and transport), and cause-effect relations from GLOBIO are used. The scope of this indicator includes habitats and species, but not ecosystem services or genes.

Limitations

The BFM and BFC is a simple, open-source tool that requires no external expertise for usage. However, the tool is more suited for supply chain analyses of single commodities, rather than assessing the detailed impact of different types of AFOLU activities, and it does not allow the separate assessment of a land use component. Moreover, the information provided are only rough estimates about the potential biodiversity impacts of an agricultural commodity. Impacts from infrastructure, fragmentation, invasive alien species and nitrogen deposition is not included in the methodology. Lastly, the spatial resolution of this tool is limited to 5x5km^2.

ReCiPe2016

ReCiPe2016 uses life cycle impact assessments to generate environmental impact scores from emissions and resource extraction information. This tool also includes dimensions on human health, ecosystem quality and resource scarcity. Specifically, it includes pressures from land use change, climate change, acidification, ecotoxicity and water consumption. Therefore, the scope of this tool covers habitats and species, but not ecosystem services or genes. Also, pressures from direct exploitation and invasive alien species are excluded.

Limitations

The methodology for using this tool includes uncertainty analysis and sensitivity analysis, which improves the reliability of the results. However, ReCiPe is a complex life cycle impact assessment, which requires significant amounts of data inputs and resources (performing a LCA using ReCiPe will take about 15 days for a quick screening and approximately 40 days for an ISO compliant LCA). In addition, external expertise is required for usage. Lastly, the metrics used ("species.yr" and "PDF.m2.yr") are difficult to understand and, because of this, the scientific community seems to opting for the MSA metric rather than PDF (potentially disappeared fraction of species).

(iii) Identifying IFAD biodiversity core indicator

ABC-Map impact assessment indicators

Considering the strengths and weaknesses of the above tools, the combined metrics of (i) the area of intact biodiversity; and (ii) the average natural capital value per ha within ABC-Map are considered the most appropriate to use as an indicator to grasp the scope and magnitude of, and to measure progress towards improvements and outcomes of, biodiversity at the ecosystem-level. These are described below.

It is clear that the majority of measurement approaches only cover habitats and species. In the review of the ALIGN project, there are only five approaches that also cover ecosystem services, of which two provide only a qualitative assessment (Agrobiodiversity Index and LIFE Methodology). Of the remaining three tools only one was developed by a public entity (FAO with ABC-Map, as compared to Kering's E P&L approach and LafargeHolcim's approach).

The ALIGN project led by UNEP-WCMC and the European Commission found that none of the currently available approaches and metrics cover genetic biodiversity. In view of this and the ALIGN requirements mentioned above, the ecosystem-level biodiversity indicator (via ABC-Map) covers (i) two biodiversity dimensions (both habitat and ecosystem services are covered); and (ii) all material pressures to biodiversity.

Using the MSA and natural capital as metrics, or sub-indicators, furthermore align with the Sustainable Development Goals (SDGs), in particular SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (European Commission, 2021).

The innovative remote sensing ecosystem-based core indicator (via ABC-Map) has the advantage of being a relatively cheap and rapid method of acquiring up-to-date information over large geographical areas. This is very much in line with the goal for IFAD's biodiversity core indicator to be simple, smart, robust, measurable and globally applicable - limiting hence the extra burden to projects to a strict minimum.

Area of Intact Biodiversity - based on the MSA metric

Based on the MSA, ABC-Map provides an additional metric called Area of Intact Biodiversity (AIB), which corresponds to a surface area equivalent of the MSA value. The AIB enables users to aggregate footprinting results. For instance, an AIB of 500 ha corresponds to the value of biodiversity contained in 500 ha of a forest undisturbed by human activities.

Let $\Delta\mathrm{AIB}$ be the effect size to measure the difference in means for the MSA values with (mid-term and completion) and without (baseline) intervention, multiplied by the total area of intervention. This can be expressed as follows:

$$\Delta AIB(r,t) = \left(\frac{1}{n}\sum_{i=1}^{i=n} MSA_{P_{i,r,t}} - \frac{1}{n}\sum_{i=1}^{i=n} MSA_{B_{i,r,t}}\right) * \sum_{i=1}^{i=n} pixelArea_{i,r}$$

where :

$\boldsymbol{\Delta AIB}(\boldsymbol{r},\boldsymbol{t})$ AIB for the area of intervention for a given image resolution (r) and year (t).

$\frac{\mathbf{1}}{\boldsymbol{n}}\sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{i}=\boldsymbol{n}}\boldsymbol{MSA}_{\boldsymbol{P}_{i,r,t}}$ is the average MSA value in pixel i and year t for a given image resolution r for the project situation.

$\frac{\mathbf{1}}{\boldsymbol{n}}\sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{i}=\boldsymbol{n}}\boldsymbol{MSA}_{\boldsymbol{B}_{i,r,t}}$ is the average MSA value in pixel i and year t for a given image resolution r for the baseline situation.

$\sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{i}=\boldsymbol{n}}\boldsymbol{pixelArea}_{\boldsymbol{i},\boldsymbol{r}}$ is the total project intervention area expressed as the summed area of each pixel in a given image resolution r.

ABC-Map automatically calculates the MSA values for both the baseline and project situation and provides a time series for the AIB. Therefore, it is an appropriate metric, or sub-indicator, to use as an indicator of biodiversity outcomes at the ecosystem-level in IFAD projects. Table 1 shows scenarios of three potential projects with different outcomes for the AIB indicator. Project 1 leads to an increased biodiversity intactness equivalent to an AIB of 15,029.7 ha. In Project 2, the AIB remains constant throughout the project implementation, hence indicating no change in the AIB. The Project 3 leads to a decrease in biodiversity intactness, hence indicating a decrease in the AIB.

Table 1**. Area with intact biodiversity**

	2022	*2023*	*2024*	*2025*	*2026*	*2027*	*2028*	Δ_{AIB}	*Sign*
P1 (ha)	0	2,504	5,009	7,514	10,019	12,524	15,029	15,029	↗
P2 (ha)	0	0	0	0	0	0	0	0	→
P3 (ha)	0	-2,504	-5,009	-7,514	-10,019	-12,524	-15,029	-15,029	↘

Average Natural Capital per ha – based on ESVD

Based on the summed ecosystem service value expressed as natural capital, ABC-Map provides an additional metric called average natural capital per ha (ANC), which corresponds to an average ecosystem service value for one hectare of land within the project intervention area. It is an appropriate metric, or sub-indicator, to use as an ecosystem-based indicator in IFAD projects.

Let $\Delta \mathrm{ANC}$ be the effect size to measure the difference in means for the average natural capital values per ha for a given year with (mid-term and completion) and without (baseline) intervention, divided by the total area of intervention. This can be expressed as follows:

$$\Delta ANC(r,t) = \frac{\left(\frac{1}{n}\sum_{i=1}^{i=n} naturalCapital_{P_{i,r,t}} - \frac{1}{n}\sum_{i=1}^{i=n} naturalCapital_{B_{i,r,t}}\right)}{\sum_{i=1}^{i=n} pixelArea_{i,r}}$$

where :

$\Delta ANC(r,t)$ is the ANC value per ha for the area of intervention for a given image resolution (r) and year (t),

$\frac{1}{n}\sum_{i=1}^{i=n} naturalCapital_{P_{i,r,t}}$ is the ANC[5] value in pixel i and year t for a given image resolution r for the project situation.

$\frac{1}{n}\sum_{i=1}^{i=n} naturalCapital_{B_{i,r,t}}$ is the ANC[6] value in pixel i and year t for a given image resolution r for the baseline situation.

ABC-Map automatically calculates the natural capital values for both the baseline and project situation and provides a time series for the ANC values. Table 2 shows three potential projects with different outcomes for the ANC indicator. Project 1 leads to an increase in ecosystem service values of 0.02 US$/ha. In Project 2, the ANC remains constant throughout the project implementation, hence indicating no change in the AIB. The third project leads to a decrease in ecosystem service values of 0.02 US$/h, hence indicating a decrease in the ANC.

Table 2.
Average natural capital per ha

	2022	*2023*	*2024*	*2025*	*2026*	*2027*	*2028*	Δ_{ANC}	*Sign*
P1 (US$/ha)	2,318.78	2,318.79	2,318.79	2,318.80	2,318.80	2,318.80	2,318.80	0.02	↗
P2 (US$/ha)	2,318.78	2,318.78	2,318.78	2,318.78	2,318.78	2,318.78	2,318.78	0.00	→
P3 (US$/ha)	2,318.80	2,318.80	2,318.80	2,318.80	2,318.79	2,318.79	2,318.78	-0.02	↘

Ecosystem-based biodiversity improvements

IFAD considers that biodiversity is improved at ecosystem-level, when either the habitat indicator (Area of Increased Biodiversity) or the ecosystem indicator (Average Natural Capital per ha) show a positive change with the implementation of a project.

Ecosystem-based biodiversity improvements can therefore be denoted as follows:

$$EcosystembasedBiodiversityImprovement_{M,C} = max(\Delta_{AIB}, \Delta_{ANC}) + min(\Delta_{AIB}, \Delta_{ANC}) > 0$$

Where $\Delta_{AIB} \wedge \Delta_{ANC} \geq 0$

In other words, at least one of the two ecosystem-based biodiversity indicators needs to be positive, while the other one is at least held constant (or positive).

The Ecosystem-based Biodiversity Indicator (EcoB COI) is a boolean indicator, taking the value of 1 (true), if there is an ecosystem-based biodiversity improvement, and 0 (false) if there is no improvement. This can be expressed as follows:

[5] Adjusted for a social discount rate.
[6] Ibid.

$$EcoBCOI = EcosystembasedBiodiversityImprovement_{M,C} = \begin{cases} > 0, 1, (true) \\ \leq 0, 0, (false) \end{cases}$$

Table 3 below shows the combinations of Δ_{AIB} and Δ_{ANC}, which translate into increased biodiversity under the ecosystem-based biodiversity core output indicator.

Table 3.

Ecosystem-based biodiversity COI-Matrix

EcoB COI	Δ_{AIB}	Δ_{ANC}	***Description***
Increased Biodiversity	↗	↗	Positive $\boldsymbol{\Delta_{AIB}}$ and positive $\boldsymbol{\Delta_{ANC}}$
Increased Biodiversity	↗	→	Positive $\boldsymbol{\Delta_{AIB}}$ and constant $\boldsymbol{\Delta_{ANC}}$
Increased Biodiversity	→	↗	Constant $\boldsymbol{\Delta_{AIB}}$ and positive $\boldsymbol{\Delta_{ANC}}$
Stable Biodiversity	→	→	Constant Δ_{AIB} and constant Δ_{ANC}
Decreased Biodiversity	→	↘	Constant Δ_{AIB} and negative Δ_{ANC}
Decreased Biodiversity	↘	→	Negative Δ_{AIB} and constant Δ_{ANC}
Decreased Biodiversity	↘	↘	Negative Δ_{AIB} and negative Δ_{ANC}

Exception – the use of the dynamic baseline

There have been a few cases, where a positive biodiversity outcome has occurred, but not by increasing biodiversity per se. This is when IFAD projects avoid deforestation. Avoided deforestation may not be directly captured by the constant baseline of a project (as the $\boldsymbol{\Delta_{AIB}}$ and $\boldsymbol{\Delta_{ANC}}$ are both constant), and yet, the positive aspect of avoiding deforestation should be covered. Hence, for instances of avoided deforestation, a dynamic baseline scenario may be used as the baseline. Case Study 3 shows the use of the ecosystem-level biodiversity indicator in the case of an avoided deforestation project in Viet Nam.

Limitations of the biodiversity COI

IPBES states that "anthropogenic drivers include habitat conversion, e.g., degradation of land and aquatic habitats, deforestation and afforestation, exploitation of wild populations, climate change, pollution of soil, water and air and species introductions (2019)." While ABC-Map covers the most important pressures on biodiversity, namely the degradation of land and aquatic habitats, deforestation, and the exploitation of wild populations, it does not directly cover the pressures of climate change, pollution of soil, water and air and species introductions.

Climate change

Climate change is already having an impact on biodiversity, and is projected to become an increasingly significant threat in the coming decades. While the chosen ecosystem-based biodiversity core indicator do not cover this anthropogenic pressure directly, it is important to note that the impact of greenhouse gas emissions on climate change cannot simply be attributed to a restricted project area, nor to a specific project period (as different GHGs vary in their lifetime). In addition, the Biodiversity Core Indicator will automatically be triggered, when a project tracks Nature-based Solutions (NbS) finance. As the NbS finance tracking is embedded into the existing climate change mitigation finance tracking framework, the Core Indicator 3.2.1 (tCO2e avoided and/or sequestered) will also likely be triggered.

Pollution and introduction of alien species

While pollution and the introduction of alien species are also not covered by the IFAD ecosystem-level biodiversity core indicator, these pressures are: (i) already covered by the mandatory Social, Environment and Social Assessment Procedures (SECAP); and (ii) may be added as pressures to future versions of the ABC-Map Tool of FAO. With regards to SECAP, question 6 of the biodiversity standard specifically asks whether the project will introduce or utilize “any invasive alien species of flora and fauna, whether accidental or intentional.” In addition, SECAP dedicates a whole standard on resource efficiency and pollution prevention, with specific questions on, e.g. the release of pollutants to the environment due to routine or nonroutine circumstances, with the potential for adverse local, regional and/or transboundary impacts, or the use of inputs of fertilizers and other modifying agents.

(iv) Reporting modalities of the ecosystem-based biodiversity COI

The ecosystem-level biodiversity indicator is a core outcome indicator. As such, the indicator will be integrated in the projects' monitoring and evaluation systems. This means that the ecosystem-level biodiversity core indicator will be reported at three points during a project's lifetime, in line with IFAD's core indicator guidelines (at project design, midline and endline). This reporting modality will allow for a regular assessment of the progress and performance of a project.

The ecosystem-level biodiversity indicator will be remotely assessed via FAO's ABC-Map Tool, and in particular via changes in the metrics, or sub-indicators, of (i) the Area of Intact Biodiversity (AIB); and (ii) the Average Natural Capital per ha (ANC). Based on the implementation of the different activities of a project, ABC-Map provides an annual time series for both metrics, or sub-indicators, hence allowing for simple (i) ex-ante impact projections; (ii) the monitoring of impacts during implementation; and (iii) ex-post impact evaluation.

Considering the varying sizes of project intervention areas (in particular at project design stage), IFAD projects are expected to use the default spatial resolution of 300m (meaning that each pixel has a total size of 300*300m, or 9ha) for their ABC-Map assessment. This is mainly to ensure comparability across all projects. Projects are, however, encouraged to refine the spatial resolution in project-specific indicators to measure specific results that cannot be adequately captured by the CIs (as stated above). Technical support for measurement will be provided by IFAD's Environment, Climate, Gender and Social Inclusion (ECG) Division.

(v) Case studies

This section will provide 5 case studies for the ecosystem-based biodiversity core indicator. The case studies are ordered as follows:

- Case study 1 on the CASP+ project in Tajikistan.
- Case study 2 on the Neer-Tamba Project in Burkina Faso.
- Case study 3 on the RECAF project in Viet Nam.
- Case study 4 on the I-BE project in Haiti.
- Case study 5 on the PRIDE project in Malawi.

Case study 1 – CASP+ project in Tajikistan

Project title: Community-based Agricultural Support Project Plus (CASP+)
Project duration: 7 years (2022-2028)
Total project budget: US$99,249,043

Background
Tajikistan is the most vulnerable country in Central Asia to climate risks. Temperatures are increasing across the country, with a sharp increase in the period 1970-2017 and a clear shift in precipitation patterns, with a net decrease in precipitation during spring and most of summer. Higher temperatures, increased evaporation, and increased heat extremes negatively affect agricultural productivity, putting at risk irrigated and rainfed agricultural systems and rural livelihoods.

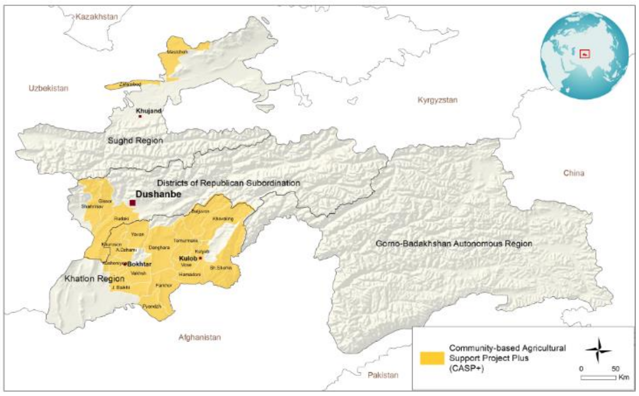
Project objective
The development objective of CASP+ is to increase the resilience of ecosystems and adaptation of livelihoods in rural areas affected by climate change. The project will achieve the objective by strengthening public sector capacity for transformative climate-resilient governance of natural resources, improving community planning and access to investment resources for climate adaptation, and supporting through market-based approaches for diversification of climate-resilient livelihoods.

Table 4.
CASP+ project activity summary

ID	*Project activities*	*Area (ha)*
1	Joint Forest Management in shrubland landscapes	5 801
2	Afforestation of extensive agroforestry landscapes	1 350
3	Joint Forest Management in shrubland buffer zones	179
4	Rehabilitation and sustainable management of currently intensively grazed rangeland	38 000*

Source: Adapted from project document.
* The PDR mentions rangeland management of 180,000 ha. In a conservative approach, the biodiversity specialists decided to account for a direct intervention of 20 per cent (or 38,000 ha) of the total targeted surface.

While the exact areas of intervention are not yet identified, CASP+ will target several provinces in east Tajikistan, namely Sharinav, Gissor, Rudaki, Khuroson, Yavan, A. Dzhami, Kushoniyon, J. Balkhi, Vaksh, Pyandzh, Fakhor, Danghara, Temurmalik, Vose, Hamadoni, Sh. Shohin, Kulyab, Temurmalik, Beljuvon, Khovaling, Zafarobod and Mastchoh.



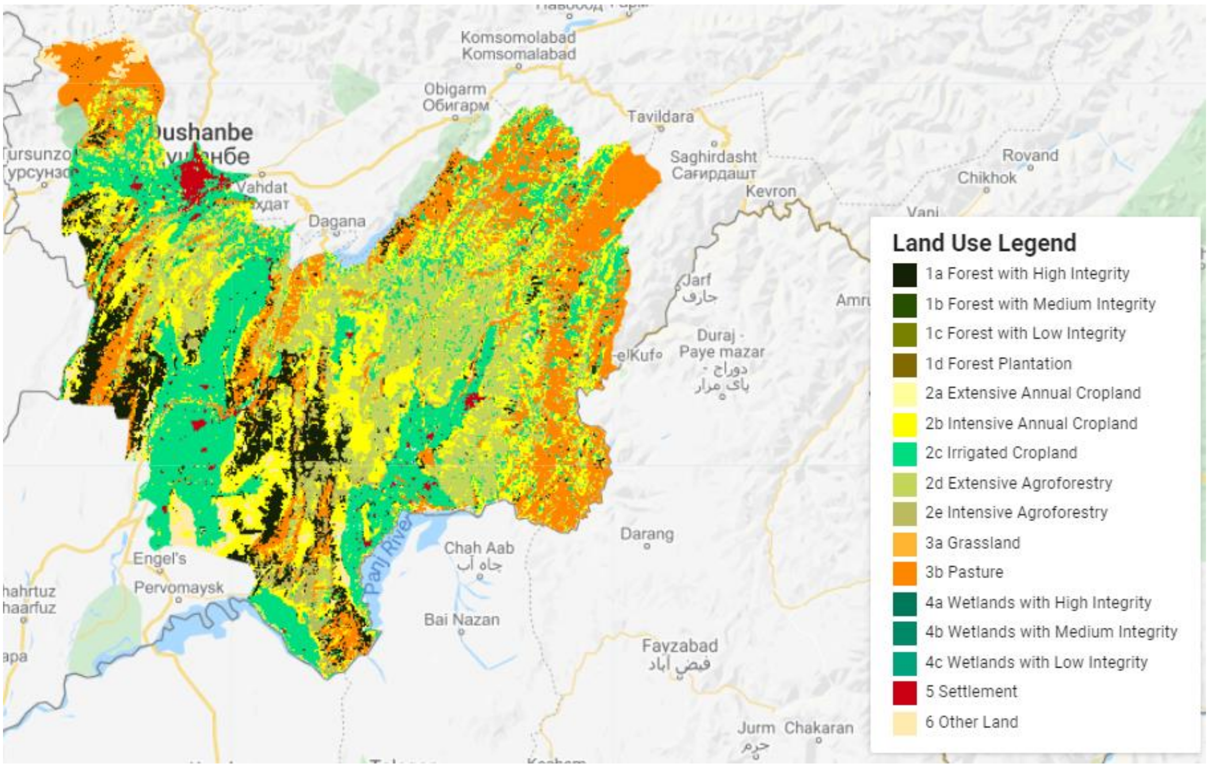
As most provinces are located in the southeast of Tajikistan, it was decided to focus on the provinces of the Khatlon and Districts of Republican Subordination regions (hereafter referred to as Area of Intervention, or AOI).

As stated above, Tajikistan faces temperature increases and precipitation decreases. ABC-Map confirms these trends for the AOI. While the mean annual temperature increased from 10.4°C to 12°C, the mean annual precipitation decreased from 449mm to 361mm between 1981 and 2020. At the same time, extreme weather events have also significantly increased. The number of heat days has increased from approximately 15 days to 28 days per year. The number of dry days (with less than 1mm of precipitation) has increased from 251 to 261 days per year (all climatic data will be shared in a separate publication on the case studies).

These more extreme weather events coincide with an unfavourable geophysical profile, which make erosion and landslides more likely. More than half of the AOI classifies as steep, extremely steep or excessively steep slopes (exceeding a 15 per cent gradient).

The project intervention area has a total of 2,147,100 ha, representing roughly one fifth of the entire area of Tajikistan. With a 300m resolution, ABC-Map provides a land use map for the year 2019 (see Figure 6).

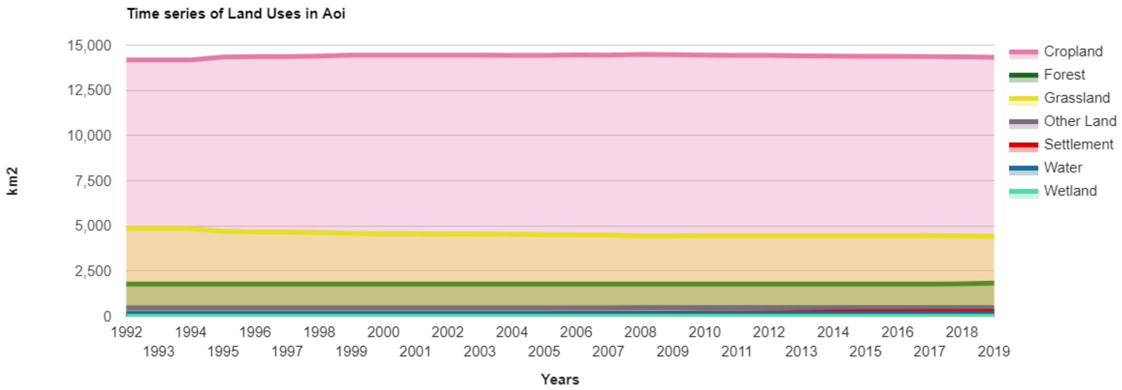
Figure 6.
CASP+ ABC-Map baseline land use map.



Source: ABC-Map.

The AOI is dominated by cropland (extensive agroforestry, irrigated cropland, intensive annual cropland and intensive agroforestry), followed by pastures and shrublands. The croplands are clustered around the main settlements in the project zone, namely Dushanbe in the north-west, Vaksh in the south-west, and Kulob in the south-east. The shrublands are highly fragmented and mainly present in the south western part of the AOI. The pastures are distributed across the AOI, with a stronger presence in the eastern and north-western parts. Figure 7 shows the land use evolution of the main Intergovernmental Panel on Climate Change (IPCC) land use groups since 1992.

Figure 7.
CASP+ IPCC land use evolution in AOI.



