Food and Agriculture Organization of the United Nations

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TECHNICAL GUIDE

FOR THE ADAPTATION, BIODIVERSITY AND CARBON MAPPING TOOL

ABC-MAP

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Preparation of this document

This technical manual has been produced as part of the effort by the Office of Climate Change, Biodiversity and Environment (OCB) of the Food and Agriculture Organization of the United Nations (FAO) to help countries to align their policies and commitments made under the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement, the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification (UNCCD). The general objective of this manual is to provide the user with (i) a detailed structure of the Adaptation, Biodiversity and Carbon Mapping Tool, ABC-Map; (ii) the methodological background; and (iii) the different data and factors used, such as the climatic and geophysical datasets, among others.

Contents

Figures, tables and boxes

Figures

Tables

Boxes

Chemical formulae and elements, units of measurement

CH_4	methane
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
N_2O	nitrous oxide

°C	degree Celsius
g	grams
ha	hectare
t	metric tonnes
tC	tonnes of carbon
tCO_2-e	tonnes of carbon dioxide equivalent

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ABC-Map and this methodological guide were prepared by Daniel Dionisio (OCB), in collaboration with Philip Audebert (IFAD), Laure-Sophie Schiettecatte (OCB), Cassandre Tribalet (OCB), Imogen Brierley (OCB) and Padmini Gopal (OCB). The case studies were adapted from IFAD's Biodiversity Core Indicator Comprehensive Guidance document, developed by a team from the Environment, Climate, Gender, and Social Inclusion Division (ECG) consisting of Philip Audebert, Imogen Brierley, and Nadine Azzu, with support from the Operational Policy and Results Division (OPR) and the Research and Impact Assessment Division (RIA).

The authors are grateful for the work on graphic design by Clara Proença (OCB).

Abbreviations and acronyms

ABC-Map	Adaptation, Biodiversity and Carbon Mapping Tool
AFOLU	agriculture, forestry and other land use
AoI	area of interest
CBD	Convention on Biological Diversity
CCI	Climate Change Initiative
ECMWF	European Centre for Medium-Range Weather Forecasts
ESA	European Space Agency
ESVD	Ecosystem Services Valuation Database
FAO	Food and Agriculture Organization of the United Nations
GEE	Google Earth Engine
GLOBIO	global biodiversity model for policy support
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPPC	International Plant Protection Convention
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre (European Commission)
KBA	key biodiversity areas
LC	land cover
MSA	mean species abundance
TEEB	The Economics of Ecosystems and Biodiversity
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
UNEP-WCMC	United Nations Environment Programme's World Conservation Monitoring Centre
WDPA	World Database on Protected Areas

Executive summary

The world is currently facing three simultaneous crises that threaten and undermine the very basis of sustainable development and human existence: climate change, biodiversity loss and land degradation. Since these crises are strongly interlinked and are mutually reinforcing in threatening food security and the achievement of the Sustainable Development Goals (SDGs), urgent action is needed to address them holistically by measuring and integrating the environmental impact of projects and investments in the agriculture, forestry and other land use (AFOLU) sector. As a response, the Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD), the Agence Française de Développement (AFD, French Development Agency) and the Bundesministerium für Ernährung und Landwirtschaft (BMEL, German Federal Ministry of Food and Agriculture) jointly developed a new geospatial app called the Adaptation, Biodiversity and Carbon Mapping Tool (ABC-Map). FAO's Office of Climate Change, Biodiversity, and the Environment (OCB) was the technical lead for the development of this tool. OCB's Biodiversity, Climate Change and Environment workstreams have collaborated on addressing the various dimensions of biodiversity, climate change adaptation and mitigation, and the environment.

ABC-Map is part of a new generation of environmental impact assessment tools together with the Nationally Determined Contribution Expert Tool (NEXT), and supports governments and international institutions in their commitments under the three Rio Conventions, namely the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification (UNCCD).

ABC-Map was designed with the specific objective of holistically assessing the environmental impacts of national policies, plans and investments in the AFOLU sector. ABC- Map helps to develop synergies and trade-offs between climate, biodiversity, and land restoration actions. ABC-Map is made up of three separate sections: adaptation, biodiversity, and carbon, which can also be utilized separately.

The adaptation section of ABC-Map helps to understand exposure to climate change risks and to assess climate change over time in a given area. It combines climatic and geophysical data with past trends, for example, temperature and precipitation trends over the past 40 years.

The biodiversity section of ABC-Map covers a series of indicators that are intended to complement each other and provide a more comprehensive view of pressures and impacts on biodiversity. These indicators are average species abundance, land use change in protected areas, key biodiversity areas, and natural capital.

The carbon section of ABC-Map aims to account for greenhouse gas (GHG) emissions in the AFOLU sector and work towards their reduction. This section is based on NEXT and shows trends in the carbon stock changes, the carbon balance, and the social value of carbon.

The overall objective of this technical manual is to provide the user with (i) a detailed structure of the ABC-Map; (ii) its methodological background; and (iii) the different data and factors used such as emission factors and default carbon stock values, reference values from the Ecosystem Service Valuation Database (ESVD), the global biodiversity model for policy support (GLOBIO), climate and geophysical datasets, among others.

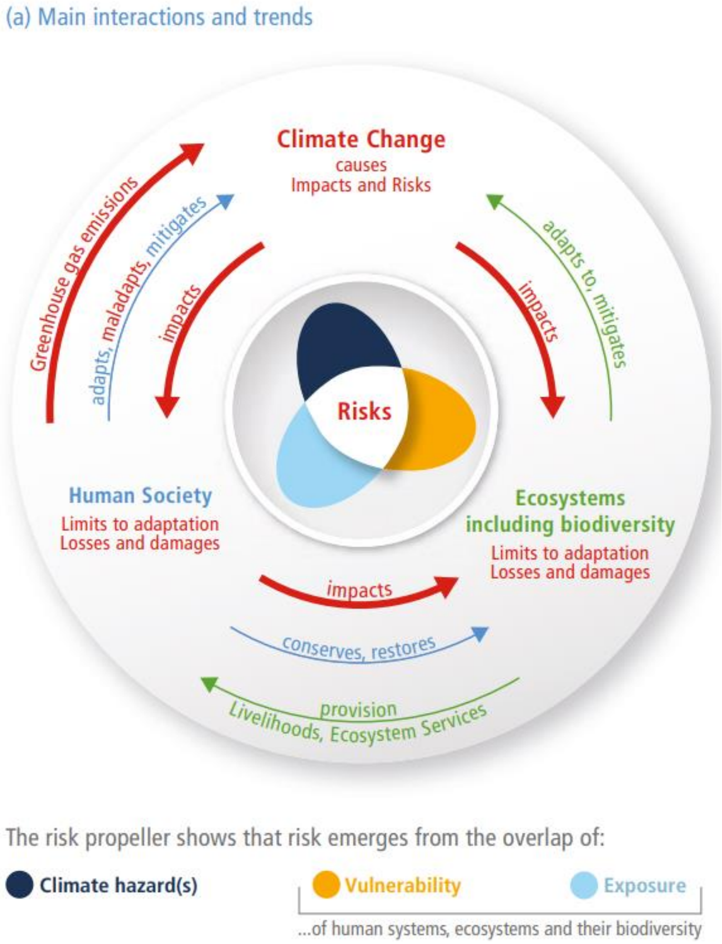
Introduction

The world is currently facing three simultaneous crises, which threaten and undermine the very basis of sustainable development and human existence: climate change, biodiversity loss and land degradation.

The decline of biodiversity for food and agriculture poses a serious risk to global food security and weakens the resilience of agriculture to climate change, pests, and diseases. As stated in the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report:

> The interaction between fire, land use change, particularly deforestation, and climate change, is directly impacting human health, ecosystem functioning, forest structure, food security and the livelihoods of resource-dependent communities (IPCC, 2022a, p. 44).

Figure 1. Impacts and risks caused by climate change



Source: IPCC. 2022a. Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, *et al*. (eds). Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 37–118, doi:10.1017/9781009325844.002

At the twenty-first Conference of the Parties (COP) to the UNFCCC, developed and developing countries adopted the Paris Agreement to undertake ambitious efforts to combat climate change and adapt to its effects. The goal of the Paris Agreement is to limit the increase of the global temperature to 1.5 Celsius (°C) above pre-industrial levels by the end of the century, recognizing that this would significantly reduce the risks and impacts of climate change (Article 2). This is motivated by the threat of immense economic, social and ecological damage if we fail to manage climate change effectively (Stiglitz *et al.*, 2017).

In 2021, the Parties to the Paris Agreement were invited to submit their revised and enhanced nationally determined contributions (NDCs). Yet, the NDC synthesis report revealed that this new set of mitigation pledges is insufficient to achieve the GHG emission reduction objectives by 2030 and the Paris Agreement's temperature goals by mid-century. The world is on track to reach 2.7 °C (UNEP, 2021; UNFCCC, 2021). Specific to the agriculture, forestry and other land use (AFOLU) sector, the new set of NDCs showed that beyond improvement in both the coverage and quality of mitigation, only a few countries managed to define measurable goals and targets for climate actions (Crumpler *et al.,* 2021). This shows that the world needs to accelerate the implementation of well-designed climate change mitigation and adaptation policies to also ensure growth, development and poverty reduction.

In addition to climate change, the world is affected by two major crises in close connection with the AFOLU sector: biodiversity loss and land degradation.

Biodiversity is declining globally at rates unprecedented in human history – and the rate of species extinction is accelerating, which may seriously impact people around the world. The World Wide Fund for Nature (WWF) estimated an average decline of 68 percent in species population sizes between 1970 and 2016 (WWF, 2022). This loss in biodiversity is likely to erode the very foundations of our economies, livelihoods, food security, health, and quality of life worldwide (IPBES, 2019). The 2019 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Report also stresses that through transformative change, nature can still be conserved, restored and used sustainably (IPBES, 2019).

Due to past and ongoing rapid declines in biodiversity, the Parties to the Convention on Biological Diversity (CBD) negotiated a new, post-2020 Global Biodiversity Framework. The framework is built around a theory of change, which recognizes that:

> … urgent policy action is required globally, regionally and nationally to achieve sustainable development so that the drivers of undesirable change that have exacerbated biodiversity loss will be reduced and/or reversed to allow for the recovery of all ecosystems and to achieve the Convention's vision of Living in Harmony with Nature by 2050 (CBD, 2022, p. 7).

In addition, human activities that exploit the land lead to a decline in its utility, biodiversity, soil fertility and overall health, a phenomenon called land degradation.

While healthy land resources and thriving ecosystems are needed to ensure food security for a growing world population, current agricultural practices are indeed causing soil erosion worldwide, up to 100 times faster than natural processes are replenishing it. Land degradation is currently affecting almost 2 billion hectares (ha) of land worldwide (Garrett *et al*, 2022).

There are interactions between biodiversity loss, land degradation, climate change (including adaptation risks), which make it necessary to adopt a holistic approach to tackle these issues. While both the scientific community and policy-making bodies recognize that these three are interconnected, in practice, they have been largely considered and addressed in isolation. The issues are covered by three functionally separate conventions and intergovernmental bodies, which provide advice on scientific and technological matters: the UNFCCC with the IPCC; CBD with the IPBES; and UNCCD with the Committee on Science and Technology.

A functional separation, however, bears the inherent risk of missing potential opportunities for joint action or leads to the implementation of actions that have unexpected adverse effects on one or more of the other issues. Although synergies can be found, an action taken to mitigate climate change may not necessarily be beneficial for biodiversity, and vice versa. It is therefore necessary to consider climate, biodiversity, and land degradation as part of the same complex problem in order to develop solutions that avoid maladaptation and maximize the beneficial outcomes (Pörtner *et al*., 2021).

Given this context, FAO, in collaboration with the International Fund for Agricultural Development (IFAD), the Agence Française de Développement (AFD, French Development Agency) and Bundesministerium für Ernährung und Landwirtschaft (BMEL, German Federal Ministry for Food and Agriculture), decided to develop a new geospatial app called the Adaptation, Biodiversity and Carbon Mapping Tool (ABC-Map). The aim of this new app is to work out possible synergies and trade-offs between climate, biodiversity, and land restoration actions by providing the user with a holistic and geospatially explicit assessment of the environmental impact of national policies and plans (NDCs, National Adaptation Plans [NAPs], National Biodiversity Strategies and Action Plans [NBSAPs]) and investments in the AFOLU sector. The tool is thereby aligned with the objectives of the three Rio Conventions (UNFCCC, CBD and UNCCD).

With its innovative approach to linking publicly available satellite imagery to land use and land management activities, ABC-Map makes use of Google Earth Engine's computation power to offer the user a range of indicators for both the baseline and project situation. These indicators are grouped into three broad categories:

1. adaptation (including a climatic and geophysical profile with, for example, information on the temperature and precipitation trends over the past 40 years);
2. biodiversity (including indicators such as mean species abundance, land use trends in protected and key biodiversity areas, and the natural capital); and

3. carbon (including trends in the carbon stock, carbon-balance and the social value of carbon).

ABC-Map was conceived as a dynamic tool that will be continuously updated with new features, updated datasets and indicators. New indicators within each section will be added depending on the user' needs and feedback.

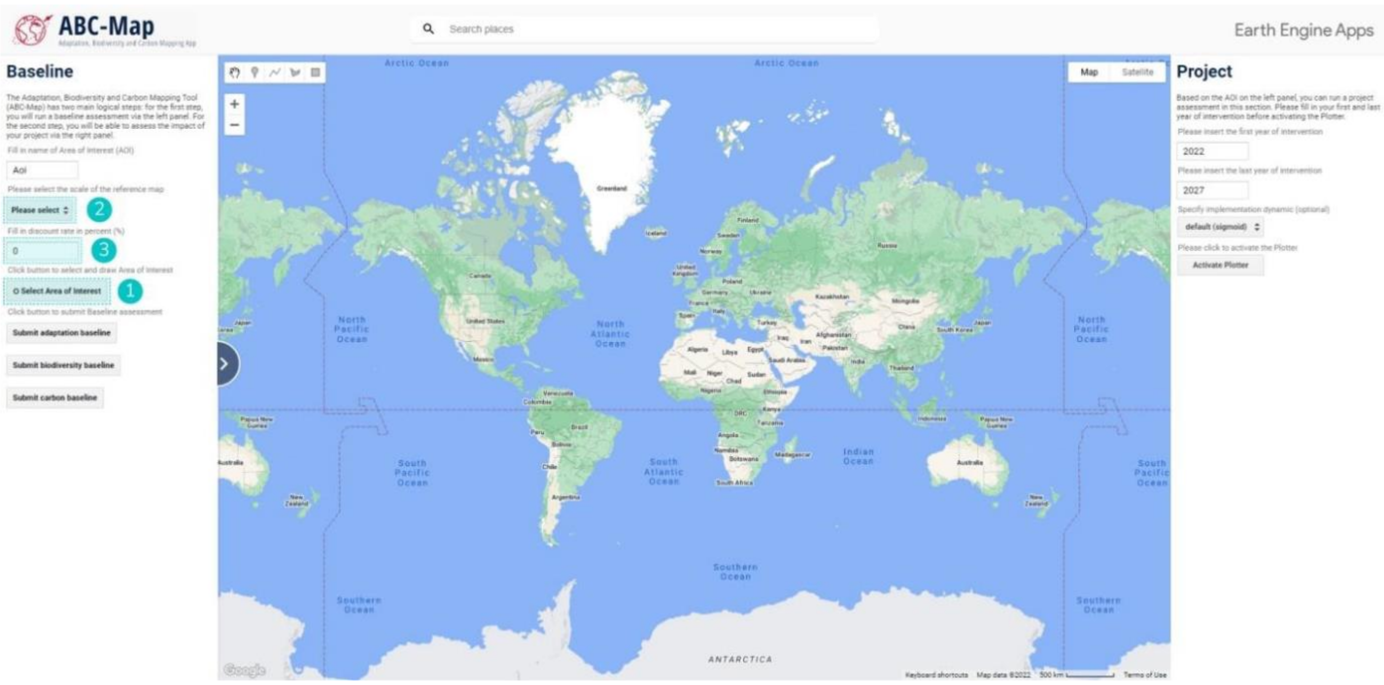
Overview of ABC-Map

ABC-Map is part of the NDC toolbox developed by the Office of Climate Change, Biodiversity and the Environment (OCB) of the Food and Agriculture Organization of the United Nations (FAO). This toolbox also includes NEXT and the NDC tracking tool, which supports countries in the annual tracking of progress made in implementing and achieving their NDCs in the AFOLU sector.