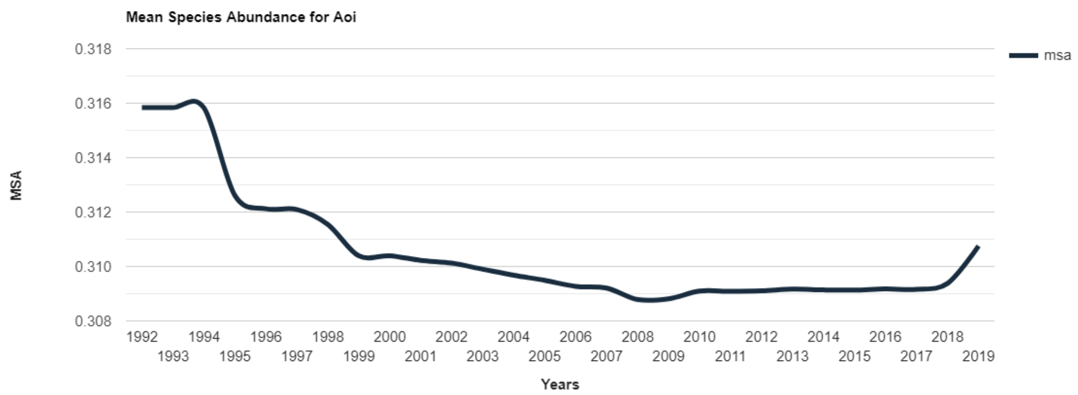
Source: ABC-Map.

Part 1. CASP+ baseline

i. Mean species abundance

The MSA of the AOI is estimated at 0.311 for the year 2019. In other words, this means that 31.1 per cent of the biodiversity is currently considered intact. The main anthropogenic pressures on biodiversity are land uses (MSA value of 0.372) and human encroachment (MSA value of 0.85). Habitat fragmentation (with an MSA value of 0.992) and infrastructure (with an MSA value of 0.998) also affect biodiversity intactness in the AOI, but to a lesser extent. Figure 8 shows the MSA evolution from 1992 to 2019. The graph shows a significant decrease of the MSA over the first 15 years, which can be explained by the conversion of grassland to cropland. The biggest loss of MSA occurred during the years 1994-95, in which the aggregate MSA decreased from 31.6 per cent to 31.2 per cent. This can be traced back to Figure 7, which shows an important loss of grassland of 162 km^2 from 1994-1995. The MSA continued to decrease due to further land use conversion from grasslands to croplands until 2008 with a minimum MSA of 30.9 per cent. In recent years, however, the trend seems to be reversed, with a partial recovery of the biodiversity intactness to 31.1 per cent. This increase can be attributed to reforestation efforts, in which 30.43 km^2 of cropland and 16.04 km^2 of grassland have been reforested (see Figure 7 and Figure 8).

Figure 8.
CASP+ MSA evolution in AOI.



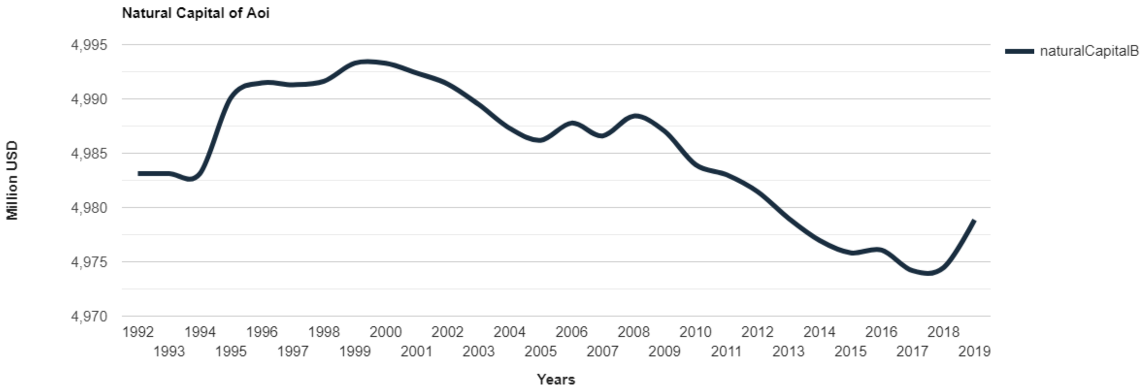
Source: ABC-Map.

ii. Natural capital

The natural capital of the AOI amounted to US$4,978,660,000 in 2019. This corresponds to an average natural capital value of US$2,318 per ha. Figure 9 shows the evolution of the natural capital value from 1992 to 2019 in the AOI. The natural capital value is rather constant in the early 90s, then increases from 1994 to 1999. This evolution is contrary to the development of the MSA as shown in Figure 8. The increase in natural capital, notably between 1994 and 1995 can be explained by the conversion of grasslands to extensive agroforestry systems. While MSA has a pure biodiversity lens, the natural capital takes into account the various ecosystem services that provided a benefit to humans. The aggregate monetary benefits provided to humans by extensive agroforestry systems are valued higher than the ones of pure grassland systems. This can mainly be attributed to higher food and raw material production together with increased carbon storage and soil organic matter in extensive agroforestry systems. The natural capital therefore provides a more anthropogenic view on biodiversity.

From 2000 to 2004 and 2008 to 2018, the natural capital then decreases significantly to below 1992 levels. This decrease can be attributed to increases in settlement areas, which provide very little ecosystem services. Overall, the settlement area has increased by 200 km^2 from 2000 to 2008, representing a 4.5-fold increase.

Figure 9.
CASP+ natural capital evolution in AOI.

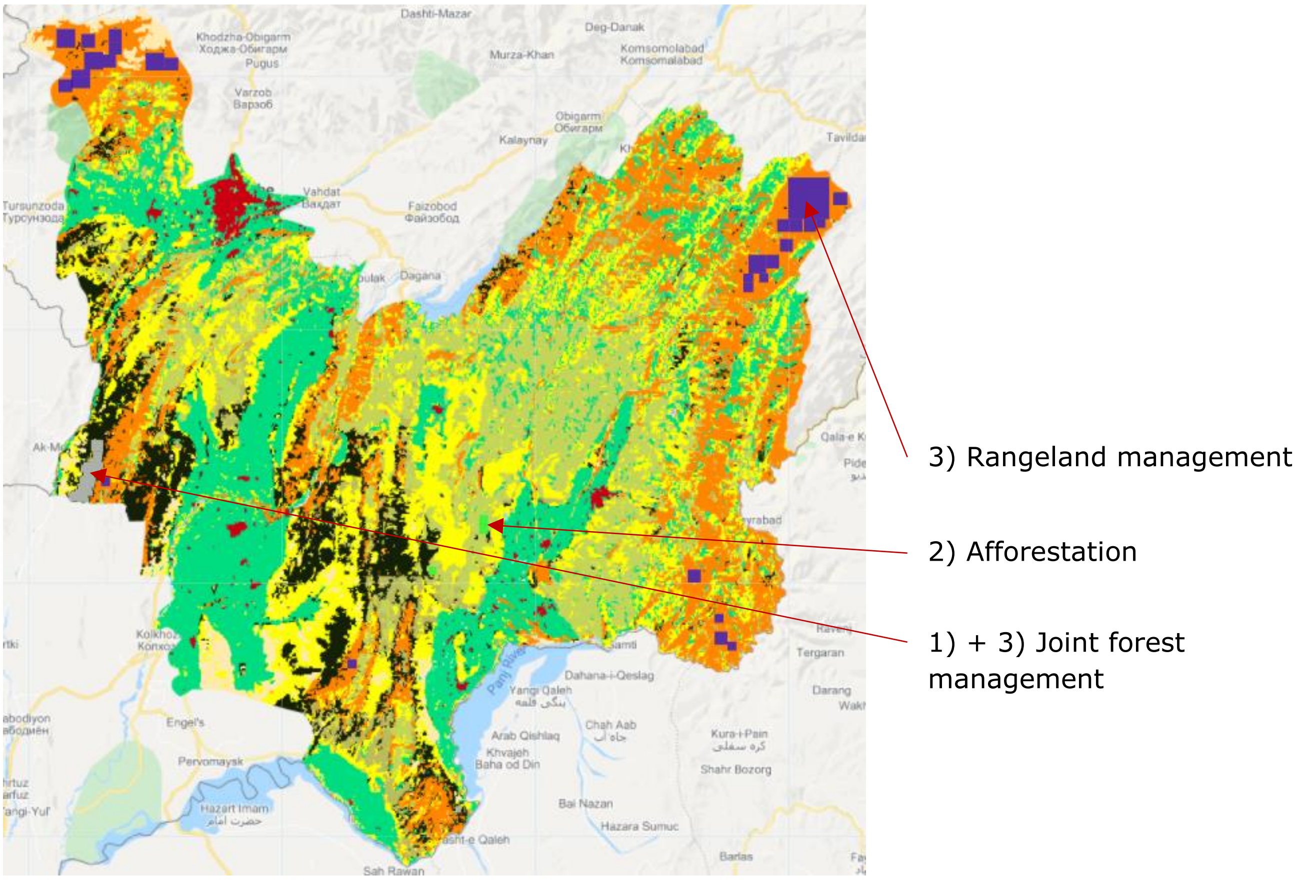


Source: ABC-Map.

Part 2. CASP+ project intervention

Considering that the exact locations of intervention will only become available during implementation, but already knowing the proposed project interventions (Table 4), here ABC-Map proposes potential plots of intervention. Figure 10 shows the project plots according to their activity. All purple areas show 38,179 ha of current pastures with high-intensity grazing that would be under improved management with the project (to reduce the grazing intensity and allow for rehabilitation of soils). The light green plots show 1,350 ha of current extensive agroforestry systems that would be fully reforested to a highly intact forest. The grey plots show 5,801 ha of existing shrublands that will be under improved forest management practices with the project.

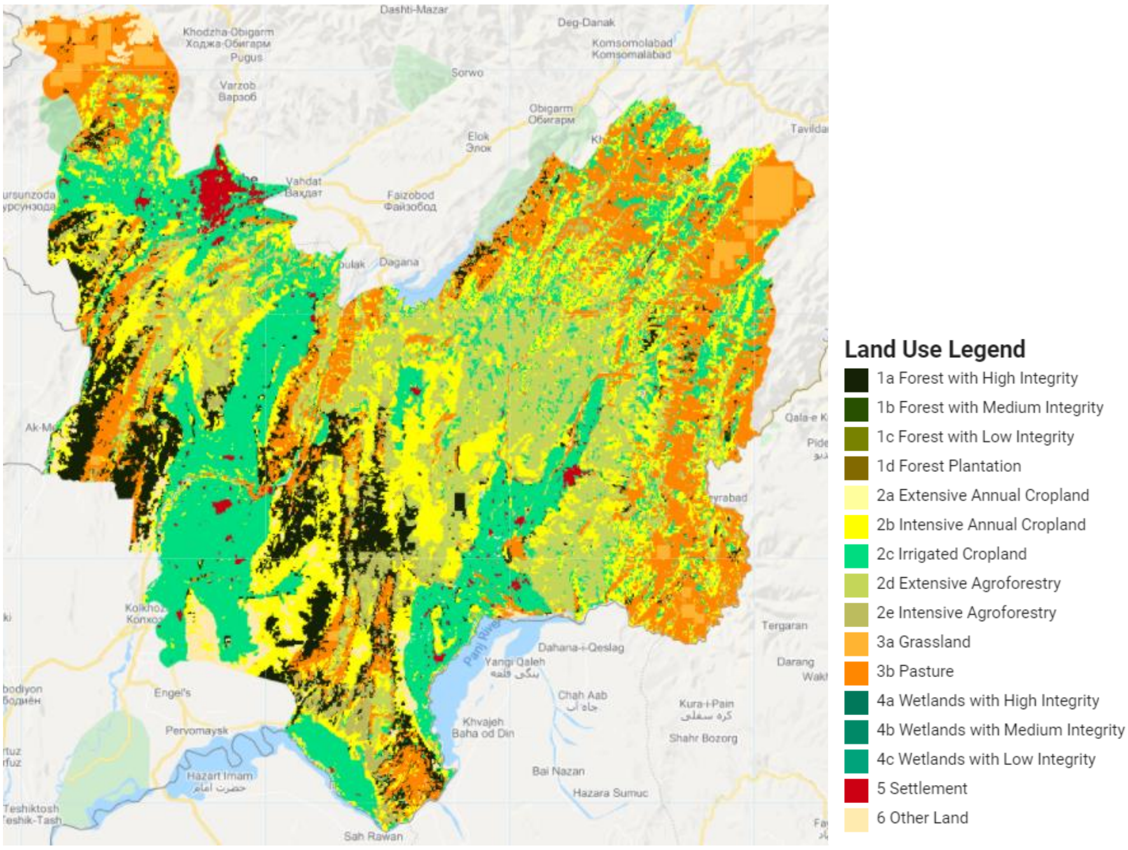
Figure 10.
CASP+ project intervention plots in AOI.



Source: ABC-Map.

Once these plots are drawn onto the map and the project land uses are specified for each plot, ABC-Map recalculates all indicators in a time series including the project activities for the period of the project 2022-2028. Figure 11 shows the newly generated land use map for the project.

Figure 11.
CASP+ ABC-Map land uses with project.

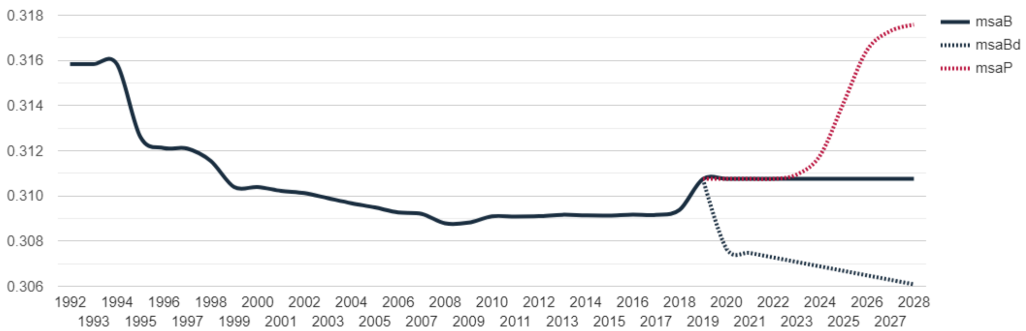


Source: ABC-Map.

i. Mean species abundance

With the implementation of the project, the MSA will increase from 31.1 per cent to 31.8 per cent. Using the constant baseline scenario as reference, the MSA will increase by 0.68 per cent with the project. This means that 31.8 per cent of the biodiversity can be considered intact after the implementation of the project (see Figure 12). This increase in MSA value can mainly be attributed to an increase in the MSA land use value from 0.372 to 0.381, while the other anthropogenic pressures on biodiversity remain constant. The corresponding AIB will increase by 146.63 km^2.

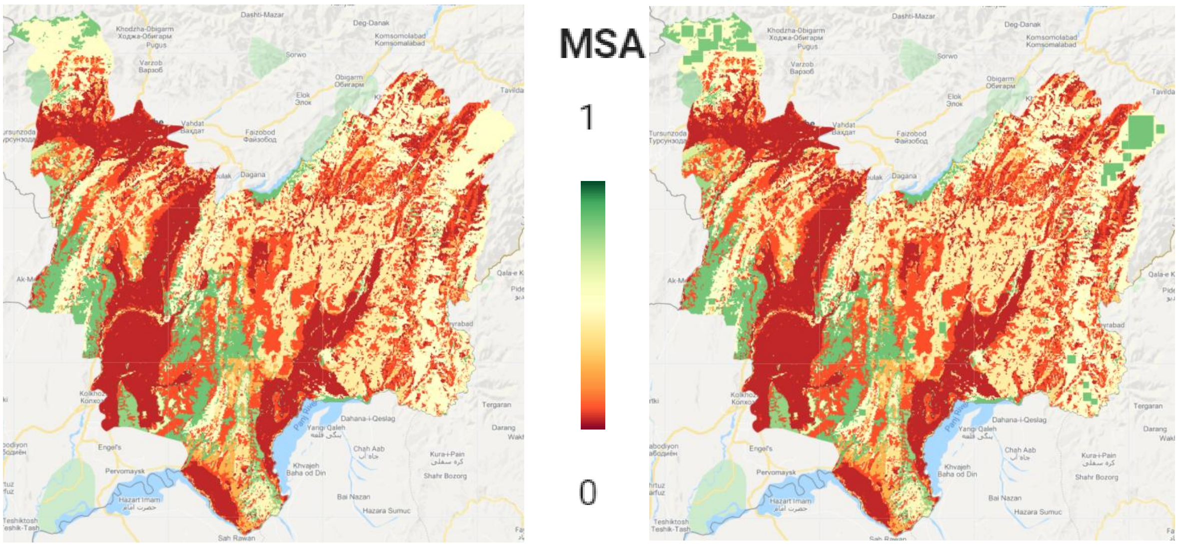
Figure 12.
CASP+ MSA evolution with the project.



Source: ABC-Map.

As ABC-Map is a mapping tool, these increases can also be directly tracked on the MSA Map. Figure 13 shows the baseline (left) versus project (right) map.

Figure 13.
CASP+ Baseline vs. project MSA map.



Source: ABC-Map.

Table 5.
CASP+ Area with intact biodiversity

	2022	*2023*	*2024*	*2025*	*2026*	*2027*	*2028*	Δ_{AIB}	*Sign*
AIB (ha)	0	2 444	4 888	7 332	9 776	1 220	14 663	+14 663	↗

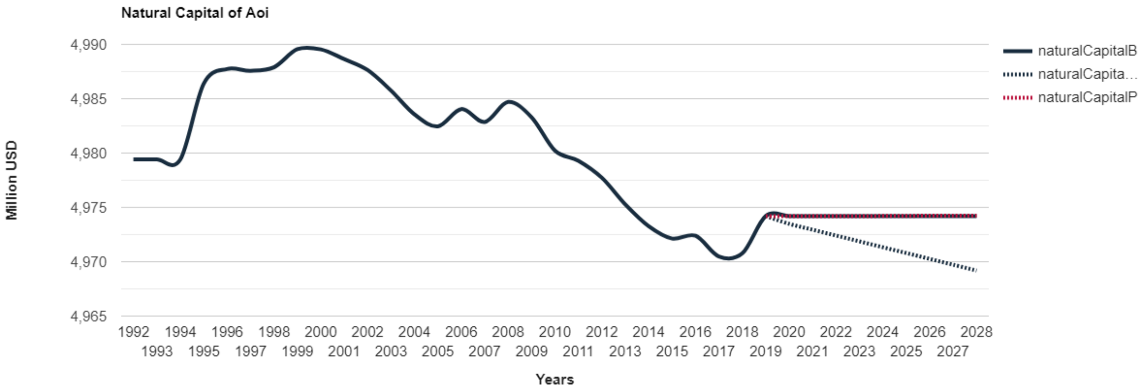
Source: Adapted from ABC-Map.

ii. Natural capital

Using the constant baseline scenario as reference, the total value of the natural capital will increase by US$40,000 with the project. It is important to note that one of the limitations of the natural capital assessment, as of now, is that there is no distinction of ecosystem service values between degraded and non-degraded grassland ecosystems (due to a lack of data). As this increase is hence likely to underrepresent the real increase in ecosystem service value by the project, it is important to look at the other indicators provided by ABC-Map (notably the increased carbon sequestration and social value of carbon as a proxy for a healthy biodiversity).

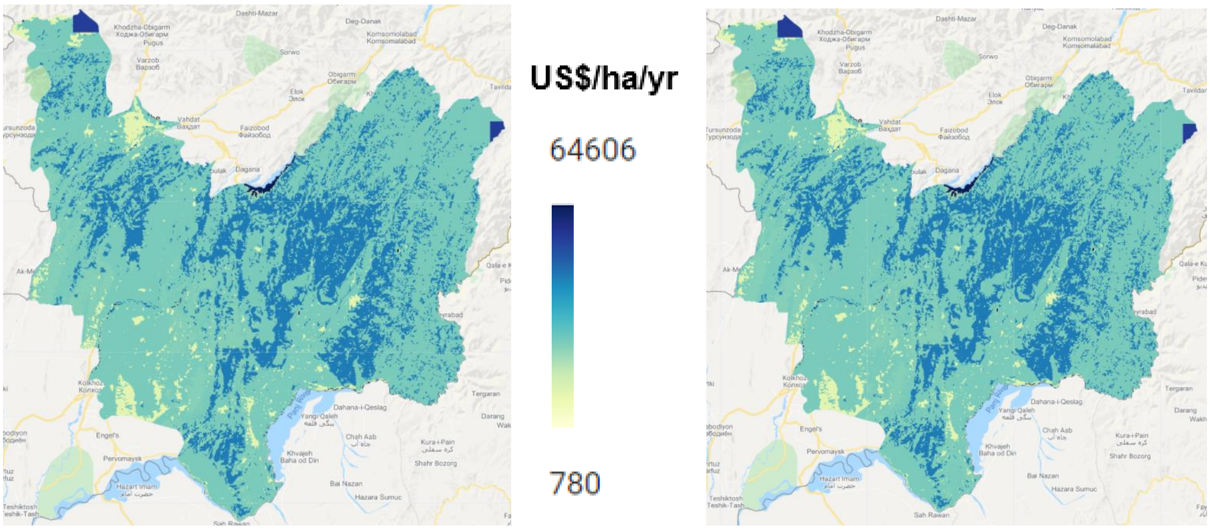
Figure *14* shows the natural capital evolution with the project and Figure 15 compares the natural capital maps of the baseline with the project scenarios.

Figure 14.
CASP+ Natural capital evolution.



Source: ABC-Map

Figure 15.
CASP+ natural capital evolution with the project.



Source: ABC-Map

Table 6.
CASP+ average natural capital per ha

	2022	*2023*	*2024*	*2025*	*2026*	*2027*	*2028*	Δ_{ANC}	*Sign*
ANC (US$/ha)	2 318.78	2 318.79	2 318.79	2 318.80	2 318.80	2 318.80	2 318.80	0.02	↗

Source: Adapted from ABC-Map.

Part 3. CASP+ ecosystem-based biodiversity core indicator

As described above, the two sub-indicators to be used as the ecosystem-based biodiversity core indicator are the AIB, which can be found in Table 5, and the ANC, which can be found in

Table *6*.

IFAD considers that biodiversity is improved at ecosystem-level, when either the habitat sub-indicator (AIB) or the ecosystem sub-indicator (ANC) show a positive change with the implementation of a project, while the other one is at least held constant. Table 7 shows the AIB and ANC per ha for the three reporting periods (project baseline, mid-term and completion), respectively.

Table 7
CASP+ area of intact biodiversity and average natural capital per ha.

	Baseline	*Mid Term*	*Completion*	*Δ*	*Sign*
AIB (ha)	0	7 332	2 318.79	+14 663	↗
ANC (US$/ha)	2 318.78	2 318.79	2 318.80	+0.02	↗

Source: Adapted from ABC-Map.

As both the Δ_{AIB} (+ 14,663 ha) and the Δ_{ANC} (+ 0.02 US$/ha) are showing a positive impact on biodiversity, the CASP+ project is improving biodiversity at the ecosystem-level at project completion. In other words, the biodiversity core indicator 3.2.4 would be reported as 1.

Case study 2 – Neer-Tamba project in Burkina Faso

Project title: Participatory Natural Resource Management and Rural Development Project in the North, Centre-North and East Regions (Neer-Tamba)
Project duration: 10 years (2013-2022)
Total project budget: US$117,452,626

Background

The project area faces relatively difficult ecological conditions linked both to the semi-arid Sahelian climate and to increasing anthropogenic pressure. Large parts of the area are subject to land degradation, notably via the disappearance of plant cover, the compaction and depletion of soils, erosion and the drop in water tables. Overall, rainfall is low, irregular and poorly distributed. Land, water, forest, and pastoral resources, and forest resources are the main natural resources on which rural populations largely base their economic and social development. Agricultural activities (in the broad sense) remain very dependent on the variability of agro-climatic conditions.

Project objective

The development objective of Neer-Tamba is to improve the living conditions and income of the most disadvantaged rural populations. Its specific objective is to support the target populations to build and strengthen their autonomy and their ability to play a growing leading role in the construction of a sustainable economic and social fabric.

Based on the importance of livestock in the strategies of rural households in the project area, three main groups of production systems can be distinguished: (i) mixed sedentary systems, in a precarious situation, (ii) mixed systems in integration/accumulation path, and (iii) agropastoral systems. The aim of the Neer-Tamba project is hence to create the enabling environment for the rural poor in the project area to move from production system (i) to production systems (ii) and ideally (iii).