Structure

ABC-Map has two side panels, the “Baseline” and “Project” panels, and a central map, as shown in Figure 2. ABC-Map has two main steps, with a dedicated panel for each. For the first step, the user will run a baseline assessment via the left panel. For the second step, the user will be able to assess the impact of a project via the right panel.

Figure 2. ABC-Map’s initial interface, showing the baseline panel (left), the map (centre) and the project panel (right)



Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

The baseline panel

The baseline panel (Figure 2, on the left) is where the user can define:

1. the area of interest (AoI), a polygon to be drawn on the map by the user, which defines the project area. This polygon will be used to calculate all the indicators, both at the baseline and project levels.

2. the resolution of the land cover map, which is used to calculate several indicators and the land use map within ABC-Map. Possible options are:

   a. 10 m (Central America and Europe for 2017)
   b. 20 m (Africa for 2016)
   c. 100 m (World for 2015–2019)
   d. 300 m (World for 1992–2019)

3. the discount rate,[1] used on both the natural capital and the social value of carbon indicators. It can be used to adapt the default values of these indicators for a given project specificities. The default used by ABC-Map is zero.

After submitting an AoI for analysis, all the baseline indicators for adaptation, biodiversity and carbon will be calculated and displayed in this panel. All these indicators are explained in detail below.

The map

At the centre of the interface is a map that displays geo-spatial data generated by both the baseline and project assessment and allows for a visual comparison of the AoI before and after the project activities. It is also on this map that the user will draw the project area and plots (explained below).

[1] Since the natural capital and social value of carbon are expressed as monetary values, it is important to determine the present value of future cash flows using the discount rate (and ultimately the net present value). Discounting permits a comparison of the value of money in different time periods, considering that a dollar today is worth more than a dollar received tomorrow. See IFAD (2015).

The layers generated by the indicators are:

- slope map
- elevation
- carbon stock
- IPCC land use classes with forest landscape integrity
- natural capital
- protected areas
- key biodiversity areas
- aggregated mean species abundance (MSA)
- MSA (land use)
- MSA (habitat fragmentation)
- MSA (infrastructure)
- MSA (human encroachment)

The project panel

The project panel is where the user can access the Plotter and use it to define project plots. After defining all of the project plots and submitting them for analysis, ABC-Map will compute the indicators for biodiversity and carbon and assess the impacts of the project.

The plotter

ABC-Map is a spatially explicit, land-based accounting system, which requires the user to divide the project area into both baseline and project activity plots. To assess impact from project-level activities, the user needs to run a project assessment. To do so, the user is required to first specify the project plots on the map.

PLOT IDENTIFICATION AND CLASSIFICATION

Each area of the project intervention (plot) must be identified on the map and must be within the AoI defined for the baseline.

Plots are identified and defined by using the plotter tool (Figure 4). After all plots have been identified and added to the map, the user must submit them for classification (press "Submit Plot List") and classify each plot using the options available on the "*Plot Land Use and Management*" section of the plotter.

To classify the plot, the user can use any of the IPCC land use categories from a set of subdivisions defined by IPCC, GLOBIO and the Forest Landscape Integrity Index (for forests) resulting in 423 possible combinations.

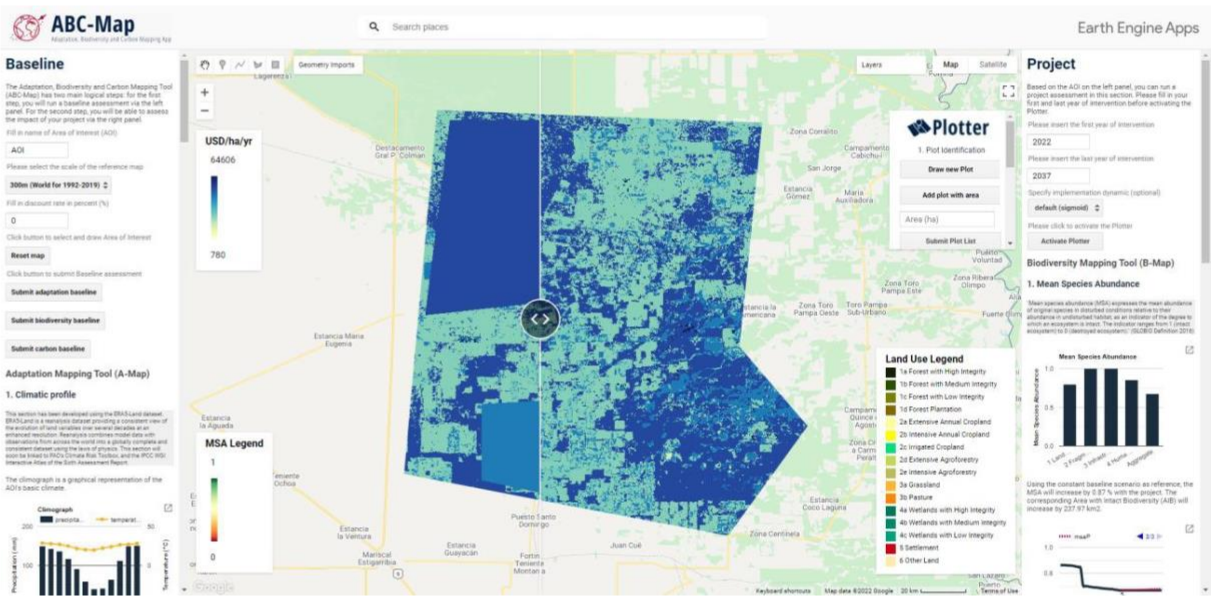
Table 1. Example of possible management options for a forest plot

Land use classification	Sub-class	Integrity
Forest	Forest	High integrity
		Medium integrity
		Low integrity
	Shrubland	High integrity
		Medium integrity
		Low integrity
	Plantation	High integrity
		Medium integrity
		Low integrity

Source: Authors' elaboration based on IPCC. 2022a. Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, *et al.* (eds). Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 37–118, doi:10.1017/9781009325844.002

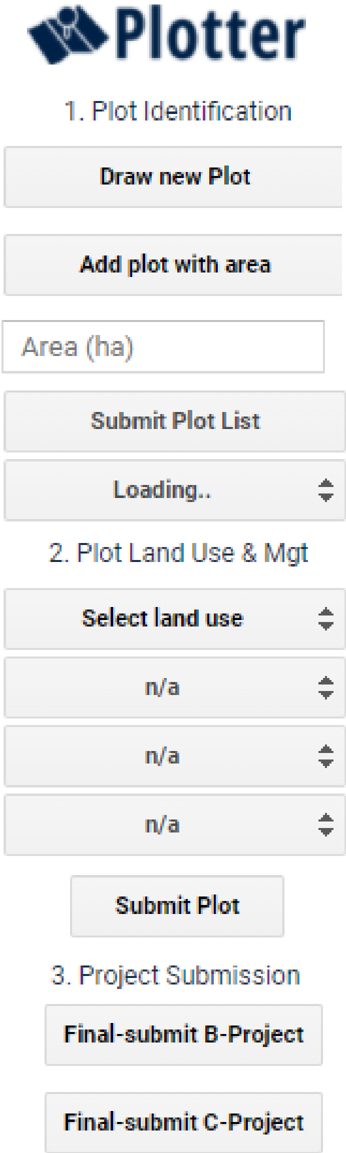
After classifying all the plots, the user can submit the project assessment for analysis, and all the project indicators for biodiversity and carbon will be calculated and displayed in this panel. These indicators will include the same data as the baseline assessment, as well as the projections for the AoI with the project implementation.

Figure 3. Example of a baseline and project assessment using ABC-Map



Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

Figure 4. The ABC-Map plotter

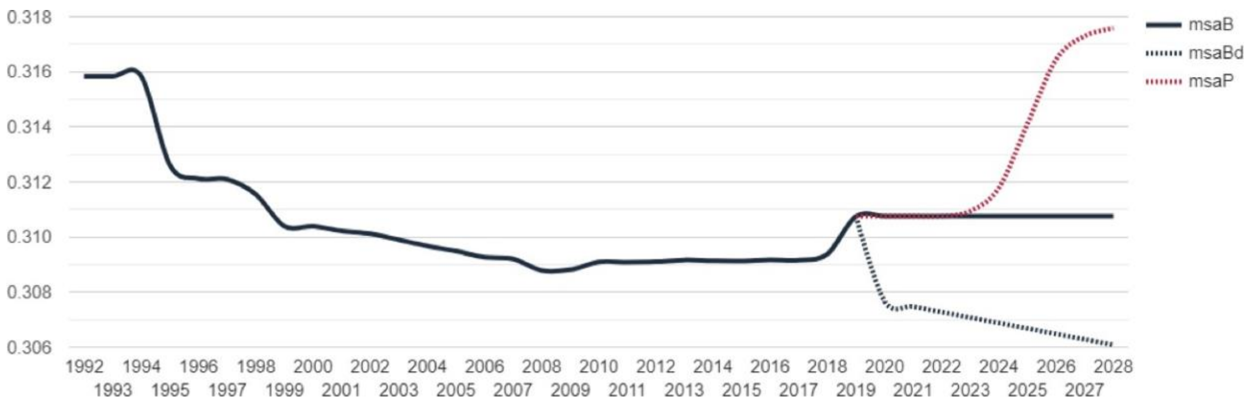


Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

Project output charts

The charts showing the predicted project impact for all sections of ABC-Map provide three different dynamics, as demonstrated in Figure 5: a static baseline (solid black line); a projection without project intervention (dotted black line); and the predicted change as a result of the project intervention (red dotted line). The data shown on the graphs until the first year of implementation, which in the case of Figure 5 is 2019, are based on the information input in the baseline.

Figure 5. Example of an output chart from ABC-Map



Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

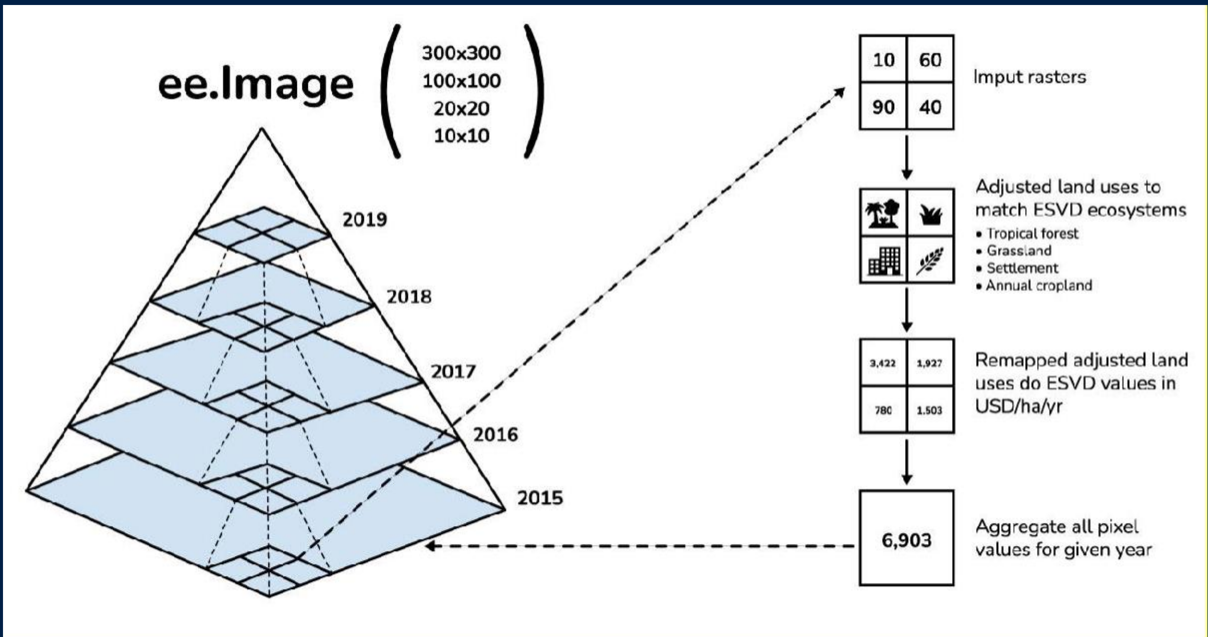
ABC-Map and Google Earth Engine

ABC-Map runs on Google Earth Engine (GEE), a Google Cloud Platform that makes it easy to access high-performance computing resources for processing very large geospatial datasets. Additionally, and unlike most supercomputing centres, GEE is also designed to help researchers easily disseminate their results to other researchers, policymakers, non-governmental organizations, field workers, and even the general public (Gorelick *et al.*, 2017).

In its current version, ABC-Map is published and deployed through the GEE, using Google Earth Engine Apps, a dynamic and publicly accessible user interface for Earth Engine analyses.

Box 1. ABC-Map spatial scales

ABC-Map uses land cover products at different spatial scales (300 m, 100 m, 20 m and 10 m), as shown in the logical framework below. For a given spatial scale, pixels are classified into land cover classes covering different types of forests, grasslands, croplands, etc. The land covers at the pixel level are then adjusted for some additional geophysical specificities such as climate (tropical vs. temperate forests) to match the Ecosystem Service Valuation Database (ESVD) ecosystems. This map is remapped to the ecosystems' respective summarized ecosystem service values in 2020 USD per ha per year in ESVD. In a final step, all pixels are aggregated over the area of interest to give the aggregate natural capital value for a given year.



Source: Authors elaboration based on ABC-Map screenshot, ABC-Map. 2022. Adaptation, Biodiversity and Carbon Mapping Tool. Cited 2 November 2022. abc-map.org

The adaptation section

The adaptation section of ABC-Map has been designed to identify and understand climate change hazards and exposure to their effects. This section allows the user to assess the evolution of climatic variables over time in a given area, which provides useful information for possible adaptation and mitigation actions. By providing this set of evidence-based indicators on climate, ABC-Map empowers decision-makers to better design projects that are more climate-resilient.

The IPCC reports that human-induced climate change, particularly through increases in the frequency and intensity of climate and weather extremes, including hot and cold extremes, heavy precipitation events, drought, and fire weather, have led to irreversible impacts as natural and human systems are pushed beyond their ability to adapt (IPCC, 2022a). These impacts disproportionately affect the most vulnerable people and systems.

Near-term warming and increased frequency, severity and duration of extreme events will place many terrestrial, freshwater, coastal and marine ecosystems at high or very high risk of biodiversity loss. Food and water security can be at risk due to increased temperature extremes, rainfall variability and drought. Adaptation, or the ability of a territory to reduce its exposure and vulnerability to climate change, is therefore essential (IPCC, 2022b).