Table 8.
Neer-Tamba project activity summary

ID	*Project activities*	*Area (ha)*
1	Introduction of *cordons pierreux* as a soil and water conservation and restoration practice on conventional annual cropland	5 500
2	Establishment of extensive agroforestry systems (*zaï* and *demi-lunes*) on conventional annual cropland	11 000
3	Development of irrigated rice via the introduction of *aménagements hydro-agricoles* on conventional annual cropland	6 000
4	Improvement of conventional annual cropland with introduction of small irrigation	600

Source: Adapted from project document.[7]

[7] While the introduction of livestock is a potential risk of this project, it is worth noting that the current livestock systems are essentially extensive and transhumant. In practice, the natural pastures occupied by the breeders are abandoned after two years with migration to other pastures. As the project's aim is to build on these extensive livestock systems, its impact was considered negligeable. With additional information from the project management unit, livestock impacts could be included in the biodiversity assessment.

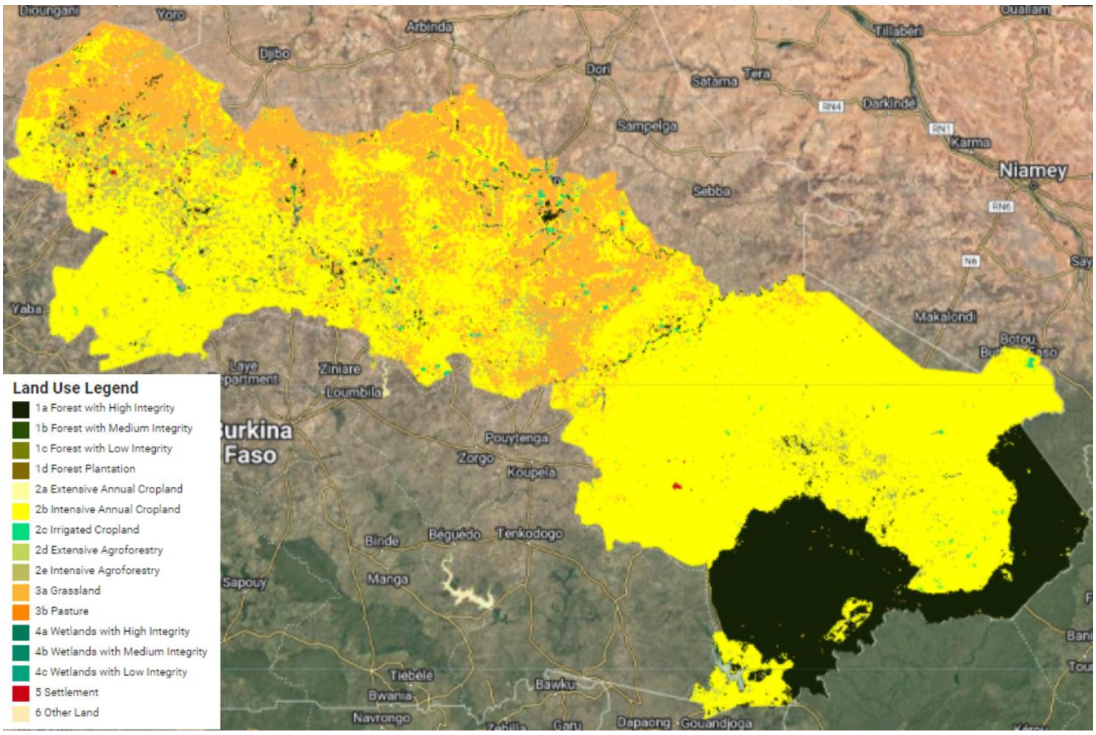
Neer-Tamba targets three regions in the North of Burkina Faso. These are *Est*, *Centre-Nord* and *Nord*. The total population in these three provinces is estimated at 190,000 households, which corresponds to approximately 1,250,000 individuals. The project will have a direct impact on 40,000 households.

Burkina Faso is one of the most vulnerable countries in a changing climate. The country and project area face significant temperature increases combined with more extreme precipitation events. Over the past 40 years, the mean annual temperature increased from 28.4°C to 29.4°C in the project area. In the meantime, the number of dry days has increased from 277 to 295 days per year, which is particularly worrisome in a region which is highly dependent on rainfed agriculture. This increase in the number of dry days is accompanied by an increased number of extreme precipitation from 0 days in 1981 to 0.35 days per year (with more than 60mm of rain). All climatic data will be shared in a separate publication on the case studies.

The project intervention area has a total of 8,300,372 ha, representing roughly one third of the entire area of Burkina Faso. Using a 300m resolution, ABC-Map generates a land use map for the year 2019 (see

Figure *16*), which is considered as the baseline.

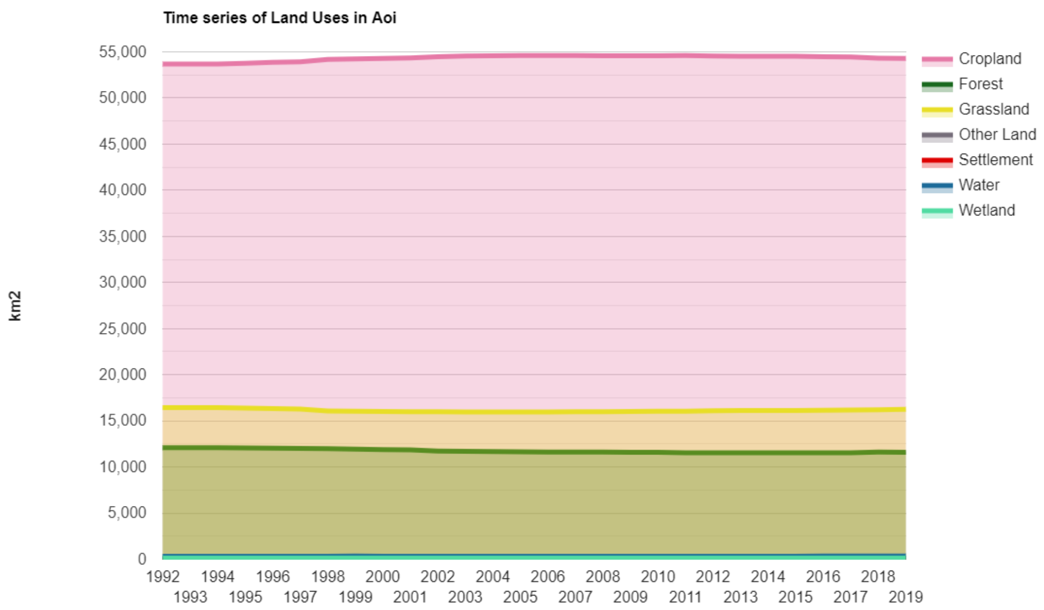
Figure 16.
ABC-Map baseline land use map.



Source: ABC-Map.

The AOI is dominated by cropland (i.e. intensive annual cropland, intensive agroforestry and to a small extent irrigated cropland), followed by pastures and shrublands. The croplands are distributed across the project zone, surrounding the urban centres of Fada-Ngourma in the east and Ouahigouya in the west. The shrublands and forests are clustered in the natural reserves of the south-east of the AOI, notably the Pama reserve, the Singou reserve and the Arli National Park. The remaining shrubland and forest stands are highly fragmented and scattered across the AOI. Most of the pastures are concentrated around the north-east of the AOI. Figure 17 shows the land use evolution of the main IPCC land uses, since 1992.

Figure 17.
Neer-Tamba IPCC land use evolution in AOI.



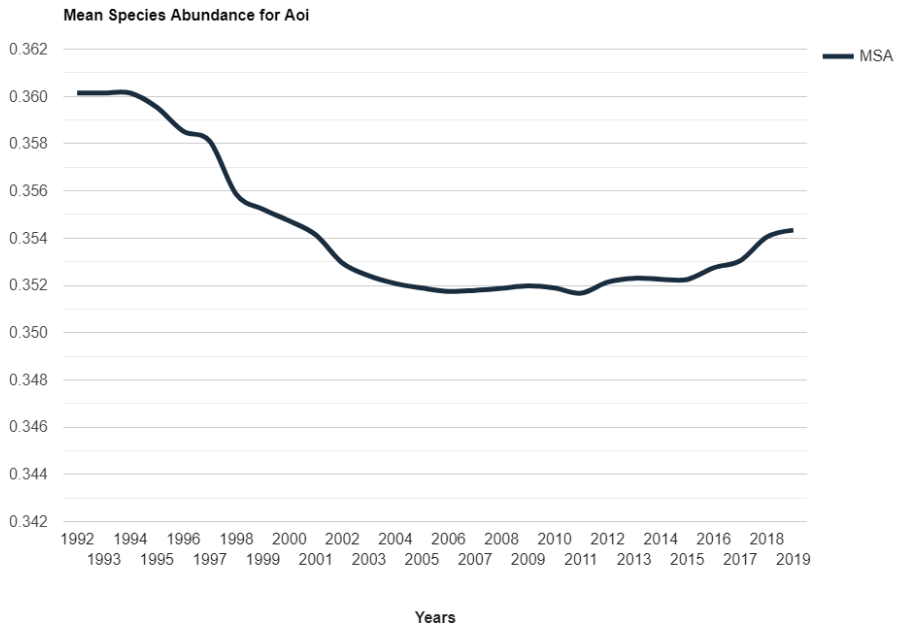
Source: ABC-Map.

Part 1. Neer-Tamba baseline

i. Mean species abundance

The MSA of the AOI is estimated at 0.354 for the year 2019, which means that 35.4 per cent of the biodiversity is considered intact. The main anthropogenic pressures on biodiversity are land uses (MSA value of 0.442) and human encroachment (MSA value of 0.85). Habitat fragmentation (with an MSA value of 0.996) and infrastructure (with an MSA value of 0.998) also affected biodiversity intactness in the AOI, but to a lesser extent. Figure 22 shows the MSA evolution from 1992 to 2019. Over the course of the first 14 years, the MSA significantly decreased from 0.36 to 0.352. The expansion of urban settlements and agriculture together with land degradation were the main drivers of forest, wetland and grassland conversion, which explains the decrease in MSA. Figure *17* shows these land use changes, with significant losses of shrubland/forest and grassland of 468 km^2 and 476 km^2, respectively from 1992-2016. While forest cover continued to decrease from 2016 onwards - albeit at a lower rate - there has been some grassland restoration in the AOI. This led to a partial recovery of the biodiversity intactness to 35.4 per cent (see Figure 17 and Figure 18).

Figure 18.
Neer-Tamba MSA evolution in AOI.



Source: ABC-Map.

ii. Natural capital

The natural capital of the AOI amounted to US$17,217,123,000 in 2019. This corresponds to an average natural capital value of US$2,074 per ha. Figure 19 shows the evolution of the natural capital value from 1992 to 2019. The natural capital value is rather constant in the early 90s, to strongly increase from 1994 to 2000. This evolution is contrary to that of the MSA shown in Figure 18. The increase in natural capital, notably between 1997 and 1999 can be explained by the conversion of grasslands to extensive agroforestry systems. This is very similar to the changes observed in case study 1 (again, while MSA has a pure biodiversity lens, the natural capital takes into account the various ecosystem services provided to humans. The aggregate monetary benefits provided to humans by extensive agroforestry systems are valued higher than the ones of pure grassland systems. This can mainly be attributed to higher food and raw material production together with increased carbon storage and soil organic matter in extensive agroforestry systems. The natural capital therefore provides a more anthropogenic view on biodiversity).

From 2000 to 2015, the natural capital then stabilizes at around US$17,210,000,000. From 2015 onwards the overall trend of the natural capital is positive, with a net gain of US$8 million, which can be attributed to an increased forest and wetland cover together with the introduction of agroforestry systems in annual cropland.

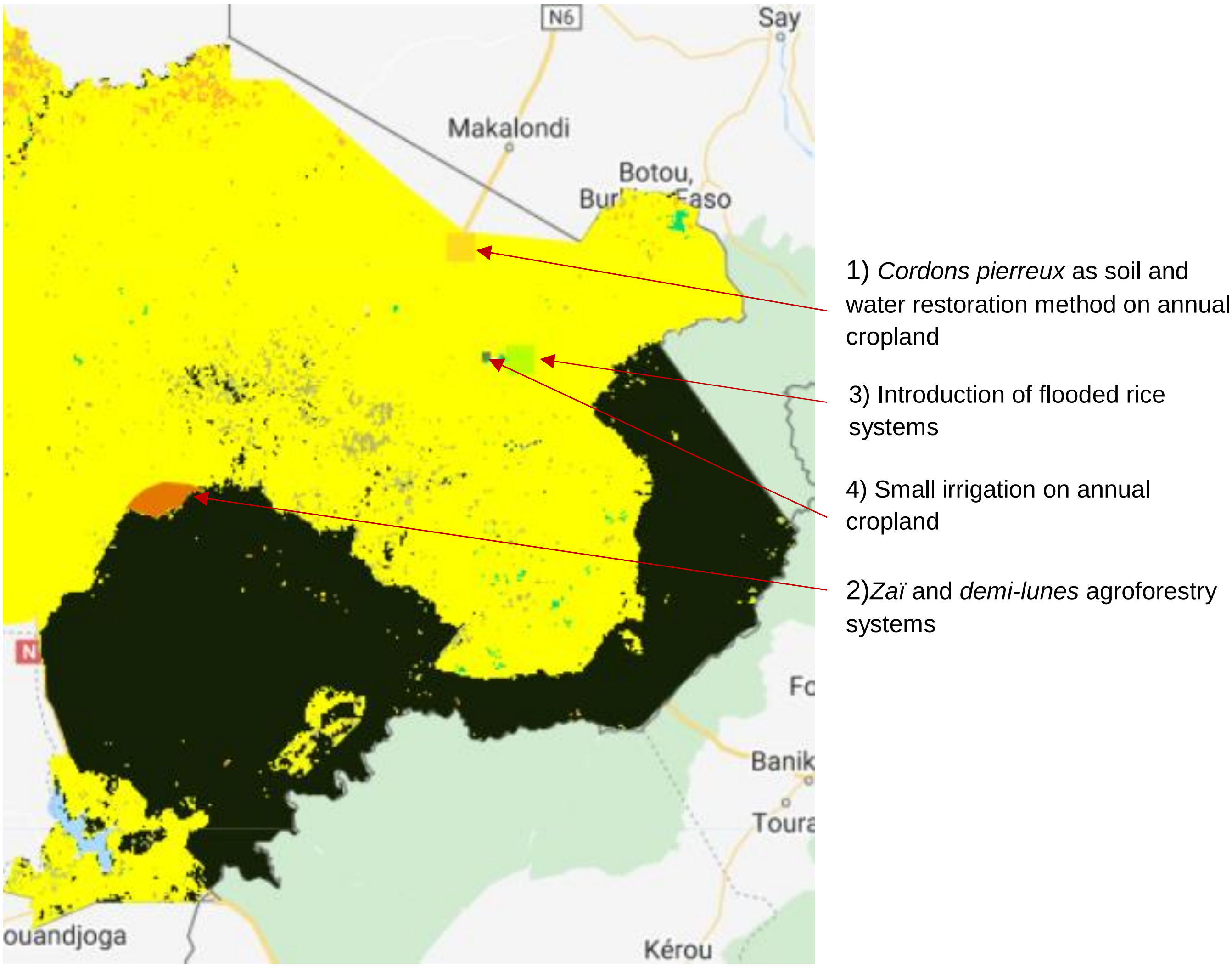
Figure 19.
Neer-Tamba natural capital evolution in AOI.

Source: ABC-Map.

Part 2. Neer-Tamba project intervention

For illustration purposes, Figure 20 shows potential project plots only in the east of the project AOI (the AOI remains however as it is). All interventions will be undertaken on annual cropland without any improvements. The first activity is the introduction of *cordons pierreux* as a soil and water conservation and restoration practice on a plot of 5,500 ha (orange square in the north). The project furthermore aims to reverse land degradation with the introduction of *zaï* and *demi-lunes* agroforestry systems (extensive agroforestry). The 11,000 ha are strategically placed around remaining forest stands to avoid further encroachment and degradation of forests (red plot). Making better use of the scarce precipitation in the region, the project also foresees the development of 6,000 ha of drought prone, rainfed paddy rice systems. These paddy rice fields have a non-flooded period of >180 days (with straw being exported) and are located close to an existing water body (light green square). Close to this water body, the project also introduces better water management practices on 600 ha of annual cropland (with better irrigation practices during the rainy season).

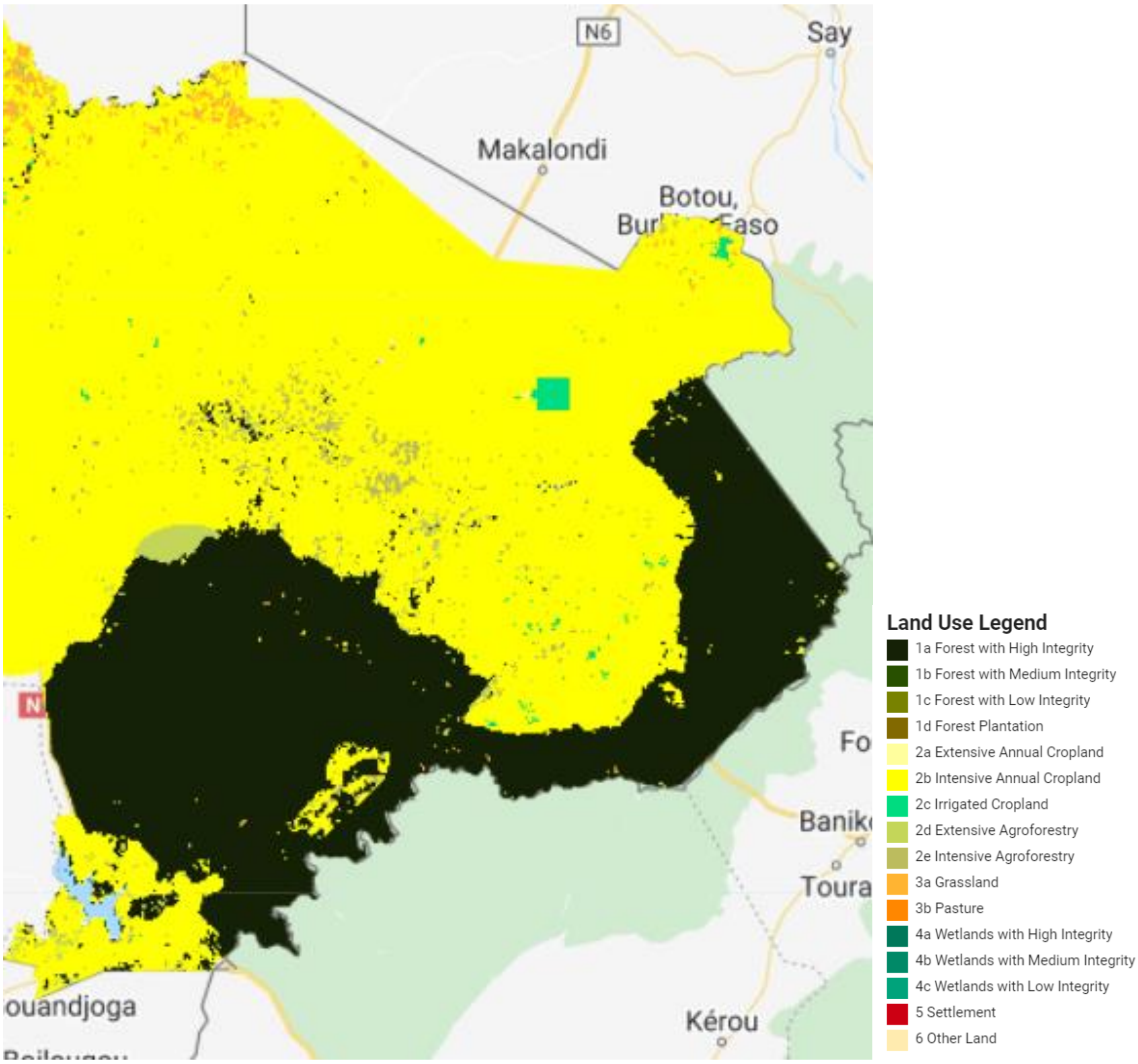
Figure 20.
Neer-Tamba project intervention plots in AOI.



Source: ABC-Map.

Once these plots are drawn onto the map and the project land uses are specified for each plot, ABC-Map recalculates all indicators in a time series including the project activities for the period of the project 2013-2022. Figure 21 shows the newly generated land use map for the project.

Figure 21.
ABC-Map land uses with the Neer-Tamba project.

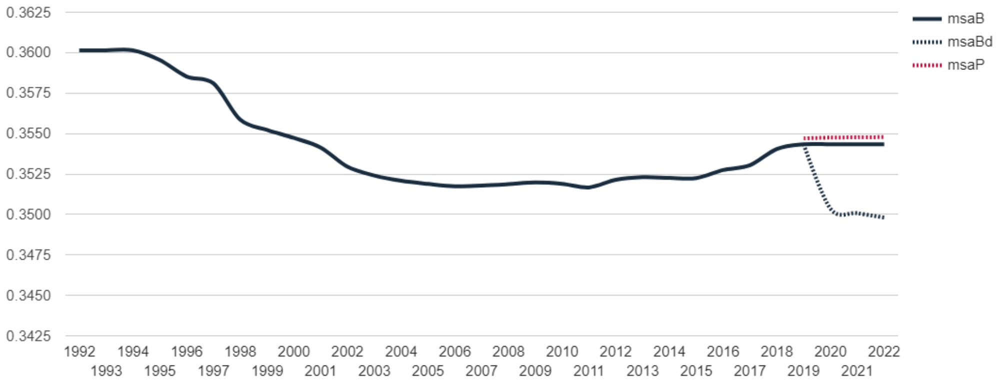


Source: ABC-Map.

i. Mean species abundance

With the implementation of the project, the MSA will increase from 35.4 per cent to 35.5 per cent. Using the constant baseline scenario as reference, the MSA will increase by 0.04 per cent with the project (see Figure 22). This increase in MSA value can mainly be attributed to an increase in the MSA land use value from 0.422 to 0.423, while the other anthropogenic pressures on biodiversity remain constant. The corresponding AIB will increase by 36.64 km^2.

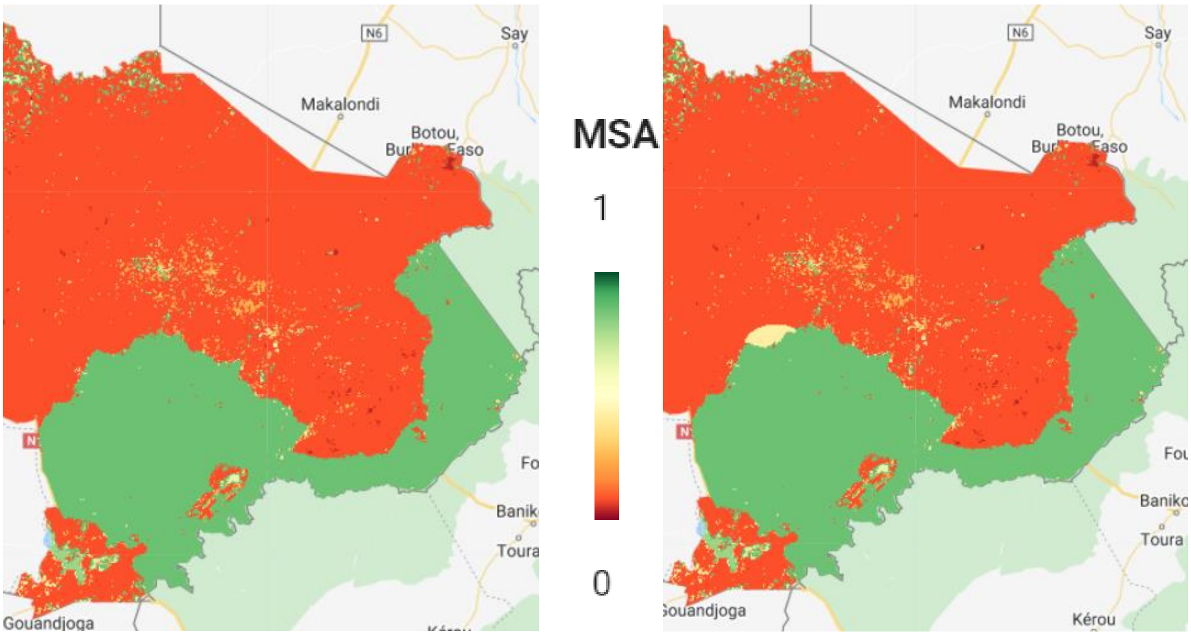
Figure 22.
MSA evolution with the Neer-Tamba project.