The following section aims at explaining the adaption section of ABC-Map and is divided into two parts:

- the climatic profile to assess the overall climate and climatic trends (past 40 years) of the area of interest (temperature, precipitation, extreme heat, etc.); and
- the geophysical analysis to assess the overall geophysical properties of the area of interest (elevation, slope and water).

The climatic profile

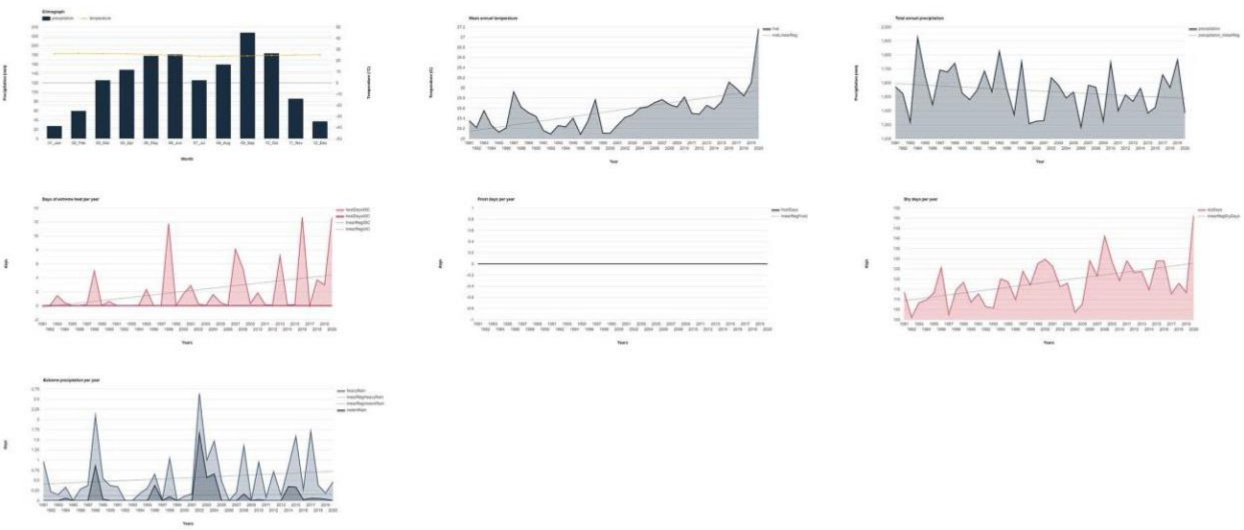
The climatic profile is composed of a set of indicators that show the climatic properties of a selected AoI and how they have changed for the past 40 years. It also includes information on average temperature, precipitation, and extreme climatic events such as hot and cold extremes and heavy precipitation. The main outputs are:

- a climograph showing the AoI's average temperature and precipitation over a year;
- a time series of the mean annual temperature;
- a time series of the mean annual precipitation;
- a time series of the number of days with extreme heat (≥35 °C and ≥40 °C) per year;
- a time series of the number of days with frost (≤ 0 °C) per year;

- a time series of the number of dry days (≤ 1 mm) per year; and
- a time series of the number of days with extreme precipitation (≥60 mm and ≥100 mm) per year.

These indicators are explained in detail in the following section.

Figure 6. Charts of ABC-Map's climate indicators



Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

Indicators

Table 2. Units of measurements for the climatic profile

Unit	Indicator
Celsius (°C)	Mean annual temperature
Millimetres (mm)	Total annual precipitation
Number of days	Days of extreme heat, frost days, dry days, extreme precipitation

Source: Authors' elaboration based on ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

Climograph

The climograph displays data for two variables: monthly average (mean) precipitation and monthly average temperature throughout the year. These are two useful metrics that provide an overview of the basic climate for the selected AoI.

Mean annual temperature

Slow onset events such as increasing temperature may have a high impact on biodiversity and the livelihoods of rural populations in some regions. For example, in some dryland areas, increased land surface air temperature contributes directly to desertification and subsequently to loss of biodiversity and land degradation

(IPCC, 2019b). This indicator provides the mean annual temperature since 1981 (using the *2 m air temperature* parameter from the ERA5 monthly dataset) together with a trendline. This combination allows for a quick overview of how average temperatures have evolved over time for the selected AoI.

Total annual precipitation

Precipitation and water availability changes increase the risk to planned infrastructure projects, such as hydropower. They also have direct impacts on productivity in the food and energy sectors, particularly across countries that share river basins and in regions where there is a likelihood of decreased rainfall, agriculture could be significantly affected (IPCC, 1998; IPCC, 2022b).

This indicator provides the total annual precipitation and a trendline since 1981 by using the *total precipitation* parameter from the ERA5 monthly dataset. Together this provides a quick overview of how average precipitation trends have evolved over time for the selected AoI.

Total annual precipitation is defined in ABC-Map as the sum of monthly aggregates. These monthly aggregates have been calculated by adding up all the observed precipitation for a given month based on the ERA5 hourly values.

Days of extreme heat

Widespread irreversible impacts to ecosystems that are pushed beyond their ability to adapt have resulted from observed increases in the frequency and intensity of climate and weather extremes, including hot extremes that lead to, *inter alia*, increased drought-related tree mortality and warm-water coral bleaching and mortality (IPCC, 2022b).

This indicator shows the total number of days annually since 1981 with maximum temperatures above 35 °C and above 40 °C. These thresholds are set as suggested by the literature, i.e. in general terms, temperatures above 32° C might affect plant growth. Extremely high temperatures above 30 °C can do permanent physical damage to plants and, when they exceed 37 °C, can even damage seeds during storage (FAO, 2017). The type of damage depends on the temperature, its persistence, and the rapidity of its increase or plants' capacity to adjust (Wahid *et al*., 2007). It also depends on the species and the stage of plant development. As the climate changes, the frequency of periods when temperatures rise above critical thresholds for maize, rice and wheat is predicted to increase worldwide (Gourdji *et al*., 2013). The days of extreme heat per year chart uses the ERA5-Land hourly dataset, specifically the *2 m air temperature* parameter, to calculate daily maximums.

Frost days

Frost days, defined on ABC-Map as days where the minimum temperature is below 0 °C, can have a significant impact on livelihoods and ecosystems. A reduction in the number of days with frost occurrence could lead to the reduction of the incidence of damaging frosts, which would allow farmers to grow horticultural produce that is susceptible to frosts at higher elevations than is currently possible. However, a reduction in frost days can also contribute to land degradation, which is particularly problematic in some drier regions, such as the Mediterranean, where the absence of frost has contributed to poorly formed soils. In addition, some plants depend on frost for their natural reproduction cycle, for example, by disrupting disease and pest cycles (Watson *et al*., 1997).

This indicator provides the number of days with potential for frost since 1981, i.e. the total of the number of days in a year where the minimum temperature is below 0 °C. With regard to the annual number of frost days, the ERA5-Land hourly dataset is used, particularly the *2 m air temperature* parameter, to calculate daily minimums.

Dry days

Projected increases in the length of dry periods between rainfall events and in the frequency or severity of droughts, or both, can cause a serious hydrological imbalance. This imbalance could lead to serious droughts. In 2009, the UNCCD reported that due to drought and desertification, 12 million ha of forest are lost every year, causing the destruction of the habitat for many species, and contributing to food insecurity due to the loss of land productivity (Brauch, Spring and UNCCD, 2009; IPCC, 2018).

This indicator provides the annual number of dry days where the total daily precipitation is below 1 mm since 1981 to the last fully completed year.

The ERA5-Land hourly dataset is used to determine the dry days indicator, specifically the *total precipitation* parameter, i.e. the accumulated liquid and frozen water, including rain and snow, which falls to the earth's surface.

Extreme precipitation

Climate-related hazards, such as storms and floods, will increase in number and intensity, hence affecting more people and enlarging economic damage as well as food insecurity (UNCCD, 2009).

The extreme precipitation indicator shows how often extreme precipitation events occur (number of days per year where the total daily precipitation is above 80 mm) and their trend since 1981.

The ERA5-Land hourly dataset is used to calculate the number of days with extreme precipitation, specifically the *total precipitation* parameter, which represents the accumulated liquid and frozen water, including rain and snow, that falls to the Earth's surface.

Climate profile datasets in greater detail

European Centre for Medium-Range Weather Forecasts ERA5

ERA5 is the fifth generation European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset. ERA5 replaces its predecessor, the ERA-Interim reanalysis.

The ERA5 monthly dataset provides aggregated values for each month for seven parameters: 2 m air temperature, 2 m dewpoint temperature, total precipitation, mean sea level pressure, surface pressure, 10 m u-component of wind, and 10 m v-component of wind.

The values are accumulated from the beginning of the forecast to the end of the forecast step. This occurs daily and is reset at midnight. The Earth Engine Data team added additional bands including hourly values computed as the difference between two consecutive forecast steps.

ERA5 data are available from 1979 to three months from real-time.

ABC-MAP uses the following ECMWF datasets provided on GEE:

- *ECMWF/ERA5/MONTHLY*: ERA5-Land monthly – ECMWF Climate Reanalysis (Hersbach *et al*., 2019); and
- *ECMWF/ERA5/HOURLY*: ERA5-Land hourly – ECMWF Climate Reanalysis (Hersbach *et al*., 2018).

Geophysical profile

The geophysical properties of an area contribute immensely to the composition of ecosystems and how they are affected by climate change. The geophysical indicators of the adaptation section help to analyse and understand which risks should be considered in a selected AoI.

In places at higher altitudes such as high mountain regions, which are home to roughly 10 percent of the global population, widespread cryosphere changes affect physical, biological and human systems far beyond the mountains, with direct impacts on surrounding lowlands and indirect impacts even in the oceans. These current trends in cryosphere-related changes are expected to continue, and impacts are expected to intensify.

While high mountains will provide new and greater habitat areas, including refugia for lowland species, at high elevations this will lead to population declines and to the risk of local extinctions. While the survival of such species will depend on appropriate conservation and adaptation measures, many projected ecological changes will alter ecosystem services, affecting ecological disturbances (e.g. fire, rock fall, slope erosion) with considerable impacts (IPCC, 2019a).

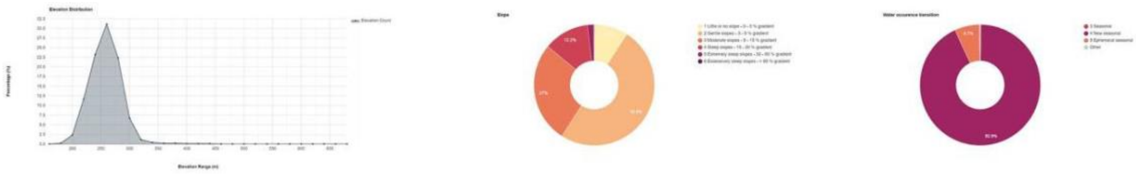
In ABC-Map, the geophysical profile is composed of a set of indicators that allow for an overview of the geophysical properties of a selected area. The indicators include the total area, information on elevation, slope (based on the Shuttle Radar Topography Mission) and water occurrence based on the European Commission’s Joint Research

Centre (JRC) Global Surface Water Mapping Layers (Pekel *et al.*, 2017). The main outputs are:

- summary statistics for the elevation profile, including an elevation distribution;
- summary statistics for the slope profile, including the slope distribution; and
- summary statistics for the water profile, including the water occurrence transition distribution.

These indicators are detailed and explained in the *Indicators* section below.

Figure 7. ABC-Map's geophysical indicators



Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

Indicators

Elevation

The elevation indicator provides elevation statistics on average elevation, maximum elevation, minimum elevation, and elevation distribution.

The elevation statistics section uses the NASA SRTM Digital Elevation 30 m to calculate the average, maximum and minimum elevation, as well as an elevation distribution chart for the selected AoI.

While the entire AoI is considered for the elevation statistics, for visualization purposes, water bodies (identified using JRC Global Surface Water Mapping Layers, v1.2 [Pekel *et al.*, 2017.]) are not displayed on the map.

Slope

The slope indicator is composed of several metrics: average slope, maximum slope, minimum slope and slope distribution.

The slope statistics section uses the NASA SRTM Digital Elevation 30 m to calculate the slope gradient statistics and map. The local gradient is computed using the four-connected neighbours of each pixel in degrees. After calculating the gradient, ABC-Map uses the categorized slope gradient (in percentage) definitions used by the Canadian Government on their National Soil Database (Government of Canada, 2013), as described in Table 3.

Table 3. Landform slope classes

Class	Description
Little or none	Little or no slope: 0–3% gradient.
Gentle	Gentle slopes: 4–9% gradient.
Moderate	Moderate slopes: 10–15% gradient.
Steep	Steep slopes: 16–30% gradient.
Extremely steep	Extremely steep slopes: 31–60% gradient.
Excessively steep	Excessively steep slopes: > 60% gradient.

Source: Government of Canada. 2013. Landform Slope Class. Cited 7 October 2022.
https://sis.agr.gc.ca/cansis/nsdb/slc/v3.2/ldt/lf_slope.html

While the entire AoI is considered for the slope statistics, for visualization purposes, water bodies (identified using JRC Global Surface Water Mapping Layers, v1.2 [Pekel *et al.*, 2017]) are not displayed on the map.

Water occurrence

Freshwater ecosystems are among the most degraded and threatened ecosystems on a global scale. Given the likelihood that demand for available water resources will increase in the future, water ecosystem services need to be protected by addressing biodiversity conservation policies and management of river basins and riverine habitats (JRC, n.d.).

On ABC-Map, the water occurrence distribution statistics use the JRC Global Surface Water Mapping Layers, v1.3 dataset to calculate the categorical classification change between the first (1984) and last year (2020) for the selected AoI.

JRC Global Surface Water Mapping Layers, v1.3 defines the following nine possible categories:

1. new permanent
2. lost permanent
3. seasonal
4. new seasonal
5. lost seasonal
6. seasonal to permanent
7. permanent to seasonal
8. ephemeral permanent
9. ephemeral seasonal

ABC-Map aggregates all of the areas that have the same classification and calculates the corresponding percentage.

Geophysical profile datasets in greater detail

NASA SRTM Digital Elevation 30 m

The Shuttle Radar Topography Mission (Farr *et al.*, 2007) digital elevation data are the result of international research that obtained digital elevation models on a near-global scale. The SRTM V3 product (SRTM Plus) used in ABC-Map is provided on GEE (ID: USGS/SRTMGL1_003) by NASA JPL at a resolution of 1 arc-second (approximately 30 m).

JRC Global Surface Water Mapping Layers, v1.2

The JRC Global Surface Water Mapping Layers, v1.2 (Pekel *et al.*, 2017) provided on GEE (ID: JRC/GSW1_2/GlobalSurfaceWater) contains maps of the location and temporal distribution of surface water from 1984 to 2019, and provides statistics on the extent and change of these water surfaces.

These data were generated using 4 185 439 scenes from Landsat 5, 7 and 8 acquired between 16 March 1984 and 31 December 2019. Each pixel was individually classified into water/non-water using an expert system, and the results were collated into a monthly history for the entire period and two epochs (1984–1999, 2000–2019) for change detection.

JRC Global Surface Water Mapping Layers, v1.3

The JRC Global Surface Water Mapping Layers, v1.3 (Pekel *et al.*, 2017) provided on GEE (ID: JRC/GSW1_3/GlobalSurfaceWater) contains maps of the location and temporal distribution of surface water from 1984 to 2020, and provides statistics on the extent and change of these water surfaces.

These data were generated using 4 453 989 scenes from Landsat 5, 7 and 8 acquired between 16 March 1984 and 31 December 2020. Each pixel was individually classified into water or non-water using an expert system, and the results were collated into a monthly history for the entire period and two epochs (1984–1999, 2000–2020) for change detection.

The biodiversity section

As reported by the IPCC:

> Unsustainable land use and land cover change, unsustainable use of natural resources, deforestation, loss of biodiversity, pollution, and their interactions, adversely affect the capacities of ecosystems, societies, communities, and individuals to adapt to climate change (IPCC, 2022a, p. 12).

The biodiversity section was therefore conceived to help safeguard the global environment through enhanced international cooperation and connected, locally relevant measures. This section within ABC-Map provides four indicators that complement each other and presents a holistic view of pressures and impacts on biodiversity, as follows:

1. mean species abundance (MSA), which expresses the abundance of original species;
2. key biodiversity areas (KBAs), which are sites that contribute significantly to biodiversity;
3. protected areas, which are geographical areas protected through legal or other effective means; and
4. natural capital, which expresses in US dollars the stock of natural assets and the ecosystem services provided by them.

Box 2. Using the natural capital and mean species abundance together as a biodiversity proxy

While the natural capital and mean species abundance (MSA) assessments are an innovative approach to allow for accounting via geospatial data, it is important to note that there are also limitations stemming from both indicators.

For example, with the natural capital indicator, if a land cover product misclassified the actual land uses, the final natural capital assessment will be distorted. Regarding the Ecosystem Services Valuation Database (ESVD), one limitation is that the data of the 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, although more studies are continuously added. Additionally, the ESVD does not account for different degradation levels of ecosystems.

For this reason, these two indicators should be considered **complementary,** i.e. while MSA has limitations on differentiating the ecological value, natural capital does not, and while natural capital does not include degradation levels of ecosystems, MSA does.

Hence, when both indicators are used in a complementary way, they provide a good proxy to measure if biodiversity is improving or deteriorating (Audebert *et al.*, 2022).

Mean species abundance

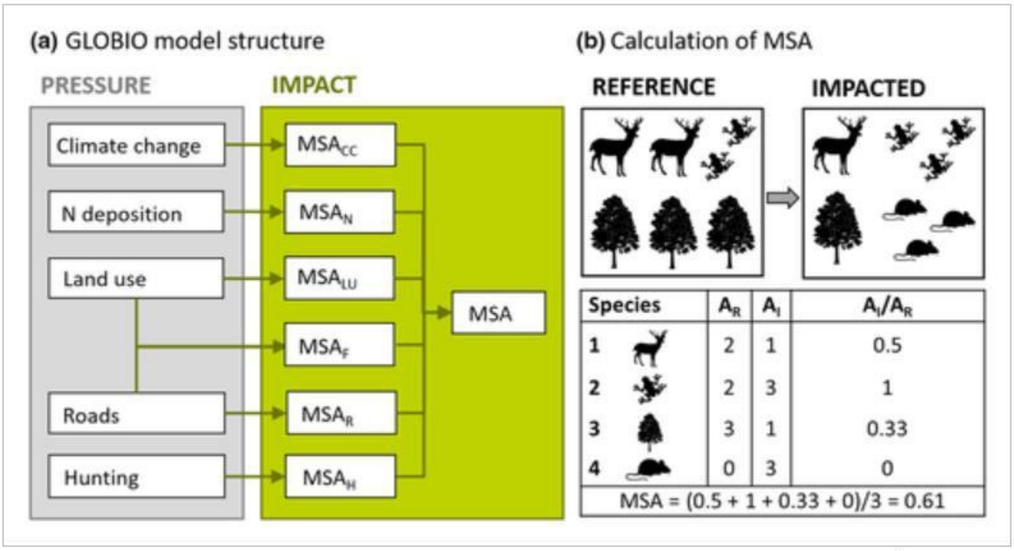
The quantitative assessment of the biodiversity section relies on the MSA metric. This metric expresses the mean abundance of original species in disturbed conditions relative to their abundance in an undisturbed habitat. It acts as an indicator of the degree to which an ecosystem is intact, and varies between 0 percent and 100 percent (or 0 and 1) (Schipper *et al.*, 2016), where:

- MSA = 100 percent, highlighting an undisturbed ecosystem where all original species remain.
- MSA = 0 percent, highlighting a destroyed ecosystem with no original species left.

This indicator can be seen as a function of six anthropogenic pressures: land use, infrastructure (also referred to as 'road disturbance'), habitat fragmentation, human encroachment (also referred to as 'hunting'), atmospheric nitrogen deposition and climate change.

The MSA, which is one of the most widely used indicators in biodiversity accounting, has been endorsed by the international scientific community and is used by the IPBES and the IPPC in their reports. (Lammerant *et al.*, 2021). The methodology of the MSA assessment is based on GLOBIO Version 3.5 (Alkemade *et al.*, 2009) developed by the Netherlands Environmental Assessment Agency (PBL). GLOBIO makes use of extensive terrestrial biodiversity databases (such as the Integrated Model to Assess the Global Environment) to establish quantitative pressure-impact relationships. A total of six major taxonomic groups are covered by GLOBIO: mammals, birds, reptiles, amphibians, terrestrial invertebrates, and vascular plants. The GLOBIO structure and calculation of the MSA are illustrated in Figure 8.

Figure 8. The GLOBIO structure and calculations of MSA values



Source: *Schipper et al., 2016. The GLOBIO Model. A technical description of version 3.5*. The Hague, PBL Netherlands Environmental Assessment Agency.

The MSA metric was chosen as one of the indicators on ABC-Map since its vast number of pressure-impact relationships, which are relevant to AFOLU activities, have been readily defined by credible sources. Moreover, with the use of the MSA metric, different weights can be given to different ecosystems depending on priorities emerging from a specific context, a useful potential for a globally developed tool applied at local levels.

Although ABC-Map applies GLOBIO's methodology, major adaptations were made to fit the scope and objectives of the tool, as shown in Table 3. Unlike GLOBIO, which focuses on global-level assessments, ABC-Map assesses impacts from project-level activities. Furthermore, while GLOBIO is used mainly for future impact estimates based on geo-spatialized trends data aggregated from a grid-cell level, ABC-Map is a spatially explicit land-based accounting system that aims to provide impact appraisals of expected project activities.

Additionally, ABC-Map excludes the climate change and nitrogen deposition pressures used in GLOBIO's structure. Since the impact of GHG 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 CO_2 equivalent (tCO_2-e). Nitrogen deposition puts an important pressure on biodiversity, and it is the consequence of global emissions of oxidized nitrogen from fossil fuel combustion and reduced nitrogen 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.

Based on the MSA, ABC-Map provides an additional indicator, the area of intact biodiversity (AIB), which corresponds to a surface area equivalent of the MSA value. For instance, an AIB of 500 ha corresponds to the value of biodiversity contained in 500 ha of a forest undisturbed by human activities.

The MSA metric does have some limitations, however, because it does not consider the ecological value of project sites. For example, both a forest and desert are considered completely intact land uses and have an MSA value of 1. To compensate for the inadequacy of the MSA metric in factoring in this ecological value, ABC-Map provides an additional natural capital indicator (see Box 2).

Table 4. Differences in scope and objectives between GLOBIO and ABC-Map

	Scope	Objective
GLOBIO v3.5	Global-level assessments	Future impact estimates based on geo-spatialized trends data
ABC-MAP	Project-level assessments	Geospatially explicit impact appraisals of expected or concluded project activities

Source: Author` s elaboration based on *Schipper et al., 2016. The GLOBIO Model. A technical description of version 3.5.* The Hague, PBL

ABC-Map is a spatially explicit, land-based accounting system, which requires the user to divide the project area into baseline and project activity plots (see the *Project panel* section).

The aggregate MSA value of each plot is derived from the area-weighted mean of the MSA values for the land use, habitat fragmentation and infrastructure pressures. This value is then multiplied by the MSA values from human encroachment impacts to obtain the final MSA. Both a baseline and project MSA are derived to allow the user to compare the difference in potential biodiversity impact.

The aggregate MSA value for both baseline and project activity is calculated as follows:

Equation 1

$$msaAggregate(r,t) = \left[\frac{\frac{1}{n}\sum_{i=1}^{i=n}(\text{msaLu}_{i,r,t} * msaF_{i,r,t} * msaI_{i,r,t}) * pixelArea_{i,r}}{\sum_{i=1}^{i=n} pixelArea_{i,r}}\right] * \frac{\frac{1}{n}\sum_{i=1}^{i=n}(msaHe_{i,r,t}) * pixelArea_{i,r}}{\sum_{i=1}^{i=n} pixelArea_{i,r}}$$

Where:

- $msaAggregate(r,t)$ = aggregate mean species abundance (MSA) for the area of intervention for a given image with resolution r and year t;
- $msaLu_{i,r,t}$ = land use MSA value in pixel i and year t in the given image with r;
- $msaF_{i,r,t}$ = habitat fragmentation MSA value in pixel i and year t in the given image with r;
- $msaI_{i,r,t}$ = infrastructure MSA value in pixel i and year t in the given image with r;

- $msaHe_{i,r,t}$ = human encroachment MSA value in pixel i and year t in the given image with r; and
- $pixelArea_{i,}$ = the area of each pixel i given image with r.

Since an image is reduced at a certain scale in GEE, each pixel will have the same size. Therefore, the formula above can be simplified to the following:

Equation 2

$$msaAggregate(r,t) = \frac{1}{n}\sum_{i=1}^{i=n}(\text{msaLu}_{i,r,t} * msaF_{i,r,t} * msaI_{i,r,t} * msaHe_{i,r,t}) * \sum_{i=1}^{i=n} pixelArea_{i,r}$$

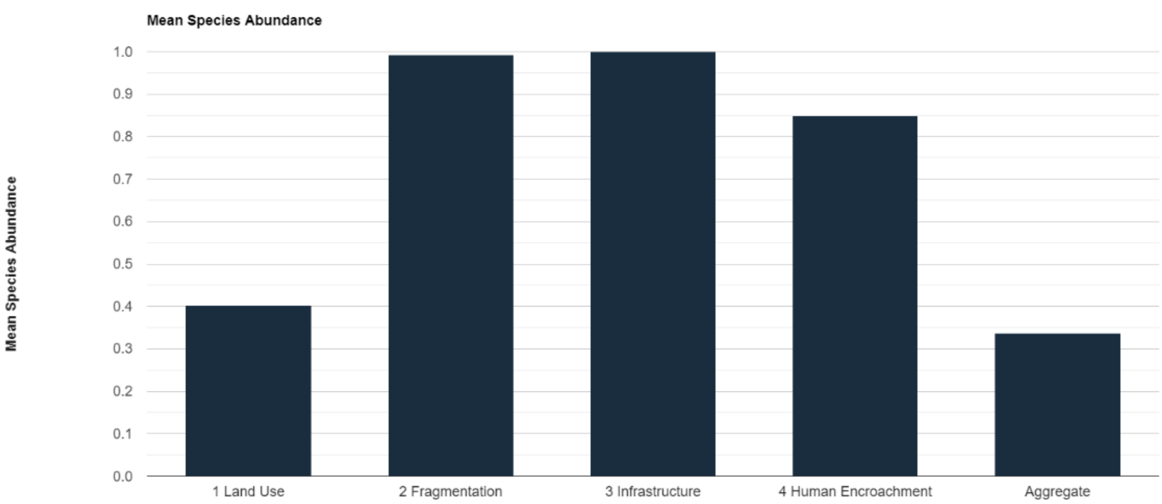
Anthropogenic pressures on MSA

ABC-Map considers four anthropogenic impacts, or pressures, on biodiversity:

1. impacts of land use;
2. disturbance by infrastructure;
3. habitat fragmentation due to land use and infrastructure; and
4. human encroachment.

By breaking down the MSA aggregate indicator in the different MSA pressures, it is possible to see how these pressures influence the MSA aggregate value for the selected AoI (for the last year of available data). In this section, the different pressures and their calculations are explained in detail.

Figure 9. MSA values for each pressure



Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

Impact of land use

Cause and effect relationships between land use and MSA were identified using GLOBIO, based on findings from studies reporting species composition in given types and intensities of land use, as well as in undisturbed reference situations. The GLOBIO land use classes and ABC-Map land use classes have been aligned, as shown in Annex I, in ABC-Map together with the MSA_{LU} values assigned to each land use class.

Below is the equivalence between ABC-Map land use classes, the GLOBIO land uses and the corresponding MSA_{LU} values:

Equation 3

$$msaLu_{i,r,t} = landUse_{ABC-Map_{i,r,t}} \equiv landUse_{GLOBIO_i}$$

Where:

- $msaLu_{i,r,t}$ = land use MSA value in pixel i and year t in the given image with r;
- $landUse_{ABC-Map_{i,r,t}}$ = ABC-Map land use in pixel i and year t in the given image with r; and
- $landUse_{GLOBIO_i}$ = matched GLOBIO land use for pixel i.

Impact of habitat fragmentation

Habitat fragmentation is assumed to be induced by roads, cropland, and urban areas. The mean species abundance due to the fragmentation (MSA_F) value on ABC-Map is based on GLOBIO, shown in Table 4, and related to the size of non-fragmented natural area.

Table 5. GLOBIO MSA values by size range of non-fragmented natural area

Non-fragmented natural area (km^2)	Mean species abundance (MSA_F)
0–1	0.35
1–10	0.45
1–100	0.65
100–1 000	0.90
1 000–10 000	0.98
>10 000	1.00

Source: Schipper *et al*., 2016. The GLOBIO Model. A technical description of version 3.5. The Hague, PBL

ABC-Map automatically calculates the MSA_F value for each plot in order to identify the impact of fragmentation by calculating the area of non-fragmented natural areas. Accordingly, all connected (or non-fragmented) natural pixels are first grouped into fragmentation groups.

These groups also consider all surrounding and adjacent pixels. The area size of the fragmentation groups, hereafter referred to as *fragmentationGroupArea*, will determine the extent of habitat fragmentation in pixels i. In mathematical terms, this can be expressed as follows:

Equation 4

If $i = artificial$ then $i = i_a$ and $\text{msaF}_{i_a,r,t} = 1$
Else $i = i_n$

$$\text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} = \sum_{i_n=1}^{i_n=n} pixelArea_{i_{n_{adjacent}},r} + pixelArea_{i_n,r}$$

If $0 \text{ ha} < \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} < 100 \text{ ha}$,

$$msaF_{i_n,r,t} = \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} * \left[0.35 + \left(\frac{0.45 - 0.35}{100 - 0}\right)\right]$$

If $100 \text{ ha} < \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} < 1e3\ ha$,

$$msaF_{i_n,r,t} = \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} * \left[0.45 + \left(\frac{0.65 - 0.45}{1e3 - 100}\right)\right]$$

If $1\text{e}3 \text{ ha} < \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} < 1e4 \text{ ha}$,

$$msaF_{i_n,r,t} = \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} * \left[0.65 + \left(\frac{0.90 - 0.65}{1e4 - 1e3}\right)\right]$$

If $1\text{e}4 \text{ ha} < \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} < 1e5 \text{ ha}$,

$$msaF_{i_n,r,t} = \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} * \left[0.90 + \left(\frac{0.98 - 0.90}{1e5 - 1e4}\right)\right]$$

If $1\text{e}5 \text{ ha} < \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} < 1e6 \text{ ha}$,

$$msaF_{i_n,r,t} = \text{fragmentationGroupArea}_{i_n,i_{n_{adjacent}},r,t} * \left[0.98 + \left(\frac{1 - 0.98}{1e6 - 1e5}\right)\right]$$

Otherwise $msaF_{i_n,r,t} = 1$

Where:

- i_a = pixel classified as 'artificial';
- i_n = pixel classified as 'natural';
- $msaF_{i_a,r,t}$ = mean species abundance for artificial pixels for a given image with resolution r and year t;
- $msaF_{i_n,r,t}$ = mean species abundance for natural pixels for a given image with resolution r and year t;
- *fragmentationGroupArea* $i_n,i_{n_{adjacent}},r,t$ = area of the connected natural pixel i_n and the sum of all adjacent natural pixels $i_{n_{adjacent}}$ for a given image with resolution r;

- $pixelArea_{i_n}$ = area of each natural pixel; and
- $pixelArea_{i_n adjac}$, = area of each natural pixel adjacent to pixel i_n.