Source: ABC-Map.

As ABC-Map is a mapping tool, these increases can also be directly tracked on the MSA Map. Figure 23 shows the baseline (left) versus project (right) map.

Figure 23.
Neer-Tamba baseline vs. project MSA Map.



Source: ABC-Map.

Table 9.
Neer-Tamba area with intact biodiversity

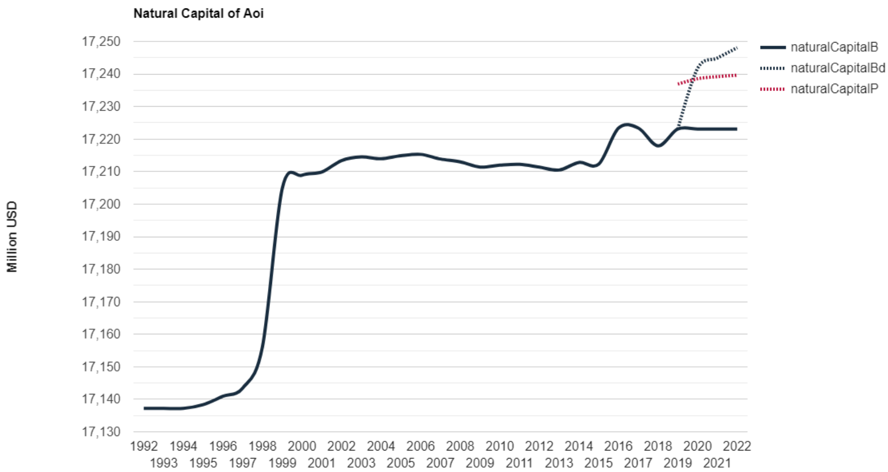
	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*Δ_{AIB}*	*Sign*
AIB (ha)	0	0	0	0	0	0	916	1 832	2 748	3 664	+3 664	↗

ii. Natural capital

Using the constant baseline scenario as reference, the total value of the natural capital will increase by US$16.54 million with the project. This increase can mainly be attributed to the conversion of conventional agriculture to extensive agroforestry systems. Figure 24 shows the natural capital evolution with the project and

Figure 25 compares the natural capital maps of the baseline with the project scenarios.

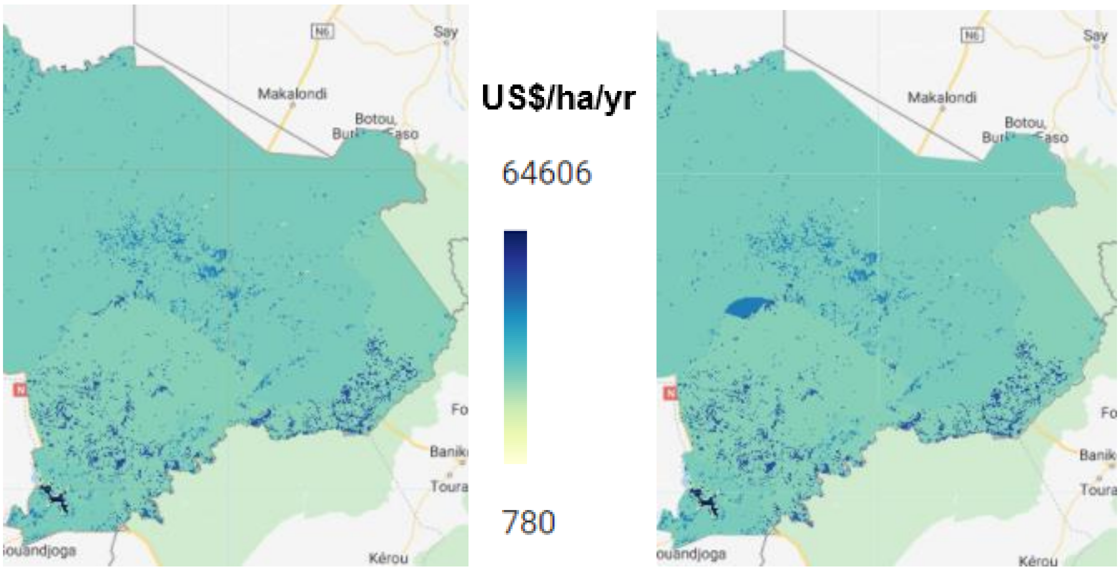
Figure 24.
Neer-Tamba natural capital evolution.



Source: ABC-Map

NB: Since ABC-Map uses data from 1992-2019 and the start date of the Neer-Tamba project was 2013, there is a time overlap of 6 years. ABC-Map is conceived in a way such that project impacts are only shown from 2019 onwards (which explains why the red dotted line only appears in 2019).

Figure 25.
Neer-Tamba natural capital evolution.



Source: ABC-Map

Table 10.
Neer-Tamba average natural capital per ha

	2013	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	Δ_{ANC}	*Sign*
ANC (US$/ha)	0	0	0	0	0	0	2 074.26	2 074.92	2 075.59	2 076.25	+1.99	↗

Part 3. Neer-Tamba ecosystem-based biodiversity core indicator

As described above, the two sub-indicators to be used as the ecosystem-based core biodiversity indicator are AIB, which can be found in Table 9, and the ANC, which can be found in Table 10. IFAD considers that biodiversity is improved at ecosystem-level when either the habitat sub-indicator (AIB) or the ecosystem sub-indicator (ANC) show a positive change with the implementation of a project, while the other one is at least held constant.

Table 11 shows the AIB and ANC per ha for the three reporting periods (project baseline, mid-term and completion), respectively.

Table 11.
Neer-Tamba area of intact biodiversity and average natural capital per ha.

	Baseline	*Mid Term*	*Completion*	*Δ*	*Sign*
AIB (ha)	0	0	3 664	+3 664	↗
ANC (US$/ha)	0	0	2 318.79	+1.99	↗

Source: Adapted from ABC-Map.

As both the Δ_{AIB} (+ 3,644 ha) and the Δ_{ANC} (+ 1.99 US$/ha) show positive impacts on biodiversity, the Neer-Tamba project is improving biodiversity at the ecosystem-level at project completion. In other words, the biodiversity core indicator 3.2.4 would be reported as 1.

Case study 3 – RECAF project in Viet Nam

Project title: Reduced Emissions through Climate Smart Agroforestry (RECAF)
Project duration: 12 years (2023-2034)
Total project budget: US$121,000,000

Background
The Central Highlands and the Southern Coastal area of Viet Nam are regions with high exposure and high sensitivity to climate change and with higher poverty and nutrition issues. This high sensitivity of the project area is a function of its large and largely poor, ethnic minority population, which has higher poverty and malnutrition rates than the rest of the population. Some 75 per cent of Viet Nam's minority populations live in these two regions. One of the most important basic causes of undernutrition, poverty, is concentrated among ethnic minorities, particularly those in the smaller groups and those living in the northern and central mountains. Although accounting for only 14 per cent of the population, 73 per cent of those living in poverty in 2016 were ethnic minority groups.

The areas of high incidence of poverty (ratio of poor to total population) in Viet Nam tend to overlap with the location of remaining natural forest stands. The livelihoods of poor people in remote areas are therefore highly dependent on goods and environmental services from natural forests. Forest cover has, however, been decreasing. In spite of their dependence on forests, some rural people have also benefited from the clearance of forest cover through increased access to arable land and through conversion of timber and other forest products into income and capital.

Project objective
The project's goal is to increase the resilience, nutrition and income of target groups through sustainable management of forests, agriculture and enhancement of carbon stocks. This can reduce GHG emissions from deforestation and forest degradation associated with major agricultural export commodity crops, and increase carbon capture.

Acknowledging that forest resources including timber and non-timber forest products, agroforestry practices, forest services (e.g. ecotourism, payment for ecosystem services), and derived employment all serve as crucial income and nutrition diversity sources for the rural poor, the main aim of the project is to reduce deforestation and forest degradation in the project area. As the project is at Concept Note stage, there is no information on the exact activities (and area) yet. While the project might also work on the introduction of agroforestry systems and climate smart agriculture practices in annual cropland, this case study solely focuses on the project's aim to halt deforestation and forest degradation.

Table 12.
RECAF project activity summary

ID	Project activities	Area
1	Halting deforestation and forest degradation	n/a

Source: Adapted from project document.

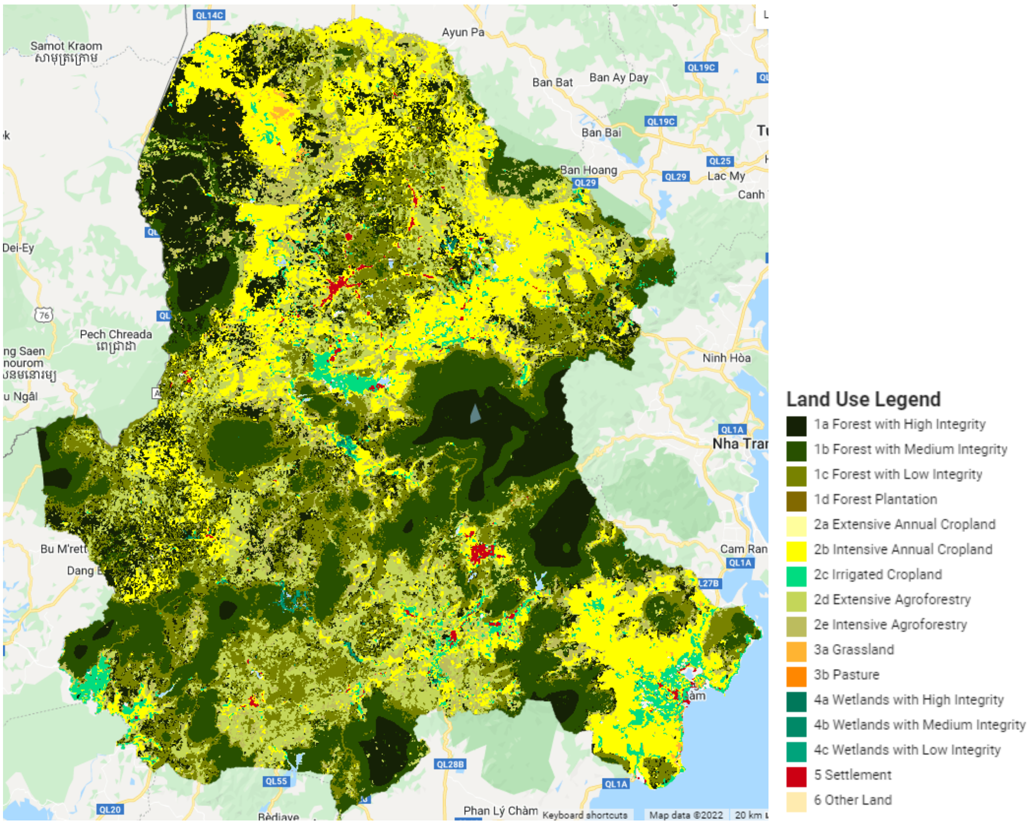
RECAF targets four provinces in the Central Highlands and South Central region of Viet Nam, namely Dak Lak, Dak Nong, Lam Dong, and Ninh Thuan. The broad target group for the project is comprised of about 60,000 smallholder producers and poor households as well as indigenous communities actively engaged in productive activities.

Viet Nam is one of the most disaster and natural hazard-prone countries in the East Asia and Pacific region, with droughts, severe storms and flooding causing substantial economic and human losses. Climate change is projected to increase the impact of disasters, especially the timing, frequency, severity, and intensity of hydro-meteorological events. Given its high exposure to floods and storms, and high vulnerability of its most important economic sectors – industry and agriculture– Viet Nam has been listed by the World Bank as one of the five countries most highly affected by climate change.

Over the past 40 years, the mean annual temperature increased from 23.5°C to 24.7°C in the project area. Temperature increases are also reflected in the number of days with extreme heat increasing from 5 to almost 9 days a year. The total annual precipitation is abundant and slightly increasing from 1,843mm to 1,977mm. All climatic data will be shared in a separate publication on the case studies.

The targeted provinces cover a total area of 3,272,531 ha. With a 300m resolution, ABC-Map provides a land use map for the year 2019 (see Figure 26).

Figure 26.
RECAF ABC-Map baseline land use map.

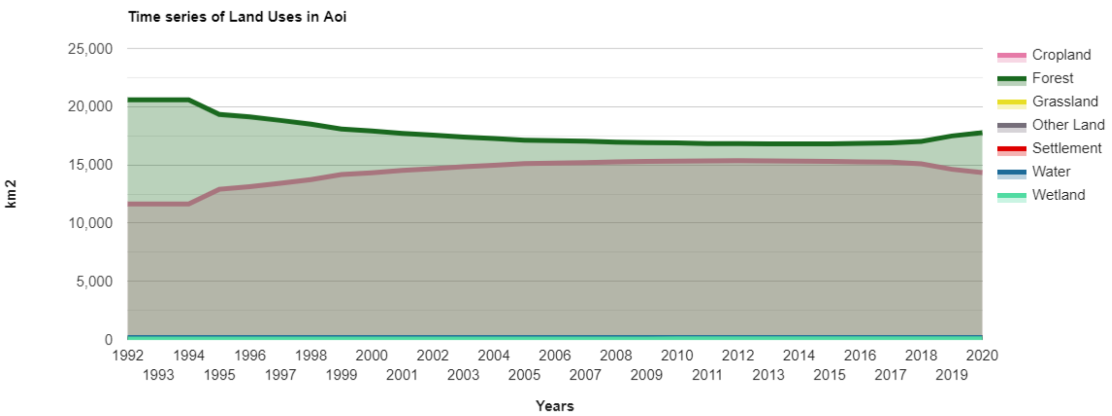


Source: ABC-Map.

The four provinces targeted by the project still have a significant amount of forest cover. The two largest stretches of unfragmented forests are in the northwest and east of the AOI. These forest stretches still have a large amount of highly intact forests. The closer the forest stretches are located to the agricultural fields, the less they are intact, with either medium or low integrity. The second largest land use in the AOI is agricultural cropland. Figure 27 shows how the agricultural expansion together with increased settlements (yet to a far smaller extent) have led to the depletion of forest cover. When adding the land use change matrix of FAO's Earthmap, a more granular overview of the exact changes between 1992 and 2020 can be seen (see Table 13). Most agricultural expansion can be attributed to agroforestry systems (mosaic cropland (>50 per cent)/natural vegetation (tree, shrub, herbaceous cover) (<50 per cent) and mosaic natural vegetation (tree, shrub, herbaceous cover) (>50 per cent)/cropland (<50 per cent)), followed by annual cropland (cropland, rainfed and cropland, rainfed: herbaceous cover) and flooded rice (cropland, irrigated or post-flooding). Table 13 also shows that most forest (605,827 ha) has been lost in the broadleaved, evergreen, closed to open (>15 per cent) tree cover category. A significant amount of forest of this category has been lost to the mosaic tree and shrubs (mosaic tree and shrubs (>50 per cent)/herbaceous cover (<50 per cent)). While this is not a land use change per se in IPCC terms, this hints towards an ongoing forest degradation in the AOI with significant loss of canopy biomass cover.

The initial forest losses seem to stabilize during the early and mid-2000s. From 2018 onwards, the trend even slightly reverses, with forest cover increasing and cropland cover decreasing. This increase, however, already starts slowing in 2020.

Figure 27.
RECAF IPCC land use evolution in AOI.



Source: ABC-Map.

Table 13 shows a more detailed land use classification comparing the land uses and land use changes in ha and percentage, between 1992 and 2020.

Table 13.
ESA CCI land cover and changes.

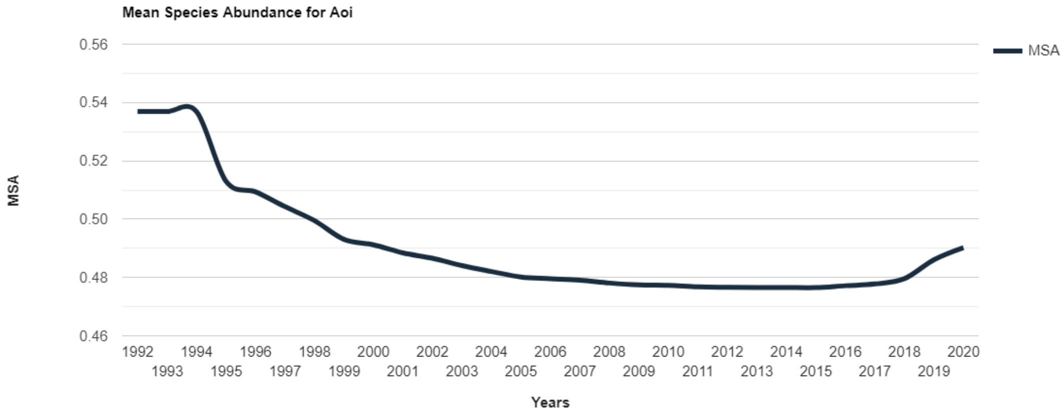
	Total area 1992 (ha)	*Total area 2020 (ha)*	*Change in area (ha)*	*Change in area (%)*
Cropland, rainfed	417 738	489 264	71 526	**17.12**
Cropland, rainfed: herbaceous **cover**	147 535	184 238	36 703	**24.88**
Cropland, irrigated or post-flooding	87 090	93 967	6 877	**7.90**
Mosaic cropland (>50%)**/natural vegetation (tree, shrub, herbaceous cover) (<50%)**	149 121	209 018	59 897	**40.17**
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%)/**cropland (<50%)**	362 686	457 318	94 632	**26.09**
Tree cover, broadleaved, evergreen, closed to open (>15%)	1 286 194	680 367	(605 827)	**(47.10)**
Tree cover, broadleaved, deciduous, closed to open (>15%)	101 734	107 311	5,577	**5.48**
Tree cover, broadleaved, deciduous, closed (>40%)	828	815	(13)	**(1.57)**
Tree cover, needleleaved, evergreen, closed to open (>15%)	170 180	175 131	4,951	**2.91**
Mosaic tree and shrub (>50%)/**herbaceous cover (<50%)**	337 454	569 510	232 056	**68.77**
Mosaic herbaceous cover (>50%)/**tree and shrub (<50%)**	69	103	34	**49.28**
Shrubland	50 671	73 336	22 665	**44.73**
Evergreen shrubland	111 906	170 223	58 317	**52.11**
Deciduous shrubland	52	52	0	**0**
Grassland	7 726	7 065	(661)	**(8.56)**
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	60	68	8	**13.33**
Tree cover, flooded, saline water	4 419	6 099	1 680	**38.02**
Shrub or herbaceous cover, flooded, fresh/saline/brakish water	218	479	261	**119.72**
Urban areas	6 042	17 024	10 982	**181.76**
Bare areas	419	227	(192)	**(45.82)**
Water bodies	17 423	17 950	527	**3.02**

Part 1. RECAF baseline

i. Mean species abundance

The MSA of the AOI is estimated at 0.49 (or 49 per cent) for the year 2019. The main anthropogenic pressures on biodiversity are land uses (MSA value of 0.582) and human encroachment (MSA value of 0.85) followed by habitat fragmentation (with an MSA value of 0.995) and infrastructure (with an MSA value of 0.998). Figure 28 shows the MSA evolution from 1992 to 2020. From 1994 to 2009, the MSA decreased from 0.537 to 0.477. This decrease in MSA coincides with the decrease in forest cover. Indeed, when calculating the correlation coefficient between the MSA evolution and the evolution of the forest cover in this AOI, 99.67 per cent of the variation of the MSA value can be explained by the variation of forest cover[8]. This correlation also explains why the increase in forest cover leads to an increase in biodiversity intactness.

Figure 28.
RECAF MSA evolution in AOI.



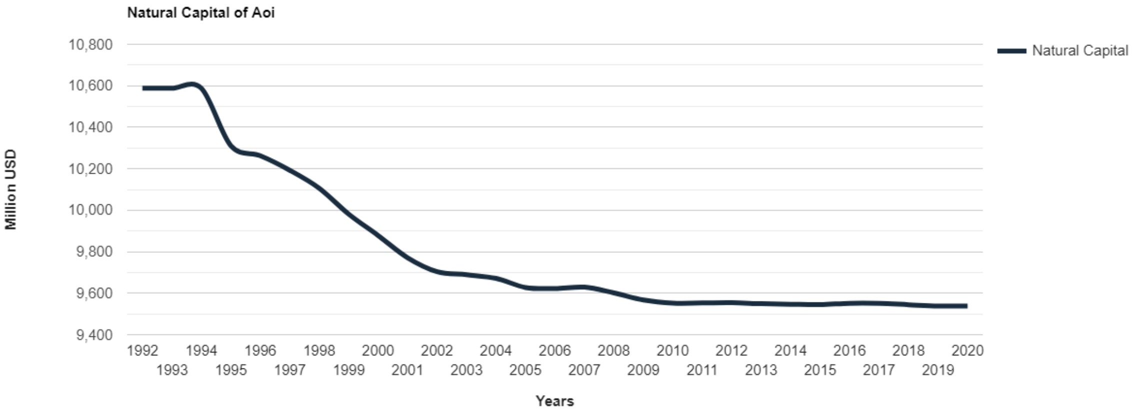
Source: ABC-Map.

ii. Natural Capital

The natural capital of the AOI amounted to US$9,538,521,000 in 2020. This corresponds to an average natural capital value of US$2,914 per ha. Figure 29 shows the evolution of the natural capital value from 1992 to 2020 in the AOI. The AOI is in large parts located in a tropical moist or wet climate. ESVD estimates that tropical forests have higher average ecosystem values per ha and year (as their ecosystem services valued by humans are higher). One example to illustrate this is carbon stock and sequestration rates. Tropical moist and wet forests sequester more carbon in the five carbon compartments, namely above- and below-ground biomass, litter, deadwood and soils, as compared to temperate forests. The natural capital evolution follows a very similar dynamic as the MSA and land use evolution, with a decrease until 2009, a stabilisation from 2010 to 2017 and a slight increase from 2018.

[8] We downloaded both time series (land use evolution and MSA) as a CSV file and used the CORREL() function in Excel to estimate the correlation.

Figure 29.
RECAF natural capital evolution in AOI.



Source: ABC-Map

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Part 2. RECAF Project intervention

As described above, there is no information on the exact activities (and area) yet, as the project is at concept note stage. Yet, while the project might also work on the introduction of agroforestry systems and climate smart agriculture practices in annual cropland, the project's main aim is to halt deforestation and forest degradation. This means that REDD+ will be mainstreamed into relevant policies, and critical public infrastructure investments and co-financing will be leveraged to achieve reductions in emissions from deforestation and degradation associated with the expansion of agricultural export commodity production and weak conservation and protection of forest resources.

For this reason, the only assumption used for the project assessment is that the project will halt any further degradation. In this case study, the project impact is derived from the difference between the project scenario (or conservation scenario) and the dynamic baseline, which projects past trends into the future.

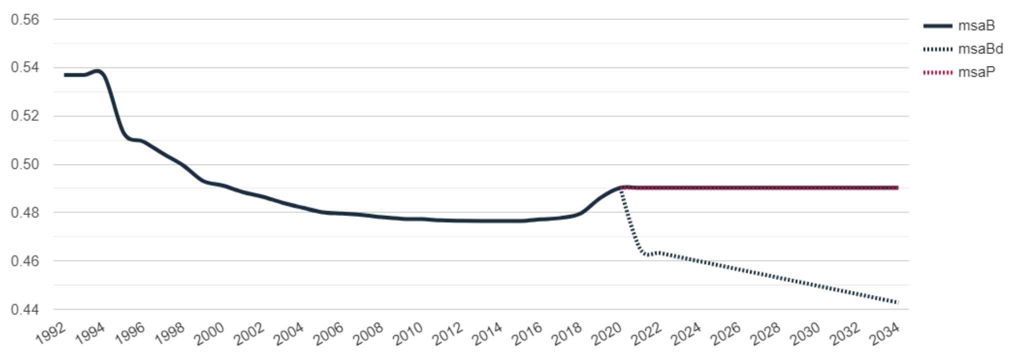
The ABC-Map land uses stay the same in the current situation and the project situation, which explains why a project land use map is not used here.

i. Mean species abundance

With the implementation of the project, the MSA will remain constant, i.e. 49 per cent of the biodiversity remain intact. Yet, in a dynamic baseline scenario (using past trends), the MSA would decrease to 44.3 per cent. The project would hence prevent the loss of 4.7 per cent. This corresponds to a total area of 1,538 km2[9] of avoided biodiversity loss.