The categorization of the land use classes into natural and non-natural areas is shown in Annex I.

Impact of infrastructure

Biodiversity disturbance from infrastructure is assumed to be confined to an impact zone of 1 km^2 around infrastructural elements under GLOBIO. Both roads and railways are considered biodiversity disturbing infrastructure. The cause-and-effect relationship between infrastructure and MSA is quantified based on a meta-analysis (Benítez-López, Alkemade and Verweij, 2010), assigning the overall MSA_I for the 1-km impact zone as 0.78. As GLOBIO assumes that infrastructure does not cause additional MSA loss in urban areas and cropland except for the direct effect of land use, the MSA_I for urban areas and cropland is 1.

ABC-Map automatically calculates the MSA_I value as follows:

Equation 5

If $i = artificical$:

$i = i_a$ *and* $\text{msal}_{i_a,r,t} = 1$

Otherwise:

$i = i_n$

If $\text{msal}_{i_n,r,t} = 1 - \left[\frac{(I_{i_n}*2)}{pixelArea_{i_n,r}} * (1 - 0.78)\right] < 0.78$ then:

$msaI_{i_n,r,t} = 0.78$

Otherwise:

$$\text{msal}_{i_n,r,t} = 1 - \left[\frac{(I_{i_n} * 2)}{pixelArea_{i_n,r}} * (1 - 0.78)\right]$$

Where:

- $msaI_{i_a,r,t}$ = infrastructure MSA value in 'artificial' pixel i and year t in the given image with r;
- $msaI_{i_n,r,t}$ = infrastructure MSA value in 'natural' pixel i and year t in the given image with r;
- I_i = infrastructure (roads and railways) in pixel i in kilometres; and
- $pixelArea_{i_n}$, = area of each 'natural' pixel in the given image with r.

Impact of human encroachment

Human encroachment can be defined as anthropogenic activities in otherwise natural areas, comprising hunting, food and fuel gathering, recreation and human settlements. GLOBIO assumes that a proportion of cropland and urban area of 1.5 percent is sufficient to have the entire project area influenced by human encroachment, based on estimates from model simulations.

Based on GLOBIO, ABC-Map automatically calculates the MSA_F as follows: **Equation 6**

If $\frac{\sum_{i_{crop,urban}=1}^{i_{crop,urban}=n} pixelArea_{i_{crop,urban}}}{\sum_{i=1}^{i=n} pixelArea_i} > 1.5\%$

Then

$$msaHe_{i_{crop,urban},i,r,t} = 0.85$$

Otherwise

$$msaHe_{i_{crop,urban},i,r,t} = 1$$

Where:

- $msaHe_{i_{crop,urban},i,r,t}$ = Human encroachment MSA value for the area of interest in year t in the given image with r ; and
- $pixelArea_{i_{crop,an}}$= Area of each pixel classified as urban or cropland in the given image with r.

Indicators

Mean species abundance

ABC-Map provides a time series for the MSA aggregate value. This allows for an overview of how the MSA aggregate has evolved throughout the years. The time series of the baseline varies depending on the spatial resolution chosen: usually, the coarser the spatial resolution, the longer the time series. For example, for the ESA CCI-LC dataset, the land use time series ranges from 1992 to 2020, while the land use time series of the ESA CCI Land Cover S2 Prototype for Mesoamerica is limited to one year. The user can specify the length of the implementation period of a project, which leads to a variable time series for the project impact evaluation.

MSA datasets in greater detail

ESA Land Cover CCI v2.1

The European Space Agency (ESA) CCI-LC project delivers consistent global land cover (LC) maps from satellite derived parameters at 300 m spatial resolution on an annual basis from 1992 to 2020 (Land Cover CCI Product User Guide Version 2.0, 2017).

CCI-LC identifies 22 classes that, for use in ABC-Map, are converted to IPCC equivalent classes using the conversion table in Annex II.

ESA CCI Land Cover S2 Prototype LC Map at 10 m of Mesoamerica

The CCI Land Cover S2 Prototype LC Map at 10 m of Mesoamerica is a prototype, high-resolution LC map at 10 m over Mexico and Central America based on more than two years of Sentinel-2A and 2B observations from January 2016 to March 2018.

CCI Land Cover S2 Prototype LC Map At 10 m of Mesoamerica identifies 10 classes that, for use in ABC-Map, are converted to IPCC equivalent classes using the conversion table in Annex II.

ESA CCI Land Cover S2 Prototype LC Map at 20 m of Africa 2016

The CCI Land Cover S2 Prototype LC Map at 20 m of Africa 2016 is a prototype, high-resolution LC map at 20 m over Africa based on one year of Sentinel-2A observations from December 2015 to December 2016.

The CCI Land Cover S2 Prototype LC Map at 20 m of Africa 2016 identifies 10 classes, that, for use in ABC-Map, are converted to equivalent classes from the IPCC using the conversion table in Annex II.

S2GLC Land Cover Map of Europe 2017

The Land Cover Map of Europe 2017 is a product resulting from Phase 2 of the S2GLC (Sentinel-2 Global Land Cover) project. The final map has been produced by Centrum Badań Kosmicznych PAN (CBK PAN). The pixel size of the map equals 10 m, and its overall accuracy was estimated at 86 percent using over 15000 Sentinel-2 images for the LC classification.

S2GLC Land Cover Map of Europe 2017 identifies 13 classes that, for use in ABC-Map, are converted to IPCC equivalent classes using the conversion table in Annex II.

Copernicus Global Land Cover Layers (CGLS-LC100): Collection 3

Copernicus Global Land Cover Layers (CGLS-LC100) Collection 3 map at 100 m resolution delivers a global land cover map at 100 m spatial resolution (Buchhorn *et al.*, 2020).

The CGLS-LC100 Collection 3 maps are provided for the 2015–2019 period over the entire globe and reach an accuracy of 80 percent at Level 1 over all years.

CGLS-LC100 Collection 3 identifies 23 classes that, for use in ABC-Map, are converted to IPCC equivalent classes using the conversion table in Annex II.

Global Roads Inventory Project (GRIP), 2018

The Global Roads Inventory Project is a harmonized global dataset of road infrastructure. The resulting dataset covers 222 countries and includes over 21 million km of roads (Meijer *et al.*, 2018). This dataset is divided into five road types: highways; primary; secondary; tertiary; and local roads.

Forest Landscape Integrity Index

The Forest Landscape Integrity Index (Grantham *et al.*, 2020) integrates data on observed and inferred forest pressures and lost forest connectivity to generate the first globally consistent, continuous index of forest integrity as determined by degree of anthropogenic modification.

Key biodiversity areas

According to the International Union for Conservation of Nature (IUCN), key biodiversity areas (KBA) are "sites contributing significantly to the global persistence of biodiversity, in terrestrial, freshwater and marine ecosystems" (IUCN, 2016, p. 9). The Global Standard for the Identification of Key Biodiversity Areas sets out globally agreed criteria for the identification of KBAs worldwide (IUCN, 2016). Identifying and monitoring KBAs can be a crucial step in conserving critical parts of biodiversity and ecosystems.

In collaboration with the IUCN, ABC-Map allows the user to geo-localize the KBAs within a given area of intervention. In addition to the mapping of the KBAs, the tool also shows the land use trends within the KBAs. Knowing both the location of the project and changes in land uses allows the user to take informed decisions on whether, where and how to implement project activities to ensure the conservation and sustainable use of biodiversity.

Indicators

Key biodiversity areas

Based on the global KBAs database, the main outputs of ABC-Map are:

- the total area of KBAs within the AoI;
- land cover time series (classified into broad IPCC categories) of the evolution of land use for the KBAs within the AoI; and
- map showing the KBAs within the AoI.

Key biodiversity areas datasets in greater detail

World Database of Key Biodiversity Areas

The Key Biodiversity Areas Programme (KBA Partnership, 2022) was developed through a partnership of 13 global conservation organisations, including BirdLife International and the IUCN, using the Global Standard for the Identification of KBAs. This program supports the identification, mapping, monitoring and conservation of KBAs, and maintains a GIS dataset of KBA boundaries.

ESA Land Cover CCI v2.1

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 10 m of Mesoamerica

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 20 m of Africa 2016

See MSA datasets in greater detail.

S2GLC Land Cover Map of Europe 2017

See MSA datasets in greater detail.

Copernicus Global Land Cover Layers (CGLS-LC100): Collection 3

See MSA datasets in greater detail.

Protected areas

As defined by IUCN, a protected area is:

> [a] clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Dudley, 2008, p. 8).

The Post-2020 Global Biodiversity Framework sets a specific target (target 3) to:

> [e]nsure and enable that by 2030 at least 30 percent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas and other effective area-based conservation measures… (CBD, 2022, p. 9).

Protected areas are identified as a means to reduce threats to biodiversity. Similar to the KBAs, ABC-Map provides the user with the exact location of the protected areas in the project zone together with a distribution of the land uses and their evolution over time within these protected areas.

Indicators

Protected areas

Based on the World Database on Protected Areas (WDPA) the main outputs of ABC-Map are:

- the total area of protected areas within the AoI, as a percentage of the AoI;
- land cover time series (classified into broad IPCC categories) of the trends in land use for the protected areas within the AoI; and
- map showing all the protected areas within the AoI.

Protected areas datasets

The World Database on Protected Areas

The WDPA is the most up-to-date and complete source of information on protected areas (UNEP-WCMC and IUCN, 2022). It is composed of submissions from governments, non-governmental organizations, landowners and communities, and is managed by the United Nations Environment Programme's World Conservation Monitoring Centre (UNEP-WCMC), with support from IUCN and its World Commission on Protected Areas (UNEP-WCMC and IUCN, 2022).

The WDPA categorizes different types of protected areas (UNEP-WCMC, 2019):

1a. strict nature reserve
1b. wilderness area
2. national park
3. natural monument
4. habitat/species management
5. protected landscape/seascape
6. protected area with sustainable use of natural resources.

On ABC-Map, all types are aggregated under a single category, and simply considered protected areas.

ESA Land Cover CCI v2.1

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map At 10 m of Mesoamerica

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 20 m of Africa 2016

See MSA datasets in greater detail.

S2GLC Land Cover Map of Europe 2017

See MSA datasets in greater detail.

Copernicus Global Land Cover Layers (CGLS-LC100): Collection 3

See MSA datasets in greater detail.

Natural capital

The CBD defines natural capital as:

> [t]he 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 services, often called ecosystem services, which make human life possible (CBD, 2021, para. 2).

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, inspirational, and cultural identity) and supporting services (e.g. life cycle maintenance). 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.

Although our well-being depends "upon the continued flow of these 'ecosystem services', they are predominantly public goods with no markets and no prices" (TEEB, 2008, p. 9). Both public and private implementing bodies, therefore, often neglect their economic and monetary value. As a result, investment decisions are still mainly based on financial cost-benefit analyses, which ignore most of the negative (and positive) externalities leading to continued degradation of our ecosystems and the loss of biodiversity. Although this will affect society at large, people in rural areas are most at risk because of their high dependence on ecosystem services, such as those that contribute to food production via agriculture, fishing and hunting.

Indicators

Natural capital

The natural capital assessment is an important indicator that links the ecosystem service values of ESVD to geospatial data. ABC-Map provides a time series analysis of the natural capital of an AoI, for both baseline and project activities.

The mathematical model of the natural capital indicator of ABC-Map can be described as follows:

Equation 7

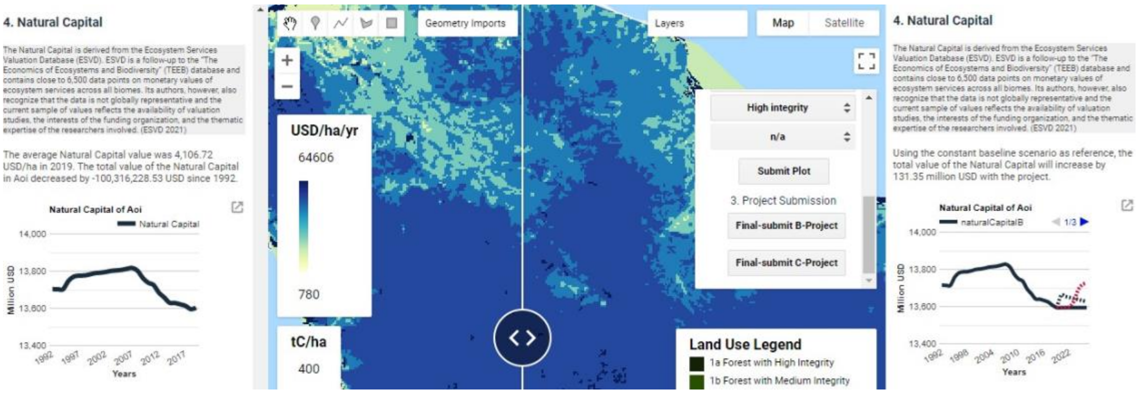
$$naturalCapitalAggregate(r,t) = \frac{\frac{1}{n}\sum_{i=1}^{i=n} naturalCapital_{i,r,t} * \sum_{i=1}^{i=n} pixelArea_{i,r}}{(1+r)^{t-2020}}$$

Where:

- $naturalCapitalAggregate(r,\ t)$ = aggregate natural capital for the area of intervention for a given image with resolution r and year t;
- $naturalCapital_{i,r,t}$ = natural capital value in pixel i and year t in the given image with r;
- $pixelArea_{i,r}$ = area of each pixel in the given image with r; and
- r = discount rate, i.e. the return that could be earned per unit of time on an investment with similar risk.

Figure 10 shows an afforestation project in which annual and perennial croplands are converted to forests. This land use change will lead to an increase in the natural capital as shown both on the map and in the graph on the right panel, which shows the project impact as a red dotted line, compared to a constant baseline shown as a blue solid line.

Figure 10. Baseline map of the natural capital (left panel: baseline; right panel: project)



Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

Natural capital datasets

The Ecosystem Services Valuation Database

One of the leading and most comprehensive studies on the economic importance of ecosystem services is The Economics of Ecosystems and Biodiversity (TEEB) study (Groot *et al.*, 2021). Within its context, a database on the monetary values of ecosystem services was developed by the Foundation for Sustainable Development (FSD). 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). 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. This was achieved with financial support from the Department for Environment, Food and Rural Affairs (UK) in 2019; FAO in 2020; the Dutch Ministry of Agriculture, Nature and Food Quality in 2020–2021; and again, FAO in 2021 through its contribution to the State of the World's Forests. The many publications used in ESVD cover many ecosystems, types of landscapes, different definitions of services, different areas, different levels of scale, time and complexity, and different valuation methods.

Wherever possible, value records are standardized to a common set of units (International dollars/ha/year in 2020 price levels) based on the combination of a biome and an ecosystem service. The summary statistics can be understood as the average of all standardized values for a combination of a biome and an ecosystem service. A summary value reflects the availability of valuation studies, the interests of funding organizations, and the thematic expertise of the researchers involved. ESVD covers a total of 16 biomes and 79 different ecosystems, with 23 TEEB ecosystem services (including genetic resources, air quality regulation, pollination, erosion prevention, etc.).

ESA Land Cover CCI v2.1

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 10 m of Mesoamerica

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 20 m of Africa 2016

See MSA datasets in greater detail.

S2GLC Land Cover Map of Europe 2017

See MSA datasets in greater detail.

Copernicus Global Land Cover Layers (CGLS-LC100): Collection 3

See MSA datasets in greater detail.

The carbon section

According to the IPCC Climate Change 2022 report (IPCC, 2022b), anthropogenic GHG emissions have increased since 2010 across all major sectors globally, and about half of total net AFOLU emissions are from land use, land use change, and forestry, predominantly from deforestation. However, a strong, rapid and sustained reduction in emissions of carbon dioxide (CO_2) and other GHGs would limit climate change and its impacts on people, ecosystems and livelihoods throughout the world.

Box 3. The Nationally Determined Contribution Expert Tool

The Nationally Determined Contribution Expert Tool (NEXT) is a greenhouse gas (GHG) accounting tool developed by the Food and Agriculture Organization of the United Nations (FAO) to support annual environmental impact assessments in the agriculture, forestry and other land use (AFOLU) sector.

NEXT provides a 30-year time-series of annual and cumulated estimates of carbon removal and GHG emission reductions from climate actions made by Parties to the Paris Agreement. It was developed using the IPCC methodologies, and estimates can be made using the IPCC 2006 guidelines (IPCC, 2006) or the IPCC 2019 refinement to the IPCC 2006 (IPCC, 2019c), which are both complemented by the IPCC 2013 wetlands supplement (IPCC, 2013).

The tool was designed to provide results that directly respond to the provisions of the Paris Agreement's enhanced transparency framework. It supports the tracking of nationally determined contributions (NDCs) as required by the modalities, procedures and guidelines.

NEXT provides a high temporal series of results and a wide set of indicators, including the social value of carbon. This allows to have a comprehensive environmental and economic overview of climate actions to achieve a mitigation target.

Finally, the tool helps countries interpret, track and scale up the ambition of their NDCs, which could ultimately feed into, and inform the global stocktake of the Paris Agreement in a harmonized manner.

The carbon section of ABC-Map is used to account for these emissions in the aim of reducing them.

This section is composed of indicators on total carbon storage and on social value of carbon, both of which are based on the same methodology used by NEXT with slight adaptations. The tool retains CO_2, methane (CH_4) and nitrous oxide (N_2O) as the main gases for estimating carbon sequestration and GHG emissions.

Total carbon stock

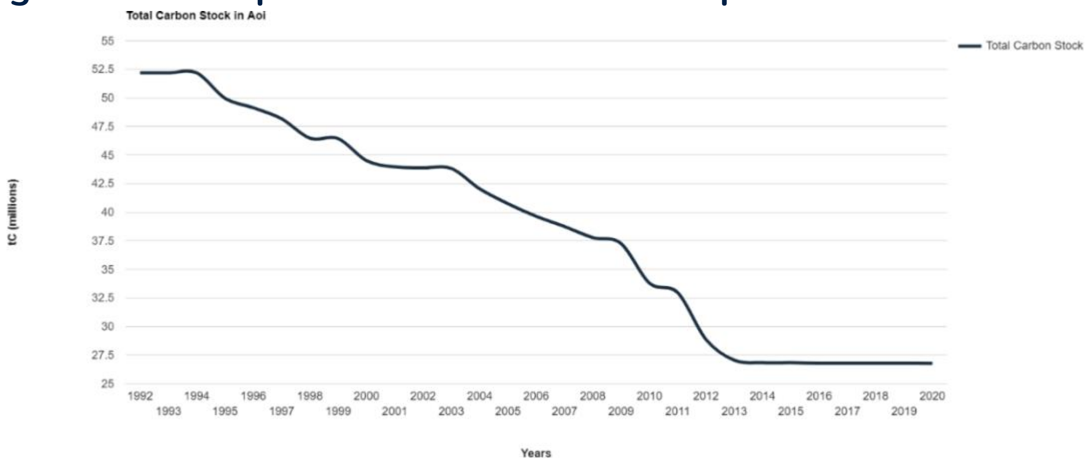
The carbon stock indicator of ABC-Map is based on NEXT and provides an estimate of the total carbon stored in all compartments (i.e. above- and below-ground biomass, soil, deadwood and litter).

Indicators

Total carbon stock

The total carbon stock indicator provides a time series of total carbon stock (tonnes of carbon [tC]) using a stock change approach. To calculate this indicator, ABC-Map matches land cover data with the various IPCC land use classes of NEXT and their associated carbon stocks. The tool begins by aggregating the carbon stocks of the different compartments at the pixel level in order to then aggregate all pixels. The sum of these pixels represents the total carbon stock for a given area and year.

Figure 11. Example of the carbon stock output chart



Source: ABC-Map screenshot, ABC-Map. 2022. Adaptation, Biodiversity and Carbon Mapping Tool. Cited 2 November 2022. abc-map.org

The stock-change approach used is derived from IPCC methodologies, where carbon-calculations follow the approach below:

Equation 8

$$cStock = GSOC \times Flu \times Fmg \times Fi + Biomass$$

Where:

- $cStock$ = the total carbon stock observed in a pixel;
- $GSOC$ = the reference soil organic carbon;
- Flu = the land use factor;
- Fmg = the management factor;
- Fi = the input factor; and
- $Biomass$ = the sum of the total aboveground biomass and belowground biomass.

For forest, plantation and wetland calculations, a slightly different version of formula 8 is used, excluding the management factor (Fmg) and the input factor (Fi), and adding an intactness factor:

Equation 9

$$cStock = (GSOC \times Flu + Biomass) \times Intactness$$

Where:

- $cStock$ = the total carbon stock observed in a pixel;
- $GSOC$ = the reference soil organic carbon;
- Flu = the land use factor (held constant at 1 for forests);
- $Biomass$ = the sum of AGB, BGB, litter and deadwood; and
- $Intactness$ = an adjustment factor for the degradation level of the forest (between 0 and 1).

The generic formula for carbon stock changes is derived from IPCC Guidelines and Refinement, Vol. 4, Ch. 2 (IPCC, 2006; 2019) details information on generic methodologies. The generic methodologies are used principally to account for carbon stock changes and biomass burning during conversion between two categories. Carbon stock changes are addressed using the stock difference method for the six pools: above-ground biomass, below-ground biomass, soil, deadwood, litter, and in some specific cases, harvested wood product.

Equation 10:

$$\Delta C_{land\,use} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{litter} + \Delta C_{HWP\,produced} + \Delta C_{soil}$$

Where:

- $\Delta C_{land\,use}$ = the carbon stock changes for a stratum of land use category;
- ΔC_{AB} = the carbon stock change in above-ground biomass;
- ΔC_{BB} = the carbon stock change in below-ground biomass;
- ΔC_{DW} = the carbon stock change in deadwood;
- ΔC_{litter} = the carbon stock change in litter;
- ΔC_{soil} = the carbon stock change in soil; and
- $\Delta C_{HWP\,produced}$ = the carbon stock change in HWP produced in the country.

Total carbon stock datasets

ESA Land Cover CCI v2.1

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 10 m of Mesoamerica

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 20 m of Africa 2016

See MSA datasets in greater detail.

S2GLC Land Cover Map of Europe 2017

See MSA datasets in greater detail.

Copernicus Global Land Cover Layers (CGLS-LC100): Collection 3

See MSA datasets in greater detail.

The social value of carbon

Governments, financial institutions, and the private sector finance activities that can have impacts on GHG emissions. In economic terms, they are generating global social benefits or costs depending on whether they are decreasing or increasing GHG emissions, respectively. These GHG emissions can be referred to as global externalities'. The social value of carbon is used to help policymakers, financial institutions and other actors determine whether the costs and benefits of a proposed project, investment, or policy to curb climate change are justified. The social cost (or value) of carbon is the discounted monetary value of future climate change damages due to one additional tonne of CO_2-e emissions (Schiettecatte *et al.*, 2022).

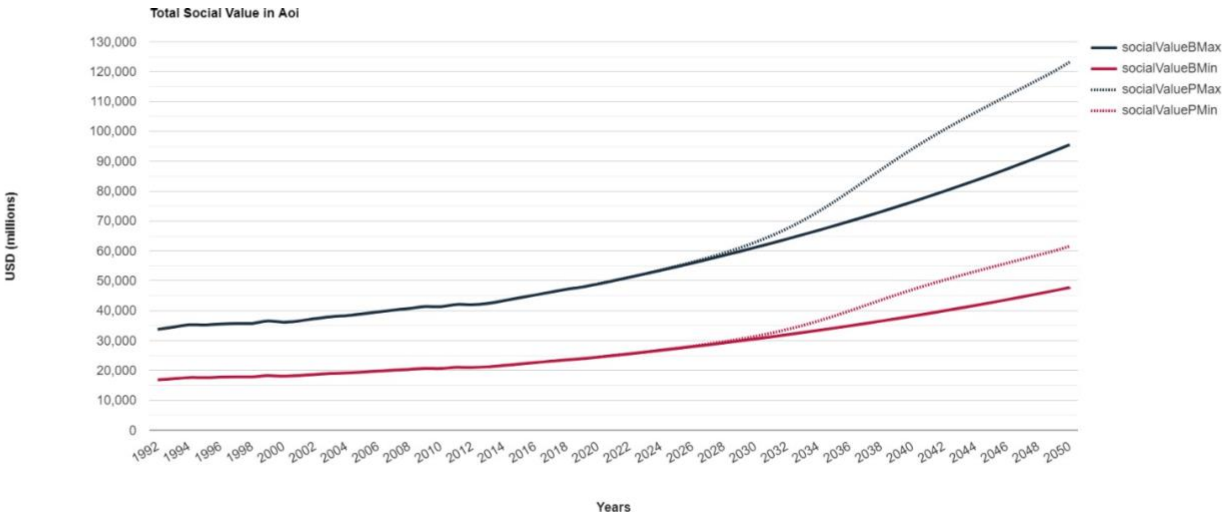
The social value of carbon used in ABC-Map is based on carbon shadow prices from the Report of the High-Level Commission on Carbon Prices, by Stiglitz and Stern (Stiglitz *et al.*, 2017). It is important to note that the carbon shadow prices estimated by the High-Level Commission on Carbon Prices are increasing over time, which is consistent in achieving the core objective of the Paris Agreement of keeping temperature rise below 2 °C, provided a supportive policy environment is in place.

Indicators

The social value of carbon

This indicator provides a time series of the social value of carbon based on carbon shadow prices from the Report of the High-Level Commission on Carbon Prices, by Stiglitz and Stern (Stiglitz *et al.*, 2017), and adjusted for their net present value. The total carbon stock (estimated for the total carbon stock indicator) is converted to tCO_2-e and then multiplied by the shadow price of carbon, adjusted for its net present value (compared to 2017 prices).

Figure 12. Example of the social value of carbon output chart



Source: ABC-Map screenshot, ABC-Map. 2022. *Adaptation, Biodiversity and Carbon Mapping Tool*. Cited 2 November 2022. abc-map.org

Based on the NEXT methodology, a range of values are provided and the minimum and maximum are calculated. The formulas of the minimum and maximum social value of carbon are defined as:

Equation 11:

$$MAXsocialvalueofcarbon_t = -\frac{\left(74.908 \times \exp^{(0.023\times(t-2017))} \times \Delta CO_{2,t}\right)}{\left((1+r)^{(t-2017)}\right)}$$

$$MINsocialvalueofcarbon_t = -\frac{\left(37.436 \times \exp^{(0.023\times(t-2017))} \times \Delta CO_{2,t}\right)}{\left((1+r)^{(t-2017)}\right)}$$

Where:

- $MAXsocialvalueofcarbon_t$ and $MINsocialvalueofcarbon_t$ are, respectively, the maximum and minimum social value of carbon based on carbon shadow process, (Stiglitz *et al.*, 2017) from the reference or target scenario for a given year t;
- $\Delta CO2$ = the carbon-balance of a climate action for a given year t;
- r = the discount rate, i.e. the return that could be earned per unit of time on an investment with similar risk; and
- t = the year of the assessment.

Social value of carbon datasets

ESA Land Cover CCI v2.1

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 10 m of Mesoamerica

See MSA datasets in greater detail.

ESA CCI Land Cover S2 Prototype LC Map at 20 m of Africa 2016

See MSA datasets in greater detail.

S2GLC Land Cover Map of Europe 2017

See MSA datasets in greater detail.

Copernicus Global Land Cover Layers (CGLS-LC100): Collection 3

See MSA datasets in greater detail.

Case studies

This following section showcases concrete uses of ABC-Map, specifically through case studies conducted by IFAD on the development of its Biodiversity Strategy 2022–2025.

IFAD's Biodiversity Strategy 2022–2025 aims to facilitate a more systematic, organized, and generalized integration of the conservation, sustainable use, and promotion of biodiversity in operations. Important aspects of the Biodiversity Strategy implementation are the identification of a core indicator and improved 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 peoples. Among the projects studied by IFAD using ABC-Map, two were selected for this section:

1. The Neer-Tamba project in Burkina Faso
2. The RECAF project in Viet Nam.

Both projects were analysed for adaptation, biodiversity and carbon and therefore provide a comprehensive overview of the type of analyses that can be made using ABC-Map. For both studies, the analysis follows the same approach. First, an analysis is carried out of the baselines of the AoI before the project for each sub-indicator of the Adaptation, Biodiversity and Carbon sections of ABC-Map. Then, an analysis of the outcomes and benefits of the project given by ABC-Map in the same area after the selection of project plots and the type of project were indicated in the tool.

Case study 1 – The Neer-Tamba project in Burkina Faso

Project title: Participatory Natural Resource Management and Rural Development Project in the *Est*, *Centre-Nord* and *Nord* Regions (Neer-Tamba)

Project duration: 10 years (2013–2022)

Total project budget: USD 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 due to 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 are the main natural resources on which rural populations largely base their economic and social development. Agricultural activities in the broad sense remain highly dependent on the variability of agro-climatic conditions.

The project's development goal and objective

The development objective of the Neer-Tamba project is to improve the living conditions and income of the most disadvantaged rural populations. Its specific objectives are to support the target populations to build and strengthen their autonomy and their ability to play an increasingly leading role in the development 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 an integration or accumulation path; and (iii) agro- pastoral systems. The aim of the Neer-Tamba project is therefore to create an enabling environment for the rural poor in the project area to move from production system (i) to (ii), and then ideally to (iii).