Figure 30 illustrates both the project scenario (in the red dotted line) and the dynamic baseline (blue dotted line).

Figure 30.
RECAF MSA evolution with the project.

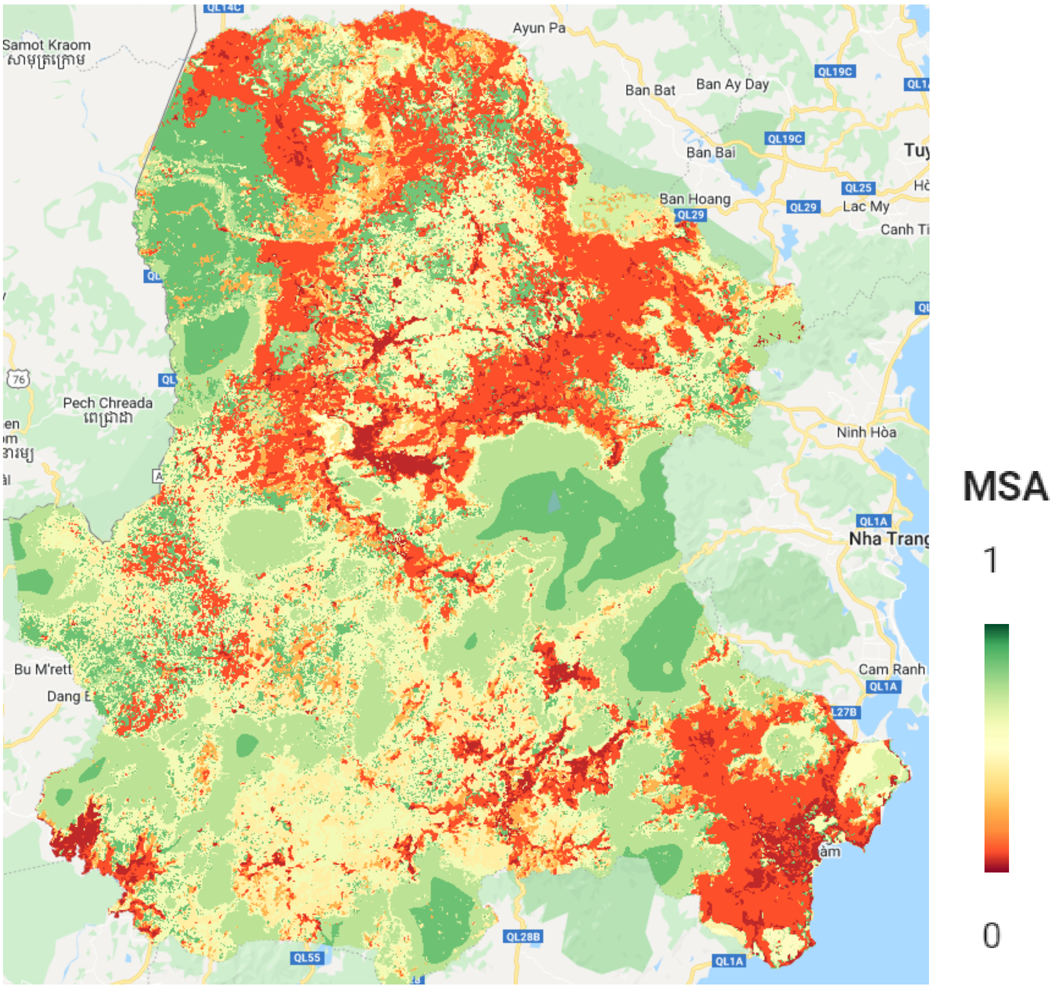


Source: ABC-Map.

[9] This is calculated by multiplying the MSA loss with the total project area.

ABC-Map only provides a map for the project scenario and the constant baseline scenario (as it would be impossible to predict the exact location of future land use changes and land use management changes). Figure 31 therefore only shows the project scenario.

Figure 31.
RECAF MSA Map with the project.



Source: ABC-Map.

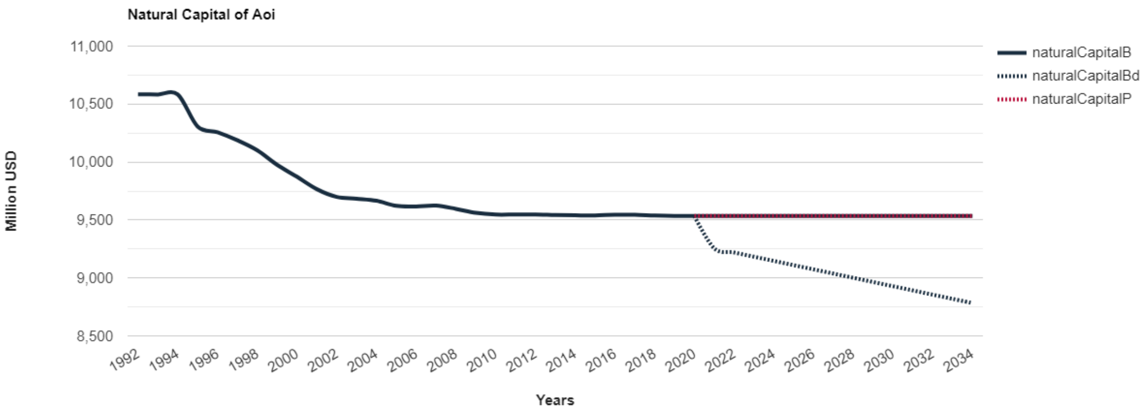
Table 14.
RECAF area of intact biodiversity using a dynamic baseline.

	2024	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	Δ_{AIB}	*Sign*
AIB (ha)	0	15 380	30 760	46 140	61 520	76 900	92 280	107 660	123 040	138 420	153 800	+153 800	↗

ii. Natural capital

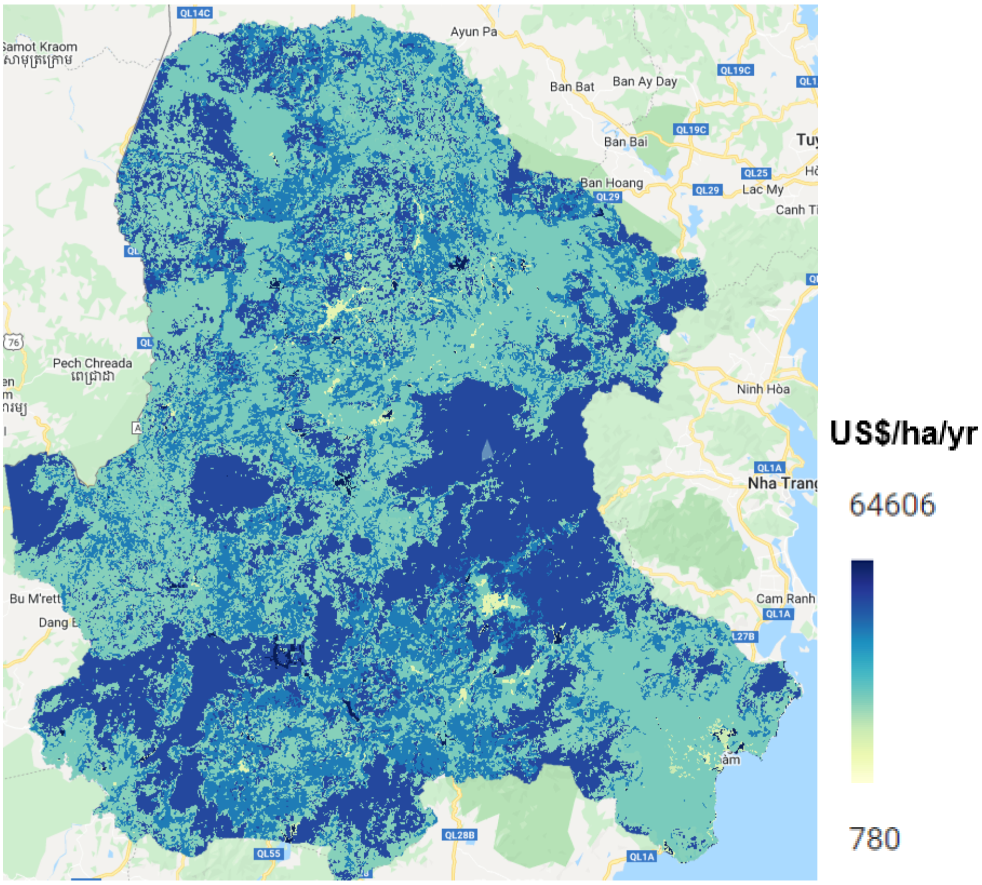
While the natural capital value is expected not to increase or decrease with the project, the natural capital value would be decreasing in a dynamic baseline scenario. The natural capital loss would amount to a total of US$714.74 million without the project. Figure 32 shows the natural capital evolution with and without the project and shows a natural capital map of the project scenario.

Figure 32.
RECAF natural capital evolution.



Source: ABC-Map

Figure 33.
RECAF natural capital of the project.



Source: ABC-Map

Table 15.
RECAF average natural capital per ha using a dynamic baseline.

	2024	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*	*2031*	*2032*	*2033*	*2034*	Δ_{AIB}	*Sign*
ANC US$/ha	0	21.8	43.6	65.4	87.2	109	130.8	152.6	174.4	196.2	218	+218	↗

Part 3. RECAF ecosystem-based biodiversity core indicator

As described above, the two sub-indicators to be used for the ecosystem-based core biodiversity indicator are the AIB, which can be found in

Table *14*, and the ANC, which can be found in Table 15. IFAD considers that biodiversity is improved at ecosystem-level when either the habitat sub-indicator (AIB) or the ecosystem sub-indicator (ANC) show a positive change with the implementation of a project, while the other one is at least held constant. The RECAF project will mainly aim to reduce deforestation, which would mean that the project will not lead to 'direct' improvements of biodiversity as the difference between the project scenario and constant baseline would be zero. However, as discussed above, for projects with a clear rationale around avoided deforestation, the project may use the dynamic baseline to show a reduction in land use changes. As land use changes are an important driver of biodiversity (as described in IPBES 2019), a reduction of deforestation can then be considered an improvement of biodiversity.

Table 16 shows the AIB and ANC per ha for the three reporting periods (project baseline, mid-term and completion), respectively.

Table 16.
RECAF area of intact biodiversity and average natural capital per ha.

	Baseline	*Mid Term*	*Completion*	***Δ***	*Sign*
AIB (ha)	0	76 900	153 800	+153 800	↗
ANC (US$/ha)	0	109	218	+218	↗

Source: Adapted from ABC-Map.

When using the dynamic baseline as a reference, **both the Δ_{AIB} (+ 153,800 ha) and the Δ_{ANC} (+ 218 US$/ha) show a positive impact on biodiversity. The RECAF project is hence improving biodiversity at the ecosystem-level at project completion. In other words, the biodiversity core indicator 3.2.4 would be reported as 1.**

Biodiversity Improvement, but not eligible for COI

Case study 4 – Haiti I-BE project

Project title: Inclusive Blue Economy Project
Project duration: 6 years (2022-2027)
Total project budget: US$26,600,000

Background

Haiti is the most threatened nation in the world by the effects of climate change according to several indices. The impacts of climate change result in increased temperatures, decreased rainfall, more frequent occurrence of extreme weather events and rising sea levels. Beyond the actual physical and ecological impacts, there is the uncertain capacity of governments and communities to cope.

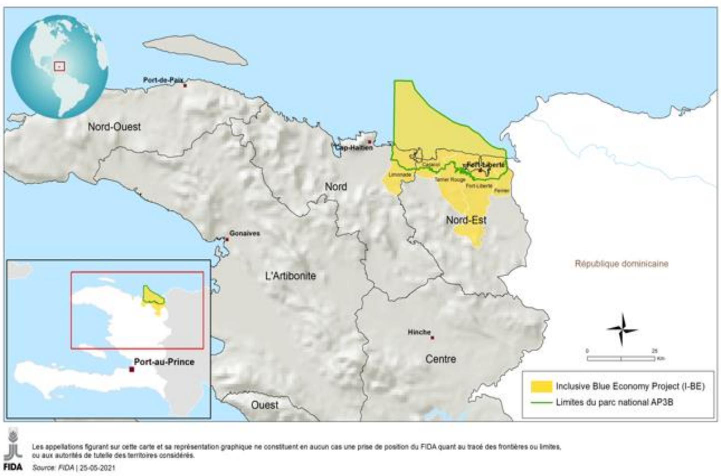
Project objective

The goal of the project is to reduce poverty and strengthen the climate resilience of rural coastal communities in the North and North-East departments of Haiti. The development objective is to diversify livelihoods, improve nutrition, and promote the conservation of coastal natural resources in order to provide sustainable incomes and improve the nutrition of rural women, men and youth in the Aire Protégée de Ressources Naturelles Gérées des Trois Baies (AP3B) communities and neighbouring areas.

Table 17.
I-BE project activity summary.

ID	*Project activities*	*Area (ha)*
1	Forest lots and creole gardens	533
2	Livestock and fodder production	100
3	Ecosystem conservation and restoration	583
4	Mangrove conservation and restoration	200*

Source: Adapted from project document.
* This is an assumption as no specific number of hectares of mangrove conservation and restoration have been defined in the project design report.

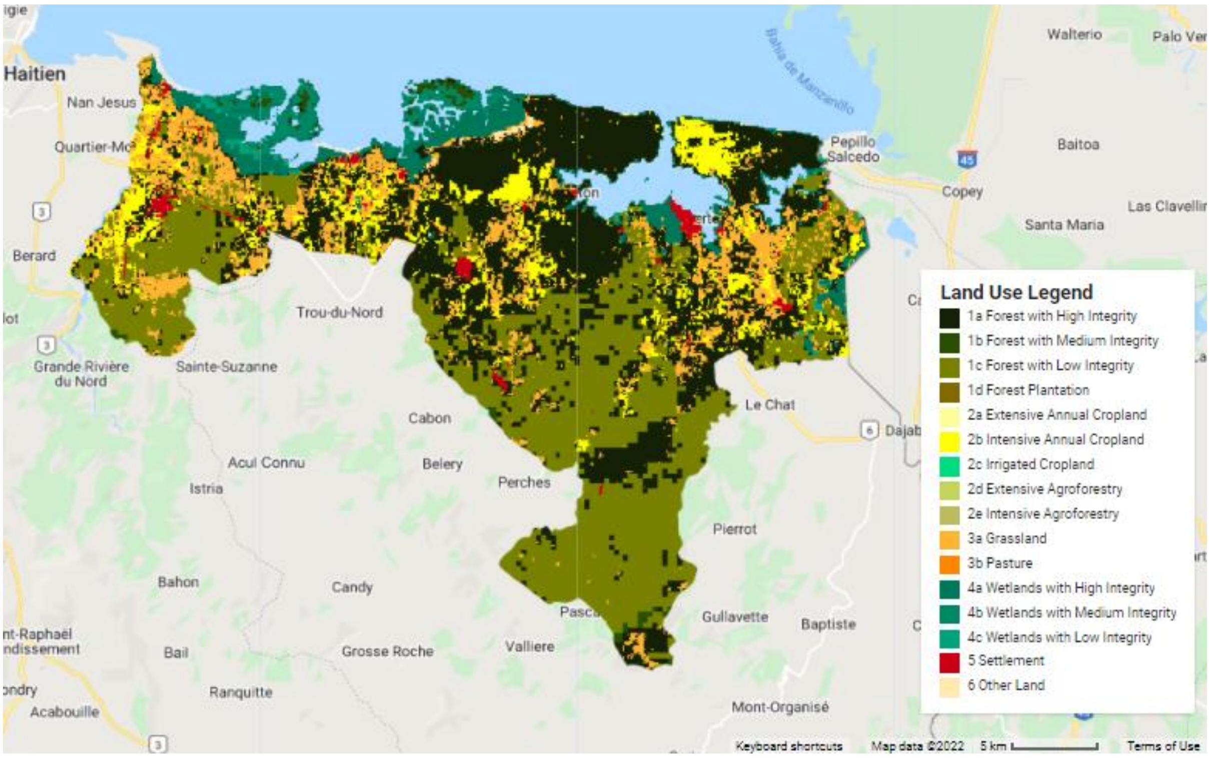


The project will target Haiti's North-East Department and part of the North Department and, more specifically, the AP3B and its surrounding areas. The AP3B's perimeter is approximately 170 km and it covers over 75,000 hectares.

As stated above, Haiti faces temperature increases and precipitation decreases. ABC-Map confirms these trends for the AOI. While the mean annual temperature increased from 25.78°C to 26.3°C, the mean annual precipitation decreased from 843.53mm to 823.52mm between 1981 and 2020. The number of dry days (with less than 1mm of precipitation) has increased from 196 to 218 days per year.

Considering the relatively small size of the project intervention area, a spatial resolution of 100m (i.e. each pixel having a size of 100m*100m) was chosen. With this 100m resolution, ABC-Map provides a land use map for the year 2019 (see Figure 34). This means as a consequence that this analysis would not be eligible for the core outcome indicator measurement, as it does not apply the standard 300m resolution. This analysis may, however, be used as a project-specific indicator.

Figure 34.
I-BE ABC-Map baseline land use map.

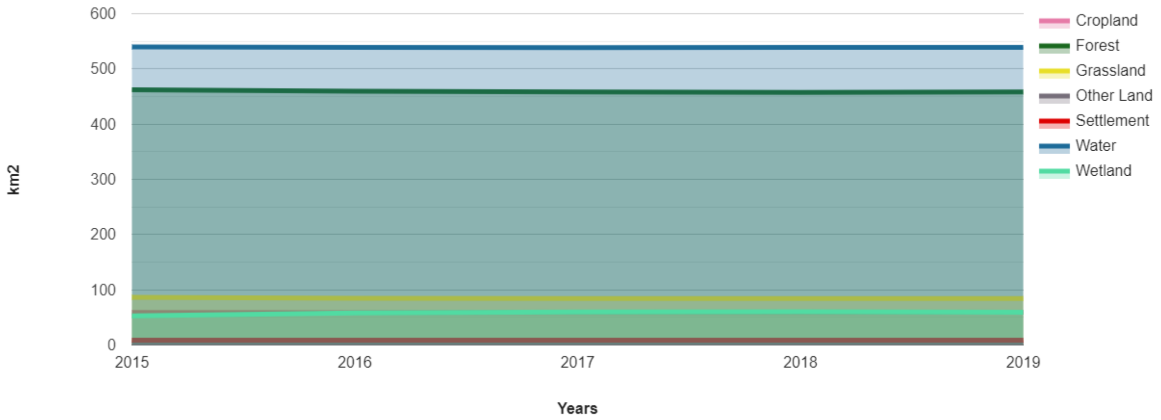


Source: ABC-Map.

The AOI is dominated by forests, followed by water and wetlands. Much of the forest area is characterized by low integrity, whereas a large proportion of the wetlands remain in a state of medium to high integrity. Croplands and grasslands are clustered around the main settlements in the project zone, namely Limonade in the west, Caracol in the north-west, Terrier-Rouge in the centre, Fort Liberté in the north-east, and Ferrier in the east. Many of the high integrity forests are directly bordering these areas.

Figure 35 shows the land use evolution of the main Intergovernmental Panel on Climate Change (IPCC) land use groups since 2015. As can be seen, the land uses have remained stable, with a slight increase in wetlands over this period.

Figure 35.
I-BE IPCC land use evolution in AOI.



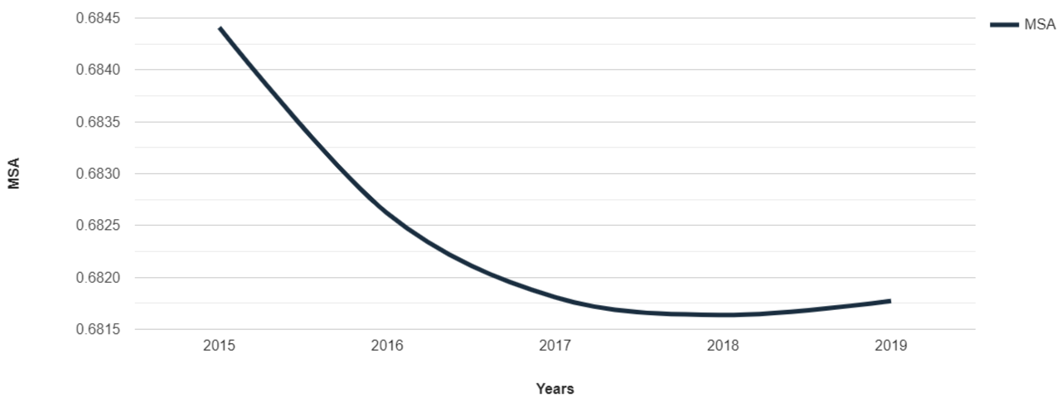
Source: ABC-Map.

Part 1. Haiti I-BE baseline

i. Mean species abundance

The MSA of the AOI is estimated at 0.6818 for the year 2019. In other words, this means that 68.18 per cent of the biodiversity is currently considered intact. The main anthropogenic pressures on biodiversity are human encroachment (MSA value of 0.85) and land uses (MSA value of 0.87). Habitat fragmentation and infrastructure also affect biodiversity intactness in the AOI, but to a much lesser extent. Figure 36 shows the MSA evolution from 2015 to 2019. The graph shows a slight decrease of the MSA between 2015 and 2018, which can be explained by an increase in cultivated land. Since 2018, however, the trend seems to be reversed, with a partial recovery of the biodiversity intactness thanks to an increase in forest cover.

Figure 36.
I-BE MSA evolution in AOI.



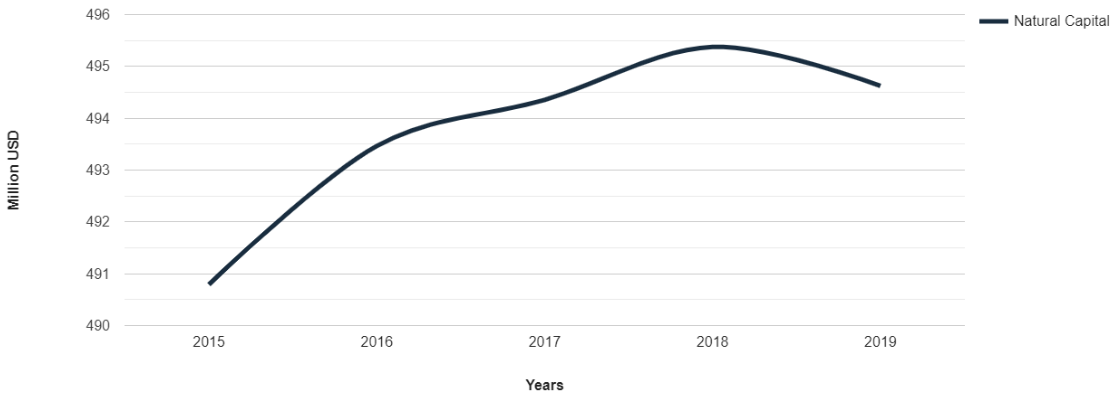
Source: ABC-Map.

ii. Natural capital

The natural capital of the AOI amounted to US$494,600,000 in 2019. This corresponds to an average natural capital value of US$9,075 per ha.

Figure *37* shows the evolution of the natural capital value from 2015 to 2019 in the AOI. The natural capital value increased steadily between 2015 and 2018, before declining after 2018. This evolution is contrary to the development of the MSA as shown in Figure 36. The increase in natural capital can notably be attributed to the increase in wetlands at the expense of forest cover, shrubs and herbaceous vegetation. While MSA has a pure biodiversity lens, the natural capital takes into account the various ecosystem services provided to humans. In terms of the aggregate monetary benefits provided to humans, wetlands are amongst the highest. This can mainly be attributed to their significant potential to moderate extreme weather events, to regulate waterflows or to provide food and water. The natural capital therefore provides a more anthropogenic view on biodiversity.