Table 6. 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 through the introduction of *aménagements hydro-agricoles* (hydro-agricultural management) on conventional annual cropland	6 000
4	Improvement of conventional annual cropland with the introduction of small irrigation	600

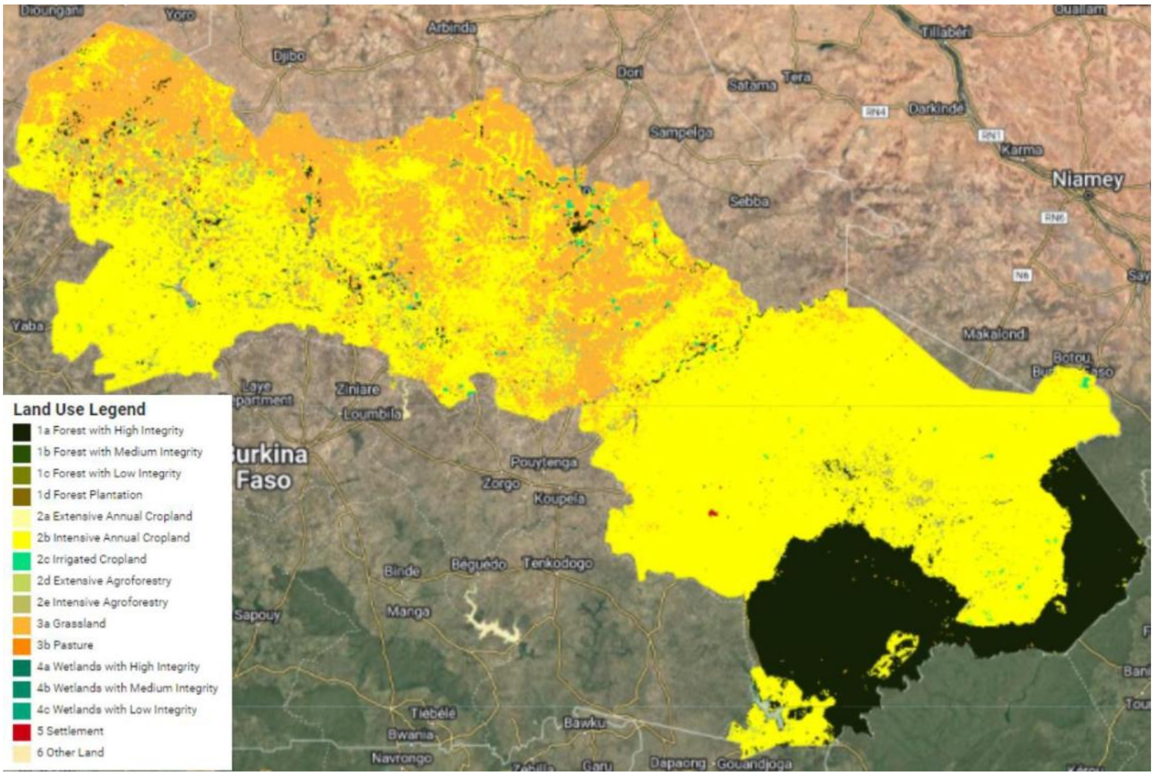
Source: Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Burkina Faso is one of the countries that is most vulnerable to 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 addition, the number of dry days has increased from 277 to 295 days per year, which is particularly worrisome in a region that is highly dependent on rainfed agriculture. This increase in the number of dry days is accompanied by an increased number of extreme precipitations from 0 days in 1981 to 0.35 days per year (with more than 60 mm of rain).

Considering the large extent of the project intervention area with a total of 8 300 372 ha, representing roughly one-third of the entire area of Burkina Faso, a spatial resolution of 300 m (i.e. the size of each pixel is 300 m * 300 m) was chosen. It is worth noting that the land cover CCI product of the ESA at 300 m has experienced issues regarding the classification (overestimation) of croplands in the Sahel region (in particular, in Burkina Faso). It is therefore recommended to reassess the impacts at higher resolution once the exact project locations become available, since both 100 m and 20 m seem to better represent the true extent of cropland.

With this 300 m resolution, ABC-Map provides a land use map for 2019 (Figure 13).

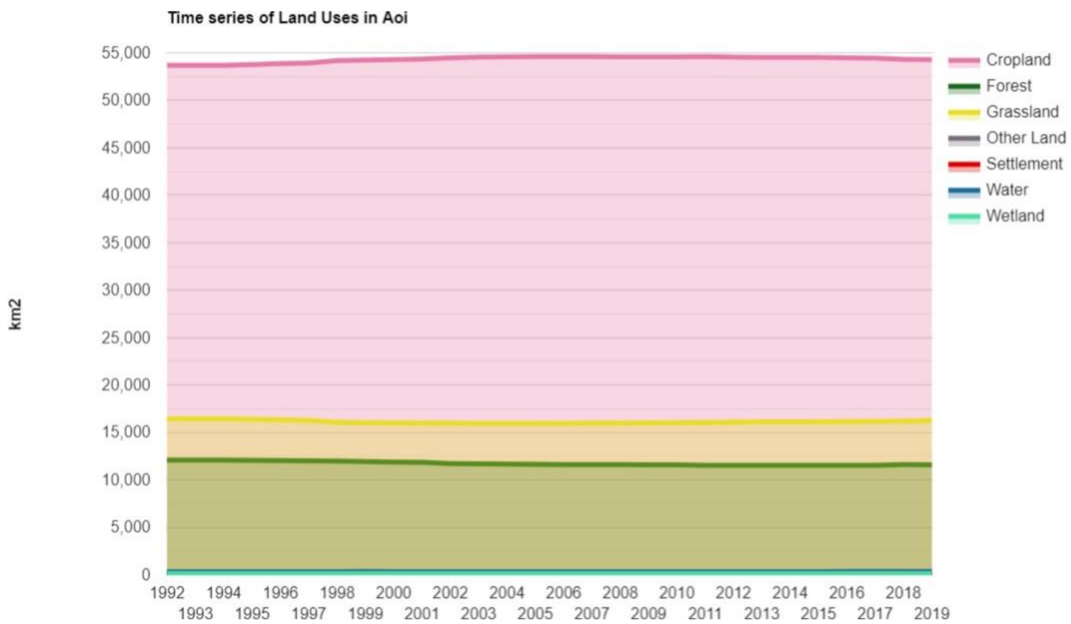
Figure 13. ABC-Map baseline land use map



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, June 2016.

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 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 14 shows the land use trends in the main IPCC land uses since 1992.

Figure 14. IPCC land use trends in the AoI, 1992–2019



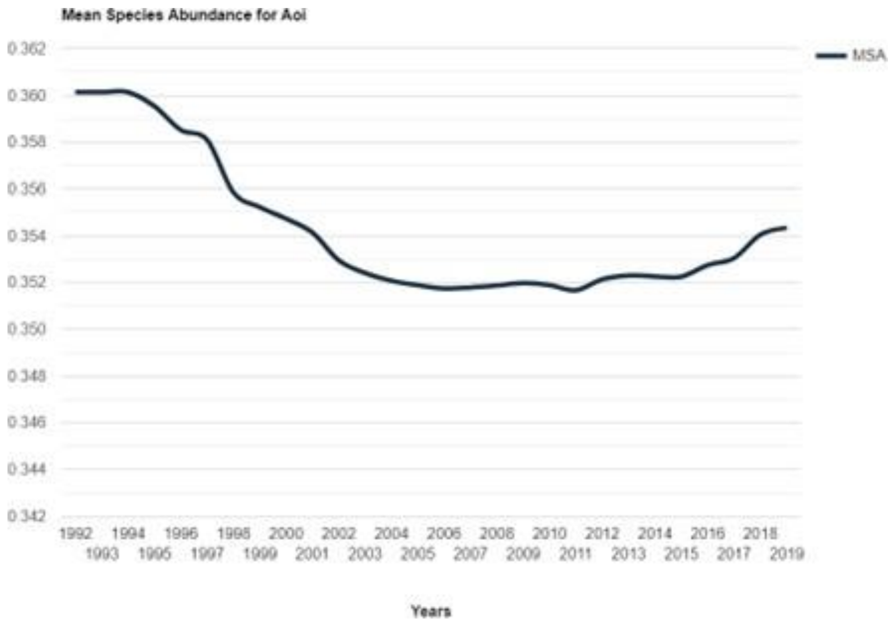
Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Section 1. Baseline

Mean species abundance

The mean species abundance of the AoI is estimated at 0.354 for 2019, i.e. 35.4 percent 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 affect biodiversity intactness in the AoI, but to a lesser extent. Figure 16 shows the MSA changes from 1992 to 2019. Over 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 are the main drivers of forest, wetland and grassland conversion, which explains the decrease in MSA. Figure 15 shows these land use changes, with significant losses of shrubland/forest of 468 km^2 and grassland of 476 km^2 from 1992 to 2016. Although the forest cover has been decreasing since 2016, albeit at a lower rate than previously, there has been some grassland restoration in the AoI. This led to a partial recovery of the biodiversity intactness to 35.4 percent in 2019 (Figures 15).

Figure 15. MSA trends in the AoI, 1992–2019

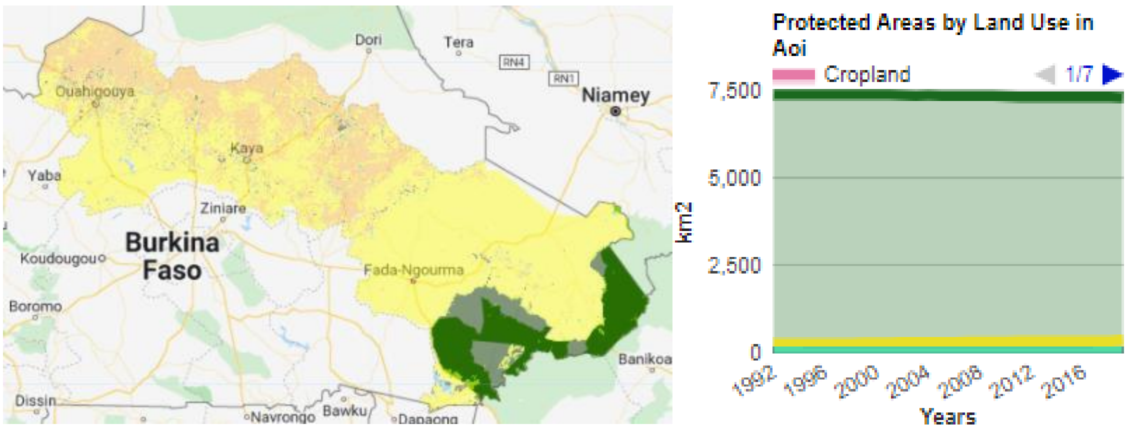


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Protected areas

As of 2020 the AoI has a total protected area of 7 652 km^2. Figure 16 shows that all the protected areas are in the southeast of the AoI. In addition, the overall trend in agricultural expansion at the expense of forests appears to be confirmed within the protected areas, which raises enforcement questions.

Figure 16. Screenshot of results for protected areas (left) and land use trends within them (right), 1992–2016

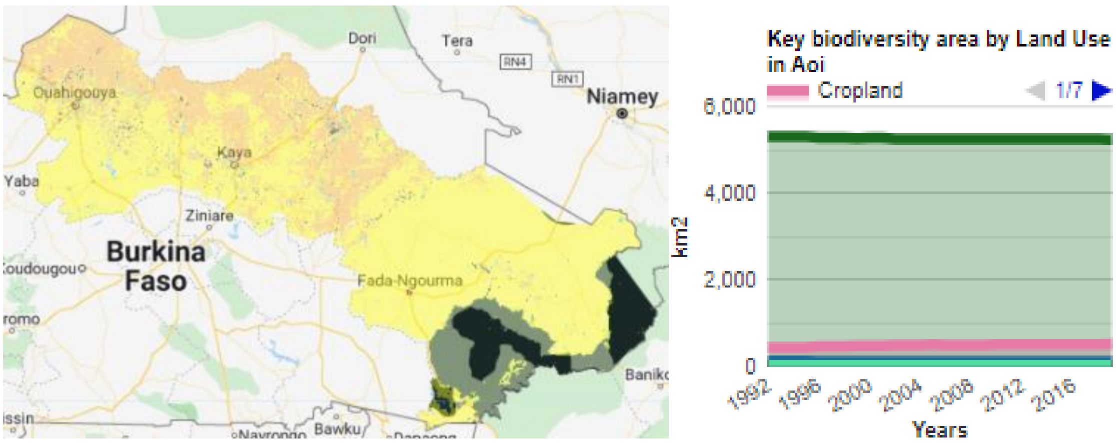


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, June 2016.

Key biodiversity areas

As of 2020. the AoI has two main KBAs, with a total surface of 5 864 km². Figure 17 shows the KBAs in the AoI, which are located towards the southeast and mostly coincide with the protected areas. The similarity between protected areas and KBAs also explains the very similar land use dynamics.

Figure 17. Screenshot of results for key biodiversity areas (left) and land use trends within them (right), 1992–2016



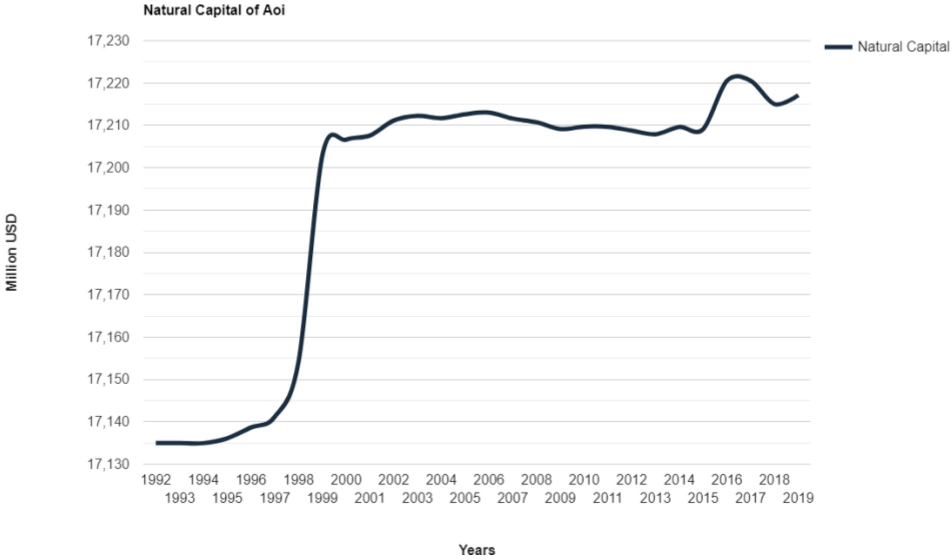
Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy. *Conforms to the UN World map, June 2016.*

Natural capital

The natural capital of the AoI amounted to USD 17 217 123 000 in 2019. This corresponds to an average natural capital value of USD 2 074 per ha. Figure 18 shows the trend in the natural capital value from 1992 to 2019 in the AoI. The natural capital value was relatively constant in the early 1990s, and strongly increase from 1994 to 2000. This trend is in contrast with the development of the MSA shown in Figure 15. The increase in natural capital, notably between 1997 and 1999, can be explained due by the conversion of grasslands to extensive agroforestry systems. It should be noted that while MSA has a pure biodiversity focus, the natural capital considers the various ecosystem services provided to humans. The aggregate monetary benefits provided to humans by extensive agroforestry systems are valued higher than those of pure grassland systems. This can mainly be attributed to higher food and raw material production together with increased carbon stock 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 USD 17 210 000 000. From 2015 onwards, the overall trend of the natural capital is positive, with a net gain of USD 8 million. This can be attributed to an increased forest and wetland cover together with the introduction of agroforestry systems in annual cropland.