Figure 37.
I-BE natural capital evolution in AOI.

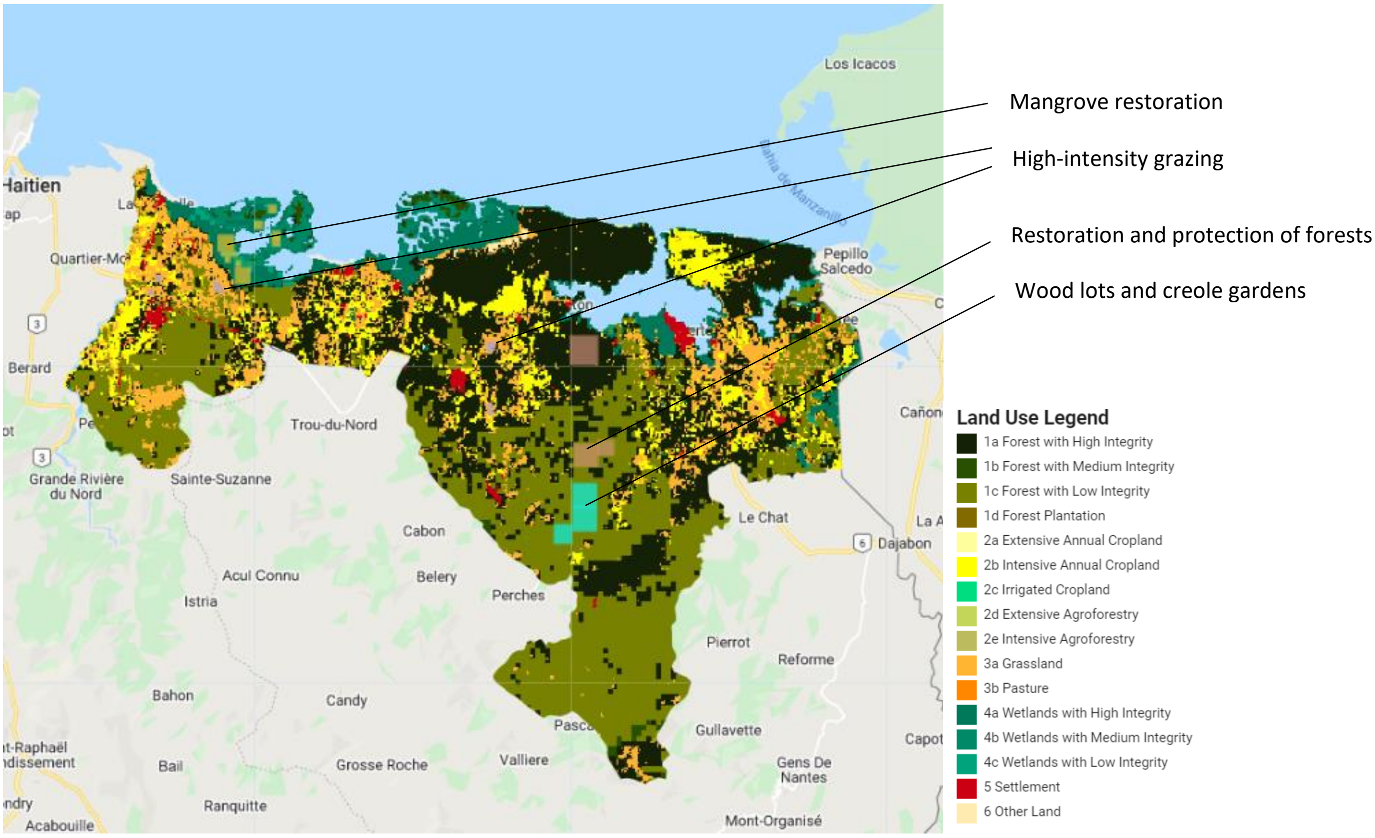


Source: ABC-Map.

Part 2. Haiti I-BE project intervention

Considering that the exact locations of intervention will only become available during implementation, potential plots of intervention are proposed hereafter, based on the project activities of Table 21. These are based on assumptions of land use changes that could occur during project implementation. Figure 38 shows the project plots according to their activity. The light blue areas show 533 ha of low integrity forests that would transition to woodlots and creole gardens (i.e. perennial cropland of multi-strata systems with low inputs and reduced tillage). The lilac plots around Terrier-Rouge and Limonade settlements show 100 ha of current grassland that would be used for high-intensity grazing. The pastel pink plots show 583 ha of forest that will be protected and restored. Of that, half is low integrity forest that will be restored to medium integrity forest and the other half will be high integrity forest that is sustainably managed and protected. Finally, the green plots show 350 ha of existing mangroves whose integrity will be improved through restoration activities and improved management. Although the exact number of hectares of mangrove restoration has not been defined in the project documents, this is an assumption that has been made for the purpose of this case study.

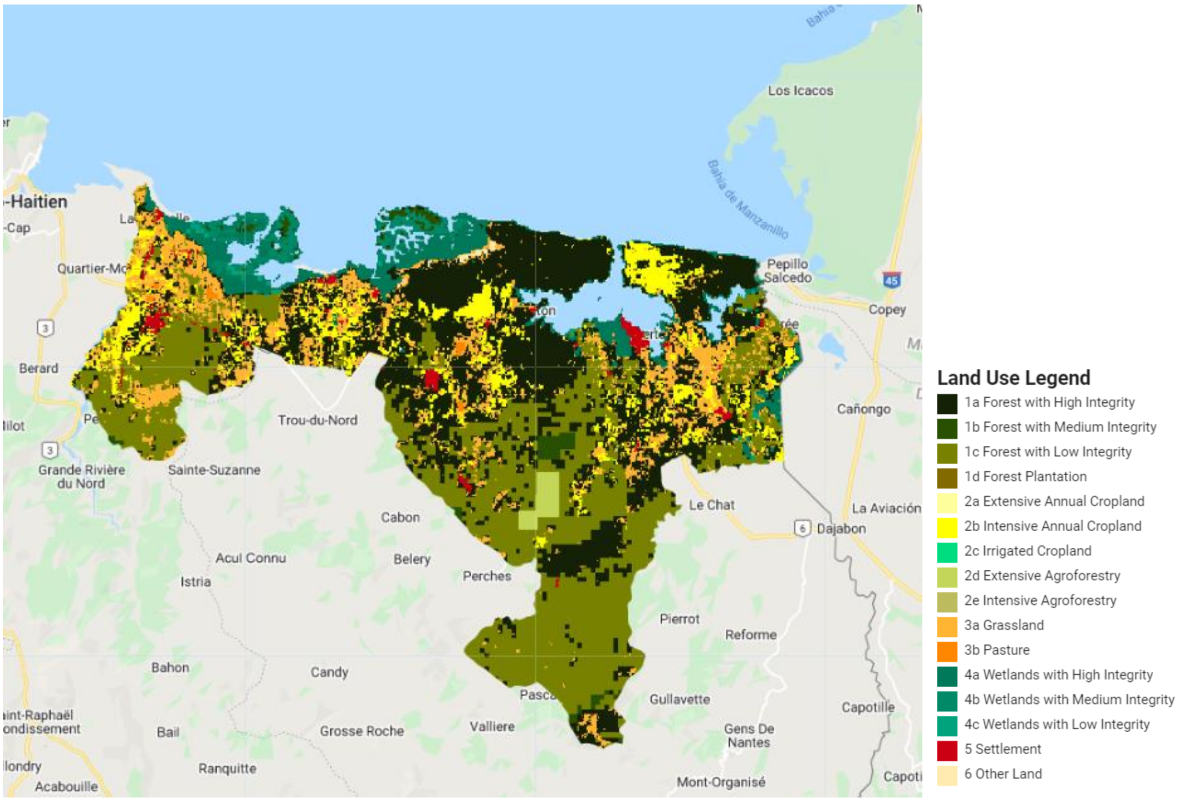
Figure 38.
I-BE project intervention plots in AOI.



Source: ABC-Map.

Once these plots are drawn onto the map and the project land uses are specified for each plot, ABC-Map recalculates all indicators in a time series including the project activities for the period of the project 2022-2027. Figure 39 shows the newly generated land use map for the project.

Figure 39.
I-BE ABC-Map land uses with project.



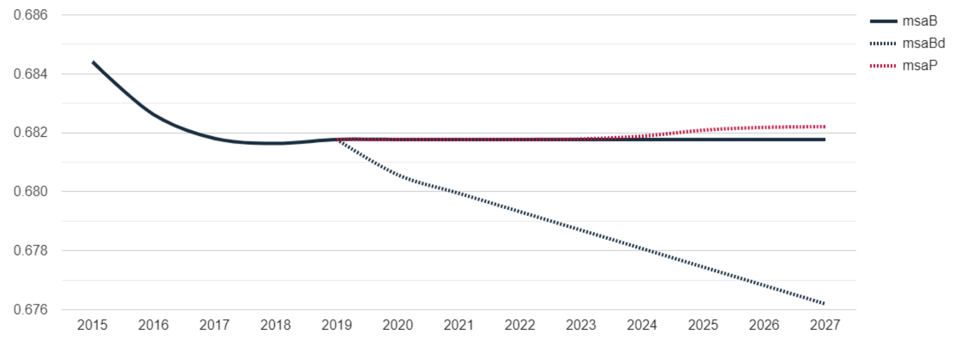
Source: ABC-Map.

i. Mean species abundance

With the implementation of the project, the MSA will increase from 68.2 per cent to 68.4 per cent. Using the constant baseline scenario as reference, the MSA will increase by 0.2 per cent with the project. This means that 68.4 per cent of the biodiversity can be considered intact after the implementation of the project (see

Figure *40*). This increase in MSA value can mainly be attributed to an increase in the MSA land use value, while the other anthropogenic pressures on biodiversity remain constant. The corresponding AIB will increase by 146.63 km^2. Whilst the increase in MSA is very small, this is due to the relatively small number of hectares that will be restored to a higher level of intactness.

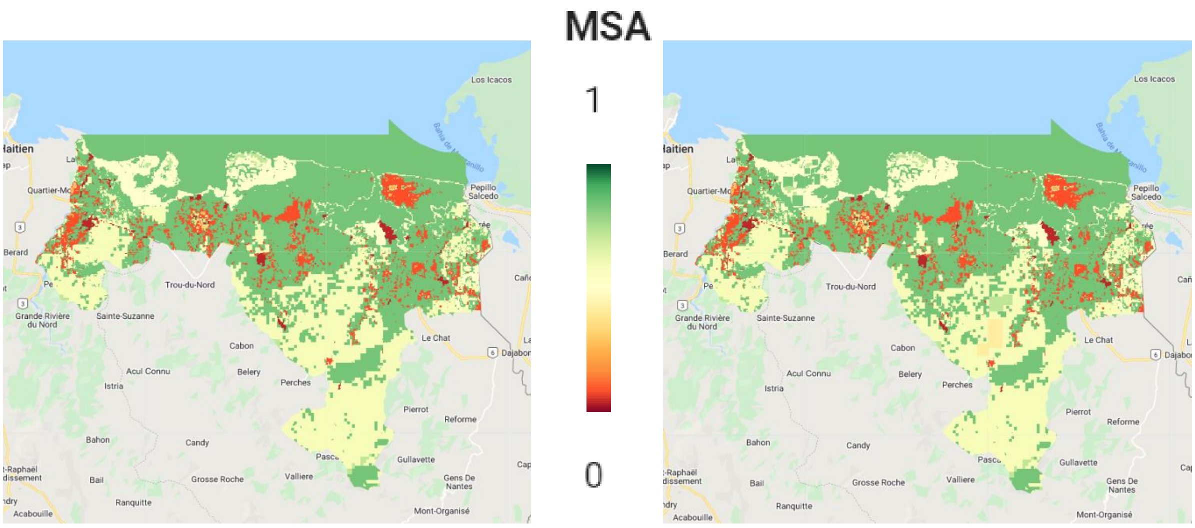
Figure 40.
I-BE MSA evolution with the project.



Source: ABC-Map.

As ABC-Map is a mapping tool, these increases can also be directly tracked on the MSA map. Figure 41 shows the baseline (left) versus project (right) map.

Figure 41.
I-BE baseline vs. project MSA Map.



Source: ABC-Map.

Table 18.
I-BE area with intact biodiversity.

	2022	*2023*	*2024*	*2025*	*2026*	*2027*	Δ_{AIB}	*Sign*

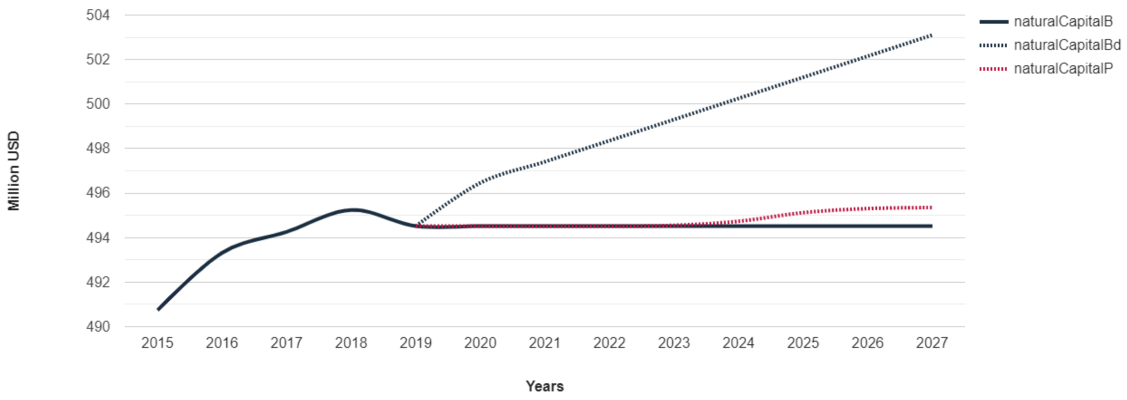
AIB (ha)	0	2 933	5 865	8 798	11 731	14 663	+14 663	↗

ii. Natural capital

Using the constant baseline scenario as reference, the total value of the natural capital will increase by US$400,000 with the project.

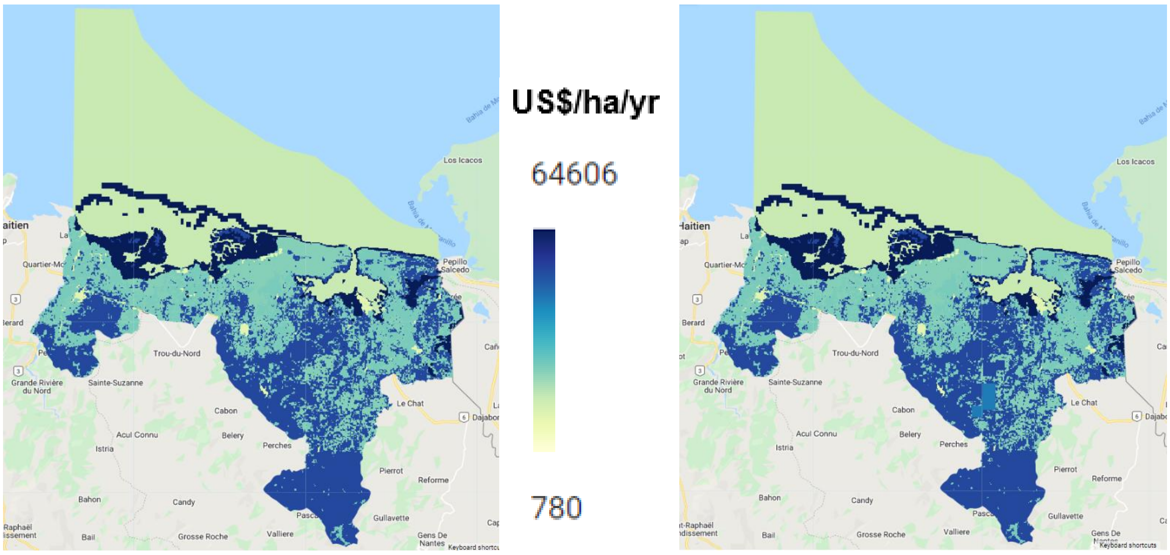
Figure 42 shows the natural capital evolution with the project and Figure 43 compares the natural capital maps of the baseline with the project scenarios.

Figure 42.
I-BE natural capital evolution.



Source: ABC-Map

Figure 43.
I-BE natural capital evolution with the project.



Source: ABC-Map

Table 19.
I-BE average natural capital per ha.

	2022	*2023*	*2024*	*2025*	*2026*	*2027*	Δ_{AIB}	*Sign*
ANC (US$/ha)	9 075.00	9 076.07	9 077.13	9 078.20	9 079.27	9 080.33	+ 5.33	↗

Part 3. Ecosystem-based biodiversity core indicator

As described above, the two sub-indicators to be used for the ecosystem-based core indicator are the AIB, which can be found in Table 18, and the ANC, which can be found in Table 23. IFAD considers that biodiversity is improved at ecosystem-level when either the habitat sub-indicator (AIB) or the ecosystem sub-indicator (ANC) show a positive change with the implementation of a project, while the other one is at least held constant. Table 24 shows the area of intact biodiversity and average natural capital per ha for the three reporting periods (project baseline, mid-term and completion), respectively.

Table 20.
I-BE area of intact biodiversity and average natural capital per ha.

	Baseline	*Mid Term*	*Completion*	*Δ*	*Sign*
AIB (ha)	0	8 798	14 663	+14 663	↗
ANC (US$/ha)	9 075.00	9 078.20	9 080.33	+ 5.33	↗

Source: Adapted from ABC-Map.

As both the Δ_{AIB} (+ 14,663 ha) and the Δ_{ANC} (+ 5.33 US$/ha) show a positive impact on biodiversity, the Haiti I-BE project is improving biodiversity at the ecosystem-level at project completion. However, as mentioned above, the assessment is based on a spatial resolution of 100m, which cannot be compared to other IFAD projects at core outcome indicator level. For COI measurement, a standard resolution of 300m needs to be applied. Since this assessment is not fully complying all requirements of the biodiversity core indicator, it is not possible to report on the COI.

No Biodiversity Improvement

Case study 5 – Malawi PRIDE Project

Project title: Programme for Rural Irrigation Development
Project duration: 7 years (2016-2022)
Total project budget: US$83,950,000

Background

Rural livelihoods in Malawi are in a state that is both precarious and stagnant. Low productivity of agricultural fields combined with a high rural population density are causing endemic hunger and malnutrition. Food distribution during deficit periods is a recurring phenomenon in rural Malawi. Livelihoods are vulnerable to economic or other shocks. In early 2015, exceptionally high rainfall caused massive floods and crop failure and necessitated yet another food distribution campaign.

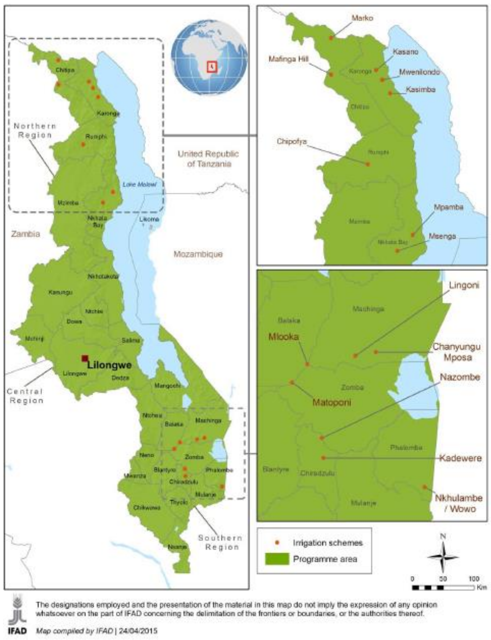
Project objective

The goal of the programme, hereafter referred to as project for simplicity, is to reduce vulnerability to food insecurity, to climate change effects and to the vagaries of the market. The project development objective is to enable smallholder farmers to sustainably enhance their production levels to such a degree that they can provide for their household nutritional demands and deliver produce to viable markets. PRIDE does so by providing smallholder farm households a combination of: (i) irrigation and soil and water conservation infrastructure; (ii) promotion of good agricultural practices; and (iii) a linkage to improved value chains.

Table 21.
PRIDE project activity summary.

ID	Project activities	Area (ha)
1	Introduction of irrigation schemes in rainfed annual cropland	1 420

Source: Adapted from project document.



The project will target approximately 15 scheme cluster areas[10] across the country (mostly in the north and south).

An estimated 19,500 smallholder households live in the project area, of which a total of 17,500 households representing 87,500 persons are envisaged to directly benefit from PRIDE's interventions. PRIDE will focus on targeting poor households, with a particular focus on female-headed households and youth.

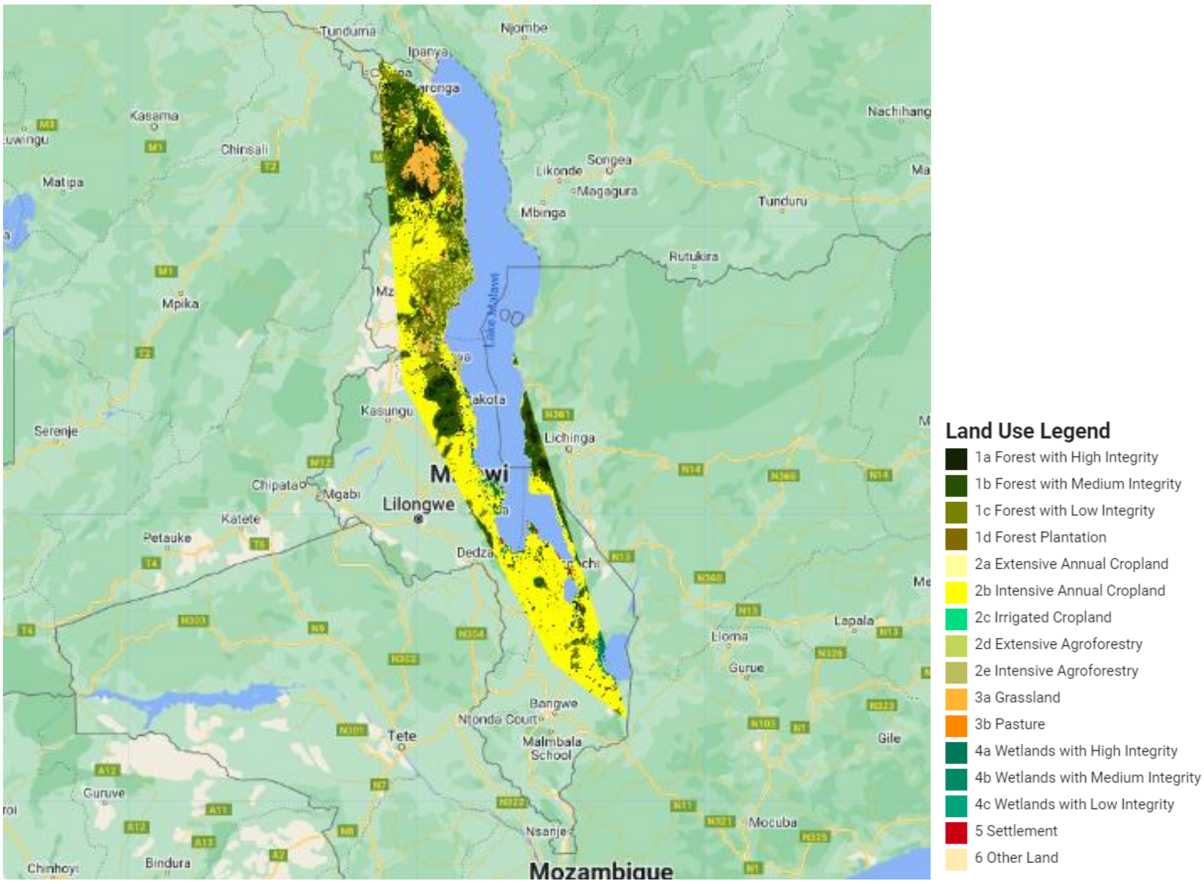
Malawi not only faces increased variability in rainfall patterns, but also an overall increase in temperature. ABC-Map confirms these trends for the AOI. While the mean annual temperature increased from 21.71°C to 22.36°C, the mean annual precipitation slightly increased from 1,201mm to 1,308mm between 1981 and 2020. The number of dry days (with less than 1mm of precipitation) has increased from 198 to 219 days per year. At the same time, the number of days with extreme heat (>35°C) changed from 1 day every 4 years to 1 day every year. As stated above, the precipitation patterns show a strong inter-annual variability with changes of up to 47 per cent from one year to another. Precipitation variability is increasingly paired with higher intensity of rain. Extreme precipitation has increased from 0.625 days per year to 1 day per year (precipitation exceeding 60mm a day).

Drawing a convex hull around the targeted clusters, the total area amounts to 5,932,627 ha. With a 300m resolution, ABC-Map provides a land use map for the year 2020 (see

Figure *44*).

[10] Of which 7 have been identified to match the land use criterion (past land use is intensive annual cropland). The total area of the 15 sites potentially amounts to a total of 4,351 ha.

Figure 44.
PRIDE ABC-Map baseline land use map.

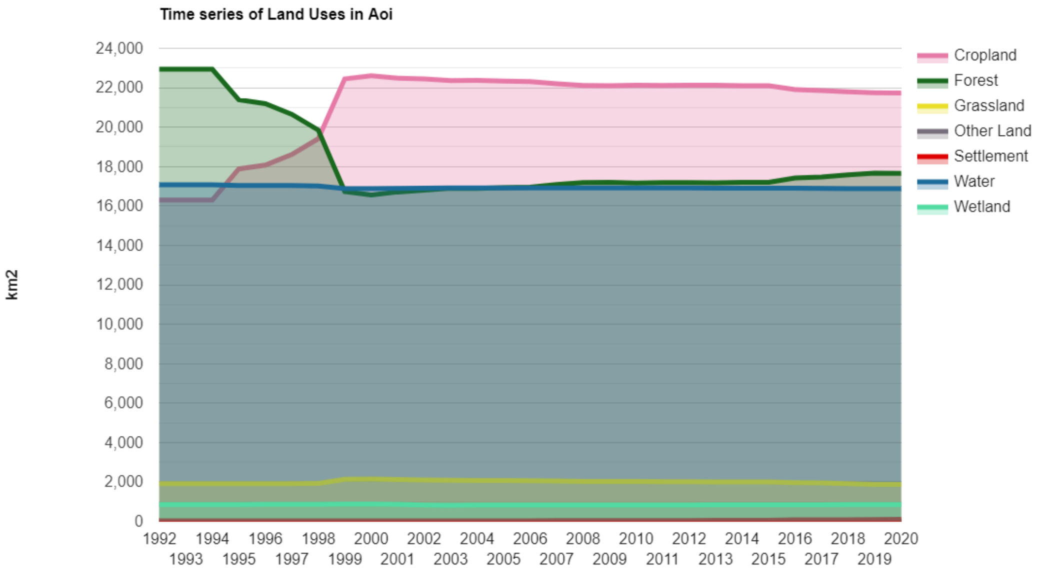


Source: ABC-Map.

The AOI is dominated by cropland, followed by forests, water reservoirs, grassland and a small portion of wetlands. Much of the cropland is used intensively with annual crops. Most of the remaining forest area is characterized by some extent of degradation (low or medium integrity). The croplands and grasslands are clustered around the main settlements in the project zone, namely Mzuzu in the centre-east, Livingstonia in the north and Mangochi on the south. Figure 45 shows the land use evolution of the main

Intergovernmental Panel on Climate Change (IPCC) land use groups since 1992. A big loss of forests can be observed during the period 1994-1999, which coincides with a period of political turmoil in Malawi. As can be seen, this forest loss can mainly be attributed to an agricultural expansion. In recent years, notably from 2006 onwards, this trend seems to be slightly reversed with a slow recovery of the forest cover.

Figure 45.
PRIDE IPCC land use evolution in AOI.



Source: ABC-Map.

Table 26 shows a more detailed land use classification comparing the land uses and land use changes in ha and percentage between 1992 and 2020.

Table 22.
ESA CCI land cover and changes.

	Total area 1992 (ha)	*Total area 2020 (ha)*	*Change in area (ha)*	*Change in area (%)*
Cropland, rainfed	**156 809**	**220 435**	**63 626**	**40.58**
Cropland, rainfed: herbaceous **cover**	**1 161 568**	**1 648 829**	**487 261**	**41.95**
Cropland, rainfed: tree **or shrub cover**	**9 025**	**17 030**	**8 005**	**88.70**
Cropland, irrigated or post-flooding	**16**	**104**	**88**	**550**
Mosaic cropland (>50%)/natural vegetation (tree, shrub, herbaceous cover) (<50%)	**98 574**	**129 133**	**30 559**	**31**
Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%)/cropland (<50%)	**202 170**	**157 232**	**(44 938)**	**(22.23)**
Tree cover, broadleaved, evergreen, closed to open (>15%)	**28 335**	**32 114**	**3 779**	**13.34**
Tree cover, broadleaved, deciduous, closed to open (>15%)	**1 287 966**	**742 597**	**(545 369)**	**(42.34)**
Tree cover, broadleaved, deciduous, closed (>40%)	**34 932**	**36 107**	**1 175**	**3.36**
Tree cover, broadleaved, deciduous, open (15 - 40%)	**762 082**	**755 708**	**(6 374)**	**(0.84)**
Tree cover, mixed leaf type (broadleaved and needleleaved)	**59 730**	**41**	**(59,689)**	**(99.93)**
Mosaic tree and shrub (>50%)/herbaceous cover (<50%)	**3 404**	**86 384**	**82 980**	**2437.72**

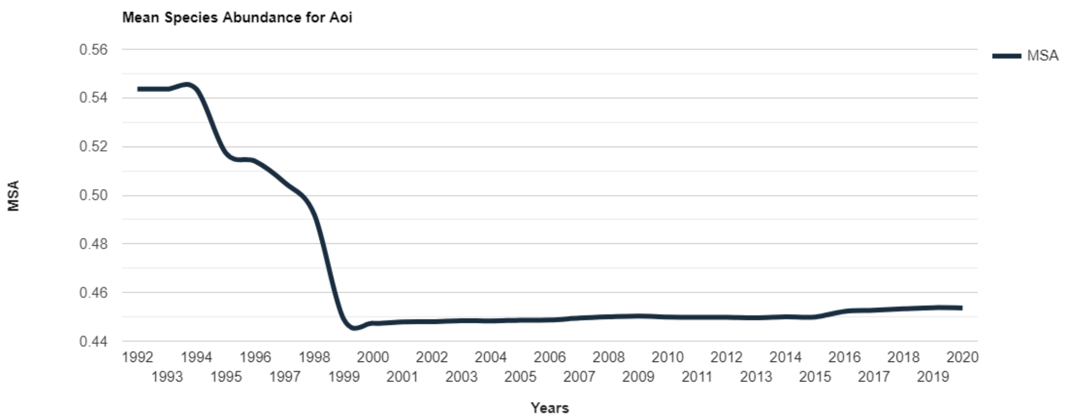
Mosaic herbaceous cover (>50%)/tree and shrub (<50%)	102 198	3 104	(99 094)	(96.96)
Shrubland	18 145	84 162	66 017	363.83
Deciduous shrubland	188 062	28 075	(159 987)	(85.07)
Grassland	33	183 918	183 885	557 227.27
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)	87	25	(62)	(71.26
Tree cover, flooded, fresh or brakish water	84 902	313	(84 589)	(99.63)
Tree cover, flooded, saline water	1 932	417	(1 515)	(78.42)
Shrub or herbaceous cover, flooded, fresh/saline/brakish water	398	85 667	85 269	21 424.37
Urban areas	1 709 406	10 288	(1 699 118)	(99.40)
Bare areas	0	450	450	+NaN
Water bodies	0	1,687,641	1,687,641	+NaN

Part 1. PRIDE baseline

i. Mean species abundance

The MSA of the AOI is estimated at 0.454 for the year 2020. In other words, this means that 45.4 per cent of the biodiversity is currently considered intact. The main anthropogenic pressures on biodiversity are land use (MSA value of 0.632) and human encroachment (MSA value of 0.85) followed by habitat fragmentation (MSA value of 0.997) and infrastructure (MSA value of 0.998). Figure 46 shows the MSA evolution from 1992 to 2020. The graph shows a strong decrease of the MSA between 1994 and 1999, which can be explained by the conversion of forests to cropland (as already explained above). Since 2006, however, the trend seems to be reversed, with a partial recovery of the biodiversity intactness attributable to an increase in forest cover.

Figure 46.
MSA evolution in AOI.



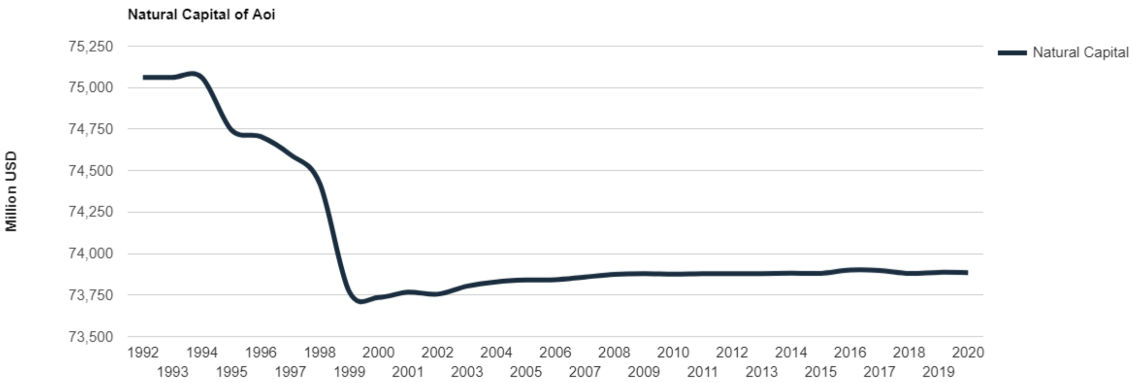
Source: ABC-Map.

ii. Natural capital

The natural capital of the AOI amounted to US$73,884,730,000 in 2020. This corresponds to an average natural capital value of US$12,453 per ha. This high natural capital value can be explained by the large extent of inland water in the project site (ESVD estimates that inland waters like lakes and rivers provide ecosystem values worth US$36,406 per ha).

Figure *47* shows the evolution of the natural capital value from 1992 to 2020 in the AOI. The natural capital values follow a very similar evolution to the one observed for the MSA. Both datasets are highly correlated (99.72 per cent of the variation in natural capital can be explained by the variation of MSA). Similarly, the loss of forest cover mostly explains the decrease in natural capital value until 1999. The natural capital value then stabilizes and slightly recovers from 2006-2020.

Figure 47.
Natural capital evolution in PRIDE AOI.

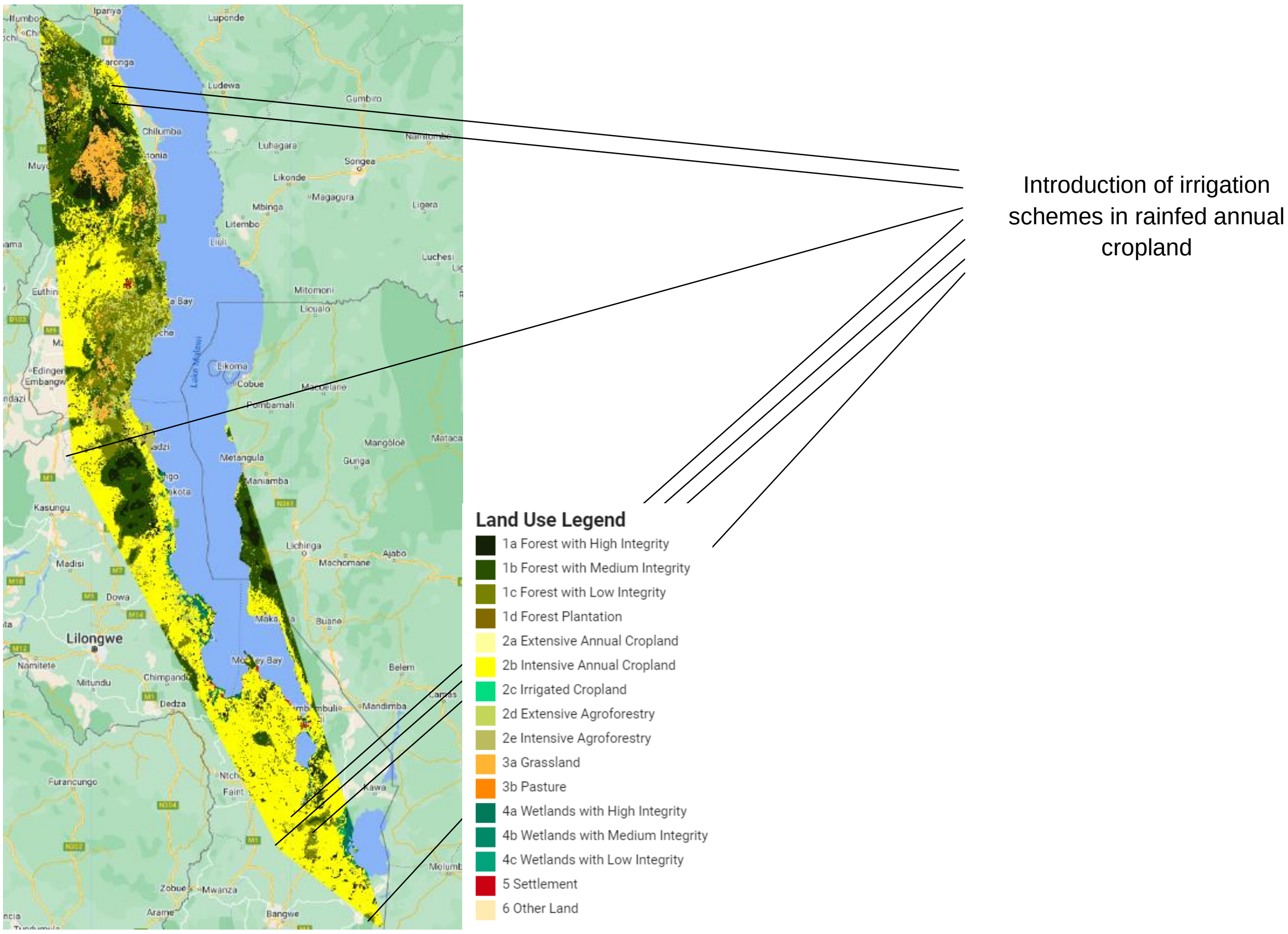


Source: ABC-Map.

Part 2. PRIDE project intervention

Based on the project activities of table 14, the seven project plots are located in the north (2), the centre (1) and the south (4) as shown in Figure 48. Due to the size of the project area, it was decided to show one of the plots of rainfed annual cropland in more detail in Figure 49. During the project, this plot of rainfed annual cropland with medium fertilizer inputs was converted to an irrigated annual cropland[11]. As described in table 25, the total area that is under irrigation schemes amounts to 1,420 ha.

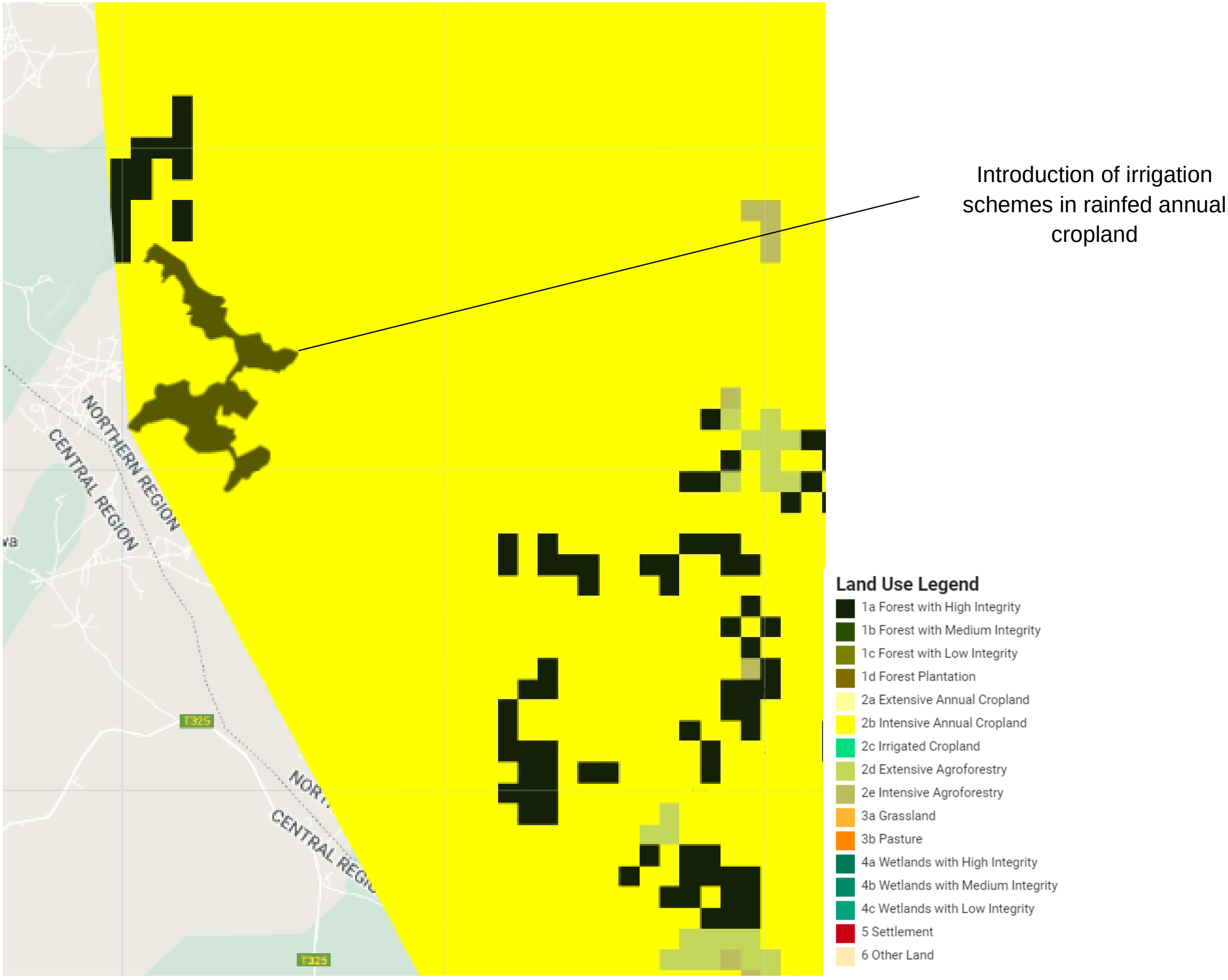
Figure 48.
PRIDE project intervention plots in AOI.



Source: ABC-Map.

[11] ABC-Map offers the user the option to select cropland, flooded rice as a land use. Under this category, the user will be able to specify the water management of the annual cropland (regardless of whether it is rice or other irrigated crops).

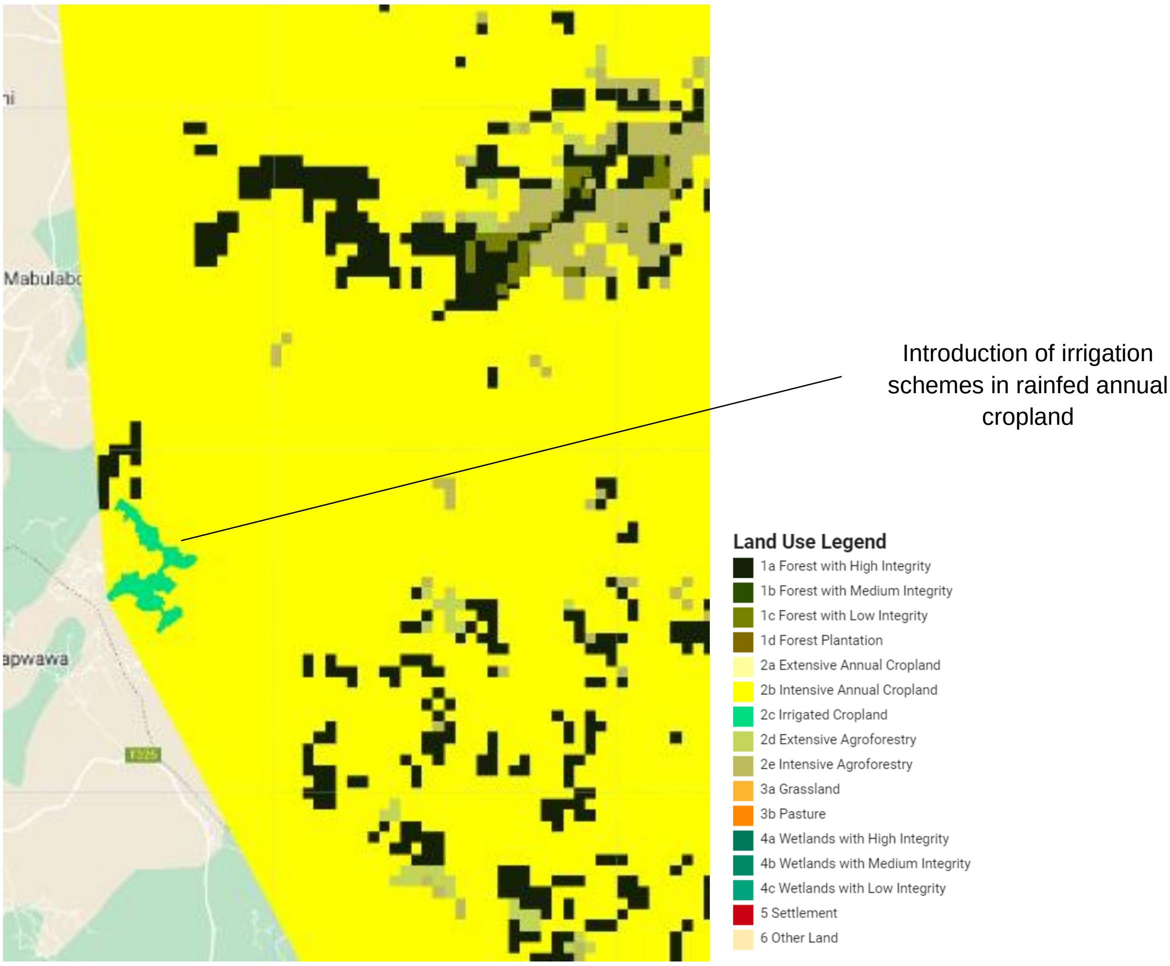
Figure 49.
Example of irrigation site in AOI.



Source: ABC-Map.

Once these plots are drawn onto the map and the project land uses are specified for each plot, ABC-Map recalculates all variables in a time series including the project activities for the period of the project 2016-2022. Figure 50 shows one of the newly generated land use plots on a land use map for the project.

Figure 50.
PRIDE ABC-Map land uses with project.

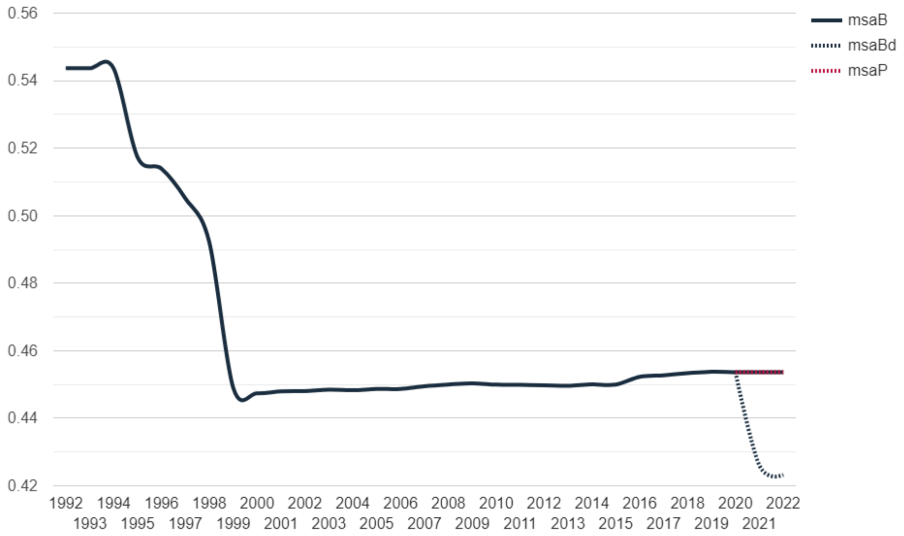


Source: ABC-Map.

i. Mean species abundance

With the implementation of the project, the MSA will slightly decrease by 0.0023 per cent (as compared to a constant baseline scenario). This decrease can mainly be explained by an increasing agricultural intensification, which puts further pressure on biodiversity, i.e. irrigated annual croplands have lower biodiversity intactness compared to rainfed annual croplands. While it is difficult to observe the slight decrease in Figure 51, the AIB gives a clearer picture on actual absolute changes. The corresponding loss of AIB is 1.38 km^2.

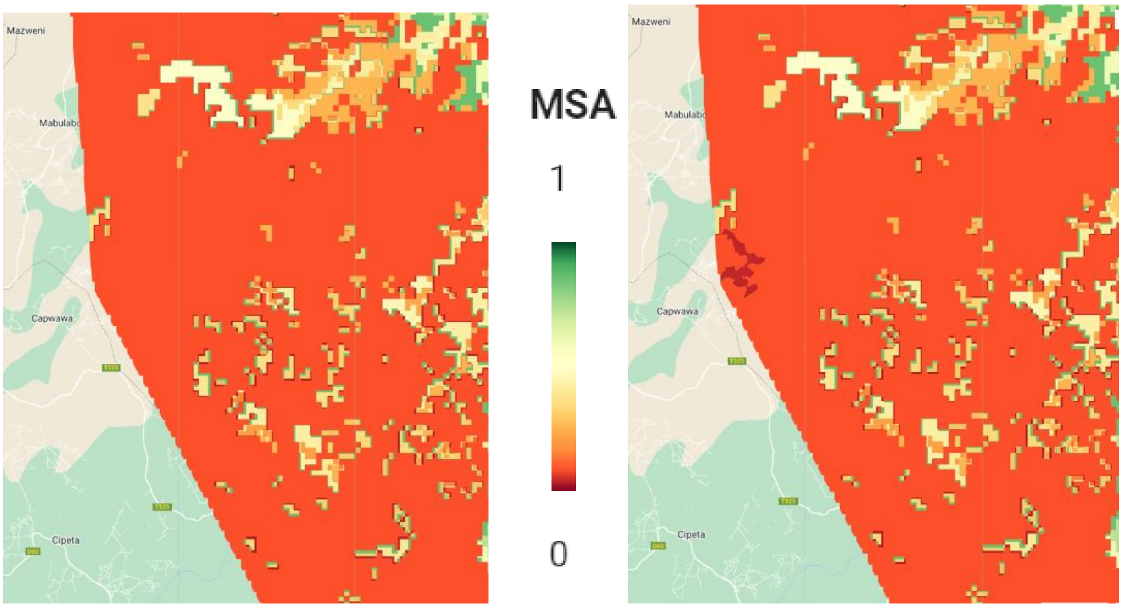
Figure 51.
PRIDE MSA evolution with the project.



Source: ABC-Map.

As ABC-Map is a mapping tool, these increases can also be directly tracked on the MSA Map. Figure 52 shows the baseline (left) versus project (right) map.

Figure 52.
PRIDE baseline vs. project MSA map.



Source: ABC-Map.

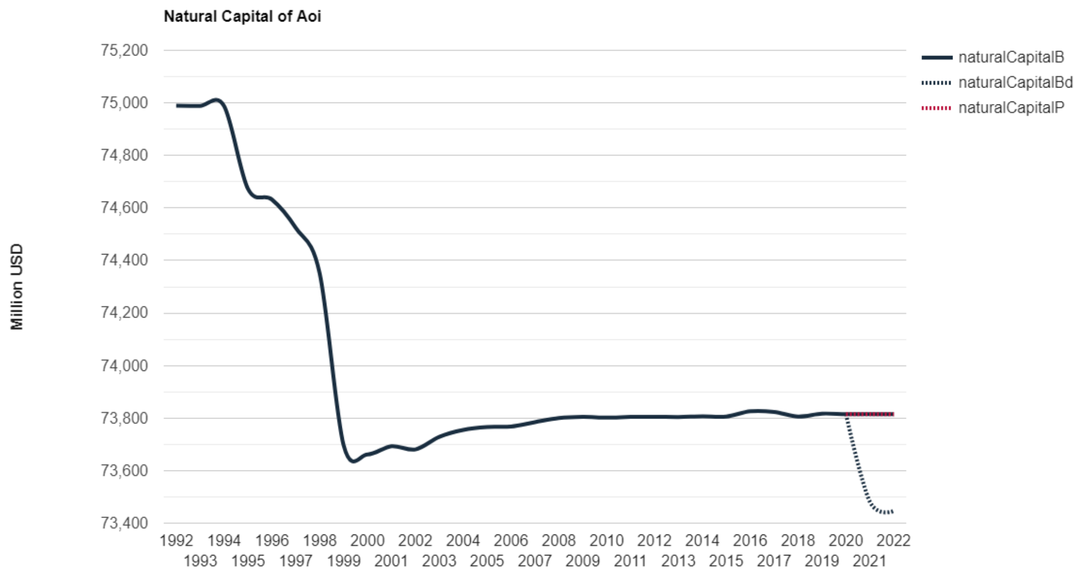
Table 23.
PRIDE area of intact biodiversity.

	2016	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	Δ_{AIB}	*Sign*
AIB (ha)	0	-23	-46	-69	-92	-115	-138	-138	↘

ii. Natural capital

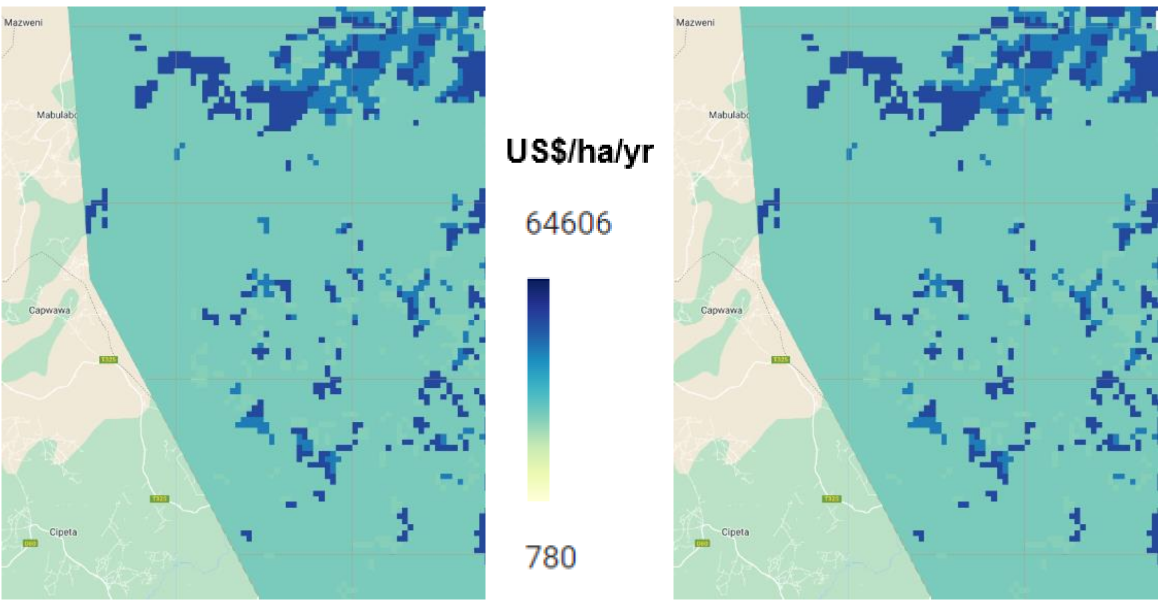
Compared to the MSA values, the natural capital does not change with the introduction of irrigation schemes in annual croplands. It is important to note that one of the limitations of the natural capital assessment, as of now, is that there is no distinction of ecosystem service values between annual croplands with different management practices and organic amendments (due to a lack of data). Figure 53 shows the natural capital evolution with the project and Figure 54 compares the natural capital maps of the baseline with the project scenarios.

Figure 53.
PRIDE natural capital evolution.



Source: ABC-Map

Figure 54.
PRIDE natural capital evolution with the project.



Source: ABC-Map

Table 24.
PRIDE average natural capital per ha.

	2016	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	Δ_{AIB}	*Sign*
ANC (US$/ha)	12 453	12 453	12 453	12 453	12 453	12 453	12 453	+/- 0	→

Part 3. PRIDE ecosystem-based biodiversity core indicator

As described above, the two sub-indicators to be used for the ecosystem-based core indicator are the AIB, which can be found in Table 23, and the ANC, which can be found in Table 24. IFAD considers that biodiversity is improved at ecosystem-level when either the habitat sub-indicator (AIB) or the ecosystem sub-indicator (ANC) show a positive change with the implementation of a project, while the other one is at least held constant. Table 29 shows the area of intact biodiversity and average natural capital per ha for the three reporting periods (project baseline, mid-term and completion), respectively.

Table 25.
PRIDE area of intact biodiversity and average natural capital per ha.

	Baseline	*Mid Term*	*Completion*	***Δ***	*Sign*
AIB (ha)	0	- 69	-138	-138	↗
ANC (US$/ha)	12 453	12 453	12 453	+/- 0	↗

Source: Adapted from ABC-Map.

As the Δ_{AIB} (-138 ha) is decreasing and the Δ_{ANC} (+/- 0 US$/ha) is constant, the PRIDE project is not improving biodiversity at the ecosystem-level. In other words, the biodiversity core indicator 3.2.4 would be reported as 0.

Glossary

Agrobiodiversity, also *Agricultural biodiversity*, is the "biological diversity that sustains key functions, structures and processes of agricultural ecosystems. It includes the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels" (IPBES, 2022).

Aichi Biodiversity Targets are the 20 targets set by the Conference of the Parties to the Convention for Biological Diversity (CBD) at its tenth meeting, under the Strategic Plan for Biodiversity 2011-2020 (IPBES, 2022).

Biodiversity, also *Biological diversity***,** means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems" (CBD, 1992)

Biodiversity loss is the reduction or loss of any aspect of biological diversity (i.e. diversity at the genetic, species and ecosystem levels) in a particular area through death (including extinction), destruction or manual removal; it can refer to many scales, from global extinctions to population extinctions, resulting in decreased total diversity at the same scale (IPBES, 2022).

Ecosystems are defined by the CBD (1992) as "a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit."

Ecosystem diversity refers to the variations of ecosystems within a given geographical location (Biology Online, 2022).

Ecosystem services are defined as benefits people obtain from ecosystems. In the Millennium Ecosystem Assessment, ecosystem services can be categorized as supporting, regulating, provisioning and cultural. This classification, however, is superseded in IPBES assessments as "nature's contributions to people" (IPBES, 2022).

Ecosystem degradation is "a long-term reduction in an ecosystem's structure, functionality, or capacity to provide benefits to people" (IPBES, 2022).

Genetic diversity refers to both the vast numbers of different species as well as the diversity within a species (Biology Online, 2022).

Habitat is defined by the CBD (1992) as "the place or type of site where an organism or population naturally occurs."

Habitat diversity refers to the "range of habitats present in a region" (OECD, 2001).

Habitat fragmentation is "a general term describing the set of processes by which habitat loss results in the division of continuous habitats into a greater number of smaller patches of lesser total and isolated from each other by a matrix of dissimilar habitats. Habitat fragmentation may occur through natural processes (e.g., forest and grassland fires, flooding) and through human activities (forestry, agriculture, urbanization)" (IPBES, 2022).

Invasive Alien Species are "Species whose introduction and/or spread by human action outside their natural distribution threatens biological diversity, food security, and human health and well-being. 'Alien' refers to the species' having been introduced outside its natural distribution ('exotic', 'non-native' and 'non-indigenous' are synonyms for 'alien').

‘Invasive’ means ‘tending to expand into and modify ecosystems to which it has been introduced’. Thus, a species may be alien without being invasive, or, in the case of a species native to a region, it may increase and become invasive, without actually being an alien species” (IPBES, 2022).

Post-2020 Global Biodiversity Framework “builds on the Strategic Plan for Biodiversity 2011-2020 and sets out an ambitious plan to implement broad-based action to bring about a transformation in society’s relationship with biodiversity, ensuring that by 2050 the shared vision of ‘living in harmony with nature’ is fulfilled” (CBD, 2021).

Species are “an interbreeding group of organisms that is reproductively isolated from all other organisms, although there are many partial exceptions to this rule in particular taxa. Operationally, the term species is a generally agreed fundamental taxonomic unit, based on morphological or genetic similarity, that once described and accepted is associated with a unique scientific name” (IPBES, 2022).

Species diversity is defined as the presence of different species in a given region (Biology Online, 2022).

Sustainable use of bbiodiversity is “the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations” (IPBES, 2022).

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Annex 1. Review of Ecosystem-based Biodiversity Tools

Name of Tool	*Developer*	*Description*	*Habitats /Species*	*Ecosystem*	*Gene*	*Advantages*	*Disadvantages*
Adaptation, Biodiversity and Carbon Mapping (ABC-Map) Tool	Food and Agriculture Organization (FAO) of the United Nations	ABC-Map is a new geospatial app built on Google Earth Engine that holistically assesses the environmental impact of National Policies and Plans (NDC, NAPs, etc.) and investments in the AFOLU sector using satellite imagery. In the Biodiversity Tool section, ABC-Map provides two complementary biodiversity impact assessment metrics, namely the Mean Species Abundance, and the Natural Capital Assessment.	X	X	O	The innovative remote sensing component of this core indicator has the advantage of being a relatively cheap and rapid method of acquiring up-to-date information over large geographical areas. This is very much in line with the goal for IFAD's Biodiversity Core Indicator to be simple, smart, robust, measurable and globally applicable - limiting hence the extra burden to projects to a strict minimum. Addresses limitations of the MSA (ecological value missing) and Natural Capital (degradation levels missing) metrics, by using both indicators in conjunction. FAO does not charge any fees for the use of its environmental assessment tools.	While time and resource constraints are low, capacity needs to be built on very basic functions (draw a polygon, etc.)
Agrobiodiversity Index (ABDi)	Alliance of Bioversity International and CIAT (Int)	Assesses risks in food and agriculture related to low agrobiodiversity. Includes 22 indicators assessing multiple components including markets and consumption, agricultural production, and genetic resource management.	X	(X)	O	Multiple spatial layers (remote sensing and spatial modelling) on biodiversity integrity in agricultural landscapes, crop/livestock/fish diversity No costs, except for the application with HowGood.	. Only partially covers ecosystems . External expertise required for usage, and expected costs for these are high . Indicator not yet operational. Economic quantification of activities is still under development.
Biodiversity Footprint Financial Institutions (BFFI)	ASN Bank (NL) CREM (NL) PRé Sustainability (NL)	Provides an overall biodiversity footprint of a financial institution's investments.	X	O	O	Provides a holistic assessment of biodiversity pressures, where scope 1, scope 2 and scope 3 are included.	. Only covers habitat/species dimension . Based on Life cycle assessment (LCA) approach, which is very time and resource intensive - and not suitable for a core indicator across projects. It can take 15 – 50 days to complete a biodiversity footprint of a financial institution.

Biodiversity Footprint Methodology (BFM) and Calculator(BFC)	Plansup	Quantifies the impact of a product, sector or company on biodiversity. Uses a pressure-based methodology for three pressure types: land use, GHG emissions, and N and P emission to water. Impact is calculated per part of the production chain, and cause-effect relations from GLOBIO are used.	X	O	O	Simple open source tool. Includes pressures from land use, GHG and N&P emissions. GLOBIO is accepted on a global level. No external expertise required for usage.	. Only covers habitat/species dimension .Information provided are rough estimates about the potential biodiversity impacts of an agricultural commodity, particularly in relation to the way it is produced . Impact of infrastructure, fragmentation, invasive species and nitrogen deposition is not included in methodology Very coarse spatial resolution of 5x5km2.
Biodiversity Impact Metric (BIM)	Cambridge Institute for Sustainable Leadership (CISL) (UK)	Tracks and assesses how a business's sourcing causes biodiversity loss as a result of agricultural production. Allows comparison of potential impacts across sourcing locations and commodities.	X	O	O	Is an entry-level approach that enables rapid risk-screening of company's sourcing in order to identify where the greatest impacts occur. This can help prioritize future interventions.	Only covers habitat/species dimension . Commodity-based (and not project-based) . Most commonly used spatial resolution is 1km2 (as finer resolutions increase the chance that a particular species is incorrectly considered for the Range Rarity Layer) the metric does not assess when land transformation took place A licence fee needs to be paid to the IBAT platform for the range rarity data.
Biodiversity Indicators for Site-based Impacts (BISI)	UNEP-WCMC, Conservation International, and Fauna & Flora International (Int)	Allows companies with significant site-based activities to understand impacts on biodiversity. The tool also provides links to mitigation performance from impacts.	X	O	O		Specifically tailored to the energy and mining sector (Extractive industries) Only covers habitat/species dimension BISI does not work with similar scale as MSA and therefore is not very compatible with MSA based tools. Less suitable for accounting purposes and for demonstrating NNL compliance.
Biodiversity Monitoring System for the Food Sector(BMS)	Lake Constance Foundation, Global Nature Fund, Germany	Designs to enable food standards and food companies the ability to monitor biodiversity standards of farms and producers. Evaluates the potential created for biodiversity, and the reduction of negative impacts on biodiversity. Monitors mid- and long-term effects of certification on wild biodiversity on farms and its direct surroundings.	X	O	O	monitor indicators with relevance for biodiversity of their certified farms / their producers.	Only covers habitat/species dimension Not suited to larger scale assessments (i.e. investments in broader landscapes) Modest user fee from November 2021

Biodiversity Net Gain Calculator (BNGC)	Arcadis	Provides insight in the land use related biodiversity value at site level by means of field survey assessments by ecologists to assign a biodiversity value score between 0 and 1 to each spatial unit.	X	O	O	The outcomes are tailor-made for the company and delivered to the company in an easy-to-understand format. A limited training is recommended for company staff to work with the tool.	. Only covers habitat/species dimension .Time and resource intensive as Field survey needs to be conducted by experienced ecologist with sound knowledge of local biodiversity .Includes Large qualitative assessment that is better suited for risk assessments (like safeguards).
Biodiversity Performance Tool (BPT) for Food sector	Solagro (France)	Assesses the integration of functional biodiversity at farm level for food sector actors. Aims to assist farmers and farma advisors to elaborate and implement Biodiversity Action Plans.	X	O	O	Simple but meaningful overview regarding the quality of the BAP and the biodiversity performance of the farm.	. Only covers habitat/species dimension . Not suited to larger scale assessments (i.e. investments in broader landscapes) . Modest user fee from February 2021 onwards.
BIRS and ES assessment	LafargeHolcim	Measures habitats and species condition as well as measuring and monetizing ecosystem services. Assesses how habitats and social benefits from resoration evolve over time.	X	X	O	BIRS is an easy-to-apply system for calculating an annual biodiversity condition index for every active or disused extraction site and reserve landholdings,	. Tailored to the Biodiversity management in the cement and aggregates sector . BIRS does not work with similar scale as MSA and therefore is not very compatible with MSA based tools. . Less suitable for integrating EIA data as BIRS is more suitable for monitoring progress of biodiversity restoration (e.g. mine rehabilitation) . Might be difficult to apply to marine sites . Costs for subcontracting e.g. university experts for wildlife inventories, ecosystem services experts.
Corporate Biodiversity Footprint (CBF)	Iceberg Data Lab	Measures impacts of corporates on biodiversity. Uses a science-based and scalable approach to cover large portfolios. The tool uses a bottom-up approach to cover to material impact of constituents throughout their value chain.	X	O	O	Covers the most material pressures on Biodiversity, as summarized in the IPBES reports (i.e. land and sea use change, pollution, climate change, overexploitation of biological resources, invasive species).	. Only covers habitat/species dimension. . the CBF is limited by data availability. Production, consumption, and prices are needed for the Input/Output model and when national sectoral data lack, regional or global data are used . Some pressure factors are not modelled yet, due to the lack of robust models and will be developed over time (Invasive alien species, Resource consumption) . Commercial tool → costs related to performed work

Environmental Profit & Loss (EPL)	Kering (France)	Measures carbon emissions, water consumption, air and water pollution, land use and waste production along supply chains. Impacts are converted into monetary values to quantify use of natural resources.	X	X	O	measures carbon emissions, water consumption, air and water pollution, land use, and waste production along the entire supply chain.	. LCA expertise is needed to run the assessment . Commercial tool
Global Biodiversity Score®(GBS)	CDC Biodiversité (France)	Provides an overall view of biodiversity footprint from economic activities. Measured through Mean Species Abundance based on PBL Netherlands Environmental Assessment Agency's model of five terrestrial pressures (land use, nitrogen deposition, climate change, fragmentation, infrastructure/encroachment) and five aquatic pressures, and their impacts on biodiversity. Impacts are expressed in MSA.km2.	X	O	O	Quantifies risks and identifies opportunities for reducing risks to biodiversity. Can be used to disclose impacts regularly. "preliminary assessment of the planetary boundary for terrestrial biodiversity have been conducted and expressed in MSA (Lucas & Wilting 2018): even though these works require significant additional research, they provide the foundations to set scientifically meaningful targets." Shows impacts but also actual gains. Data available at different geographical levels.	. Only covers habitat/species dimension . Does not cover marine biodiversity . Assessment is not made at site level, but at company level over the whole value chain . Impacts are limited to those caused by climate change . No compensation for the limitations of MSA (does not cover the risk of extinction of species, nor the degradation of the diversity of genes) . Requires expert usage - calculations are not available to non-experts currently. 3 days of training are needed for evaluators . R and RStudio are needed to be able to calculate . Application of GBS requires support by a consultant - assessment requires 40-80 human days from consultants. . The price of the membership of the B4B+ Club is € 6,500 excluding VAT per year + Training costs
LIFE Key (LIFE)	LIFE Institute (Brazil)	Provides information on a company's pressure and positive impacts on biodiversity. Also provides strategic guidance on effectiveness of conservation actions.	X	(X)	O	Robust and measurable methodology. Is adaptable to any country or region. Applicable to companies of any size or sector. Allows comparison of biodiversity pressures with the positive biodiversity outcomes of natural restoration investments.	. Only partially covers ecosystem dimension. . Severity of pressures is related to national or regional information and not specific to local biodiversity contexts . Initial user efforts to implement the methodology is estimated between 10 to 100 man-days . A fee is required for technical support, and for additional training.

Product Biodiversity Footprint (PBF)	I CARE - Sayari (France)	Combines biodiversity studies and company's data to quantify impacts of a product along its life cycle stages on biodiversity.	X	O	O	Aggregation of 3 of the 5 pressures is straightforward (habitat change, pollution and climate change). Utilises open source data. Ability to undertake analysis with geographical specificities, such as at the agricultural phase.	. Only covers habitat/species dimension . Aggregation of overexploitation and invasive species difficult. . Technical knowledge of life cycle assessments is needed, as well as technical knowledge of ecology is required to assess invasive species indicator . Experts are needed to complete assessment . Commercial tool → costs related to the performed human days
ReCiPe2016	Radboud University, RIVM, Norwegian University of Science and Technology, PRé Sustainability	Uses life cycle impact assessments to generate environmental impact scores from emissions and resource extraction information. Includes dimensions on human health, ecosystem quality and resource scarcity.	X	O	O	Includes pressures from land use change, climate change, pollution (acidification, ecotoxicity) and water consumption. Includes uncertainty analysis and sensitivity analysis, which improves the reliability of the results.	. Only covers habitat/species dimension .excludes pressures from direct exploitation and invasive species. Metrics used are difficult to understand "species.yr" and "PDF.m2.yr" . External expertise required for usage, and expected costs for these are high.
Species Threat Abatement and Restoration metric (STAR)	IUCN (International)	Measures the contribution that investments make to reduce species extinction risk. Primary data from remote sensing of land use changes, camera traps for species presence, and targeted interviews with local informants.	X	O	O	Can enable investors to target their investments to achieve conservation outcomes. Can measure the contributions investments make towards global targets such as the SDGs.	. Only covers habitat/species dimension . Field verification needed, requiring investment in time and personnel . Data gaps for some taxa of trees, reptiles, freshwater fish and marine species.

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