Figure 18. Natural capital trends in the AoI

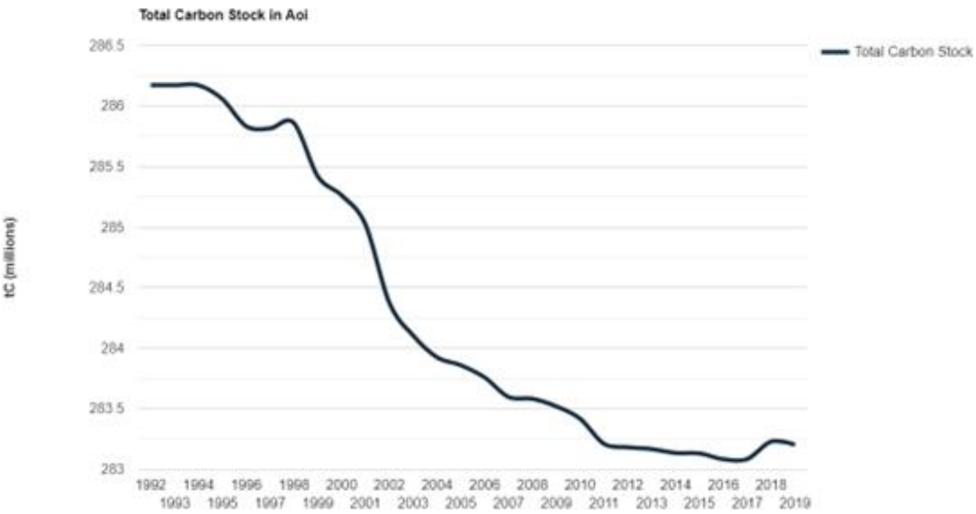


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Carbon stock

Contrary to natural capital trends, the AoI has seen important carbon stock losses over the 1992–2018 period. The losses amount to a total of 2.97 million tC in the AoI, which can be explained by substantial losses of forests, grasslands and wetlands for the benefit of cropland, human settlement or degraded other land. Annual cropland, and to a greater degree, urban settlements, store significantly less carbon in the soils, and in the case of annual cropland, only a very limited amount of carbon. In contrast, forests and wetlands store carbon in all five carbon compartments (above-ground biomass, below-ground biomass, litter, deadwood and soils). In 2018, there was a slight increase in overall carbon stock, which quickly stabilized in 2019.

Figure 19. Carbon stock trends in AoI, 1992–2019

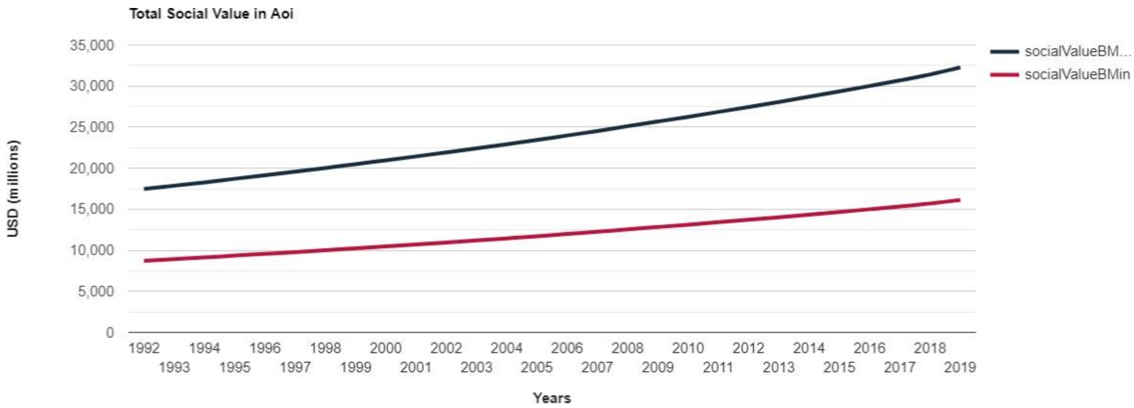


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Social value of carbon

The carbon stock can be expressed in monetary terms via the social value of carbon. The High- Level Commission on Carbon Prices estimated carbon prices to increase over time to reflect the higher cost of removing one additional tCO_2-e. in the future. Based on these carbon prices, Figure 20 shows a minimum and maximum value of the carbon stock. The social value of carbon was estimated to range between USD 40 605 487 000 and USD 81 250 022 000 in 2019.

Figure 20. The social value of carbon in the AoI, 1992–2019

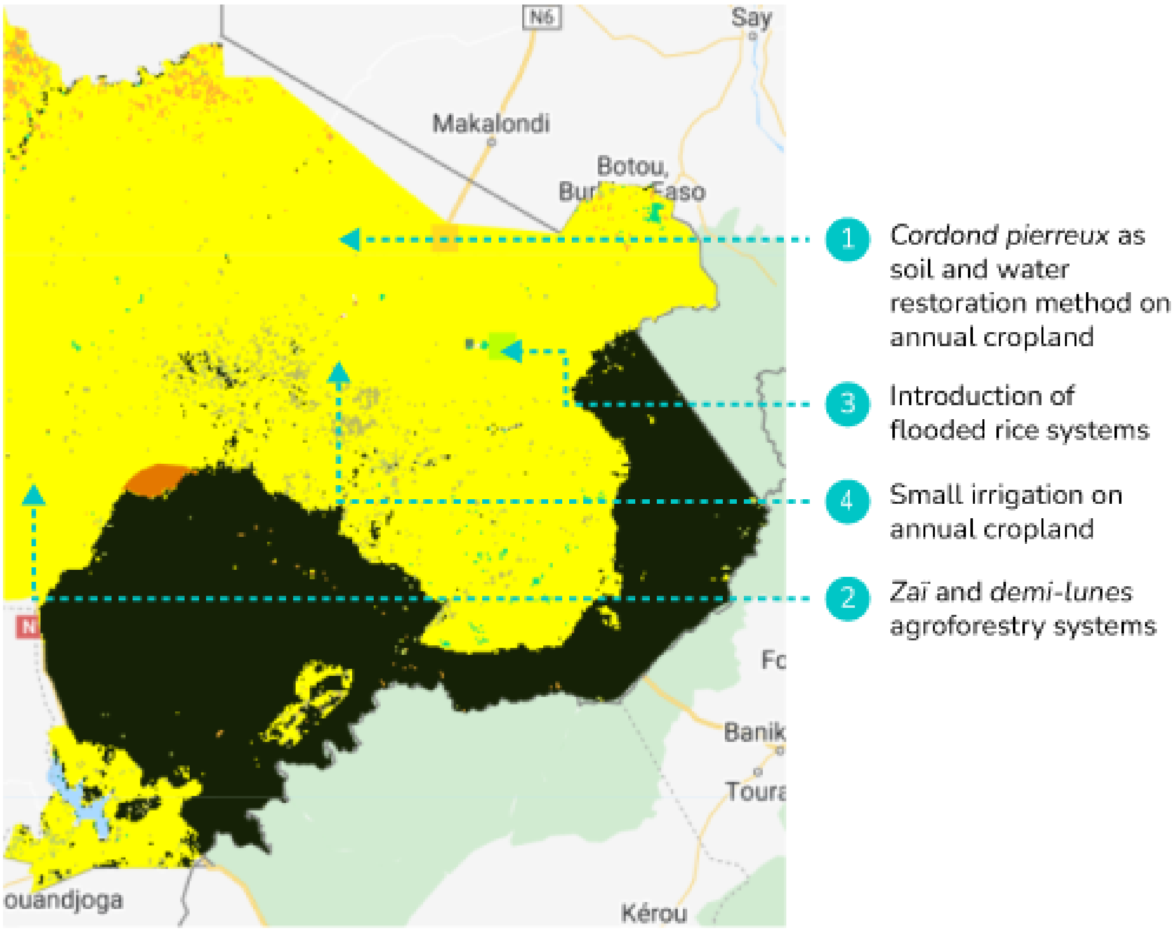


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Section 2. Project intervention

Figure 21 shows potential project plots in the east of the project AoI. All interventions will be undertaken on conventional annual cropland. 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 (the 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 over 180 days (when straw is 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).

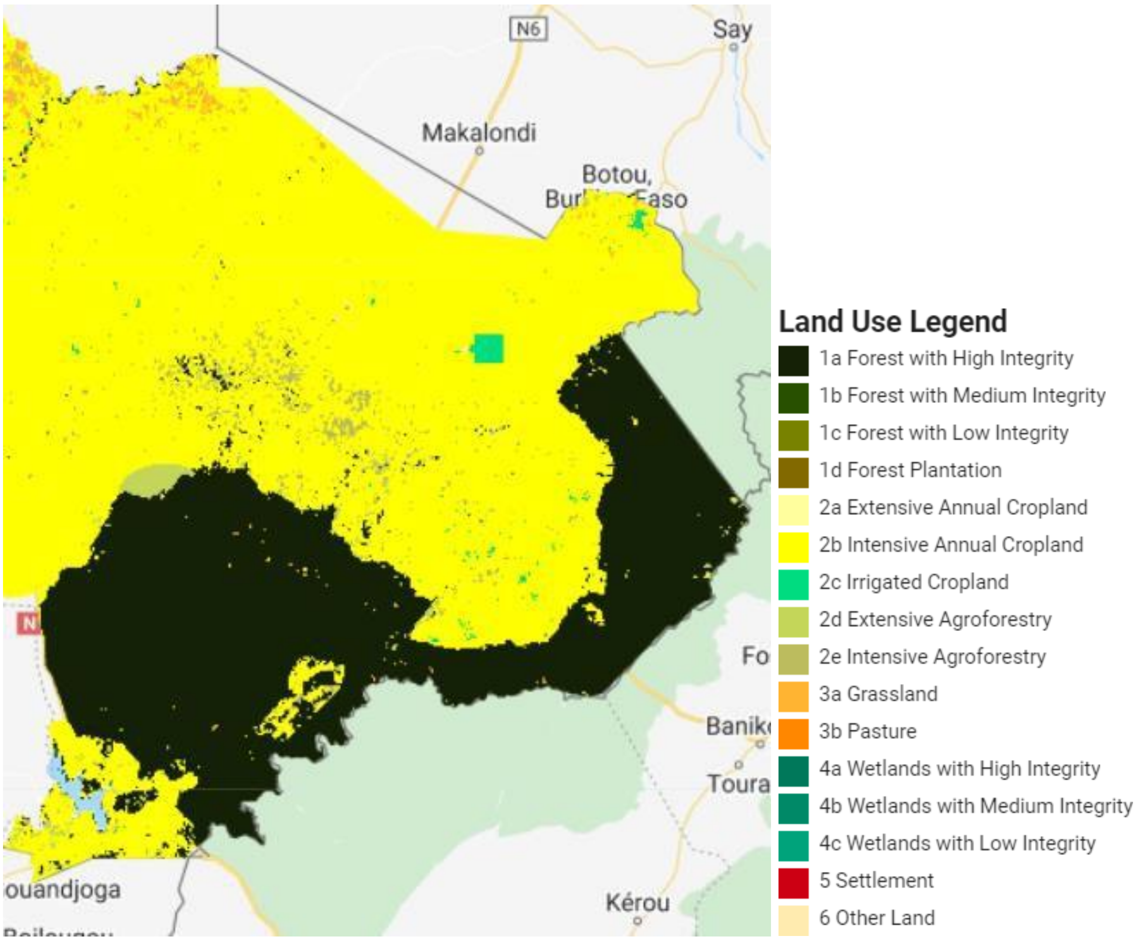
Figure 21. Project intervention plots in the AoI



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, June 2016.

Once these project plots are drawn on 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 2013–2022 project period. Figure 22 shows the newly generated land use map for the project.

Figure 22. ABC-Map land uses with project scenario

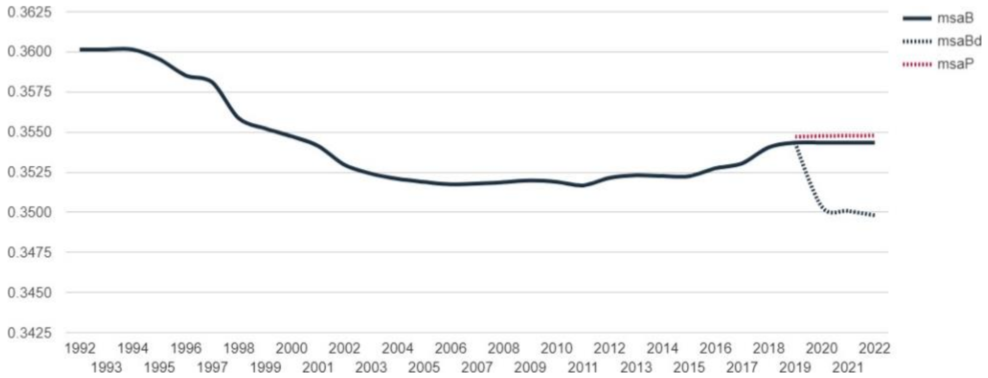


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, June 2016.

Mean species abundance

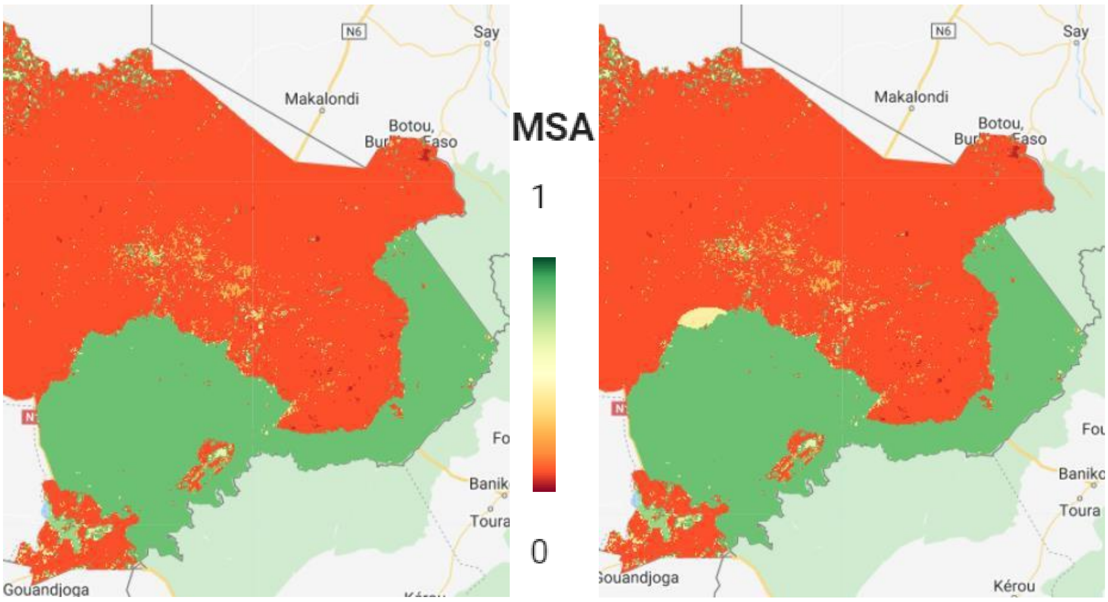
With the implementation of the project, the MSA will increase from 35.4 percent to 35.5 percent. Using the constant baseline scenario as reference, the MSA will increase by 0.04 percent with the project (Figure 24). This increase in MSA value can mainly be attributed to an increase in the MSA Land Use value from 0.422 to 0.423, while the other anthropogenic pressures on biodiversity remain constant. The corresponding area with intact biodiversity (AIB) will increase by 36.64 km^2. Since ABC-Map is a mapping tool, these increases can also be directly tracked on the MSA Map. Figure 24 shows the Baseline MSA Map vs. the Project MSA Map.

Figure 23. MSA trends with the project



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.

Figure 24. The baseline MSA map (left) vs. the project MSA map (right)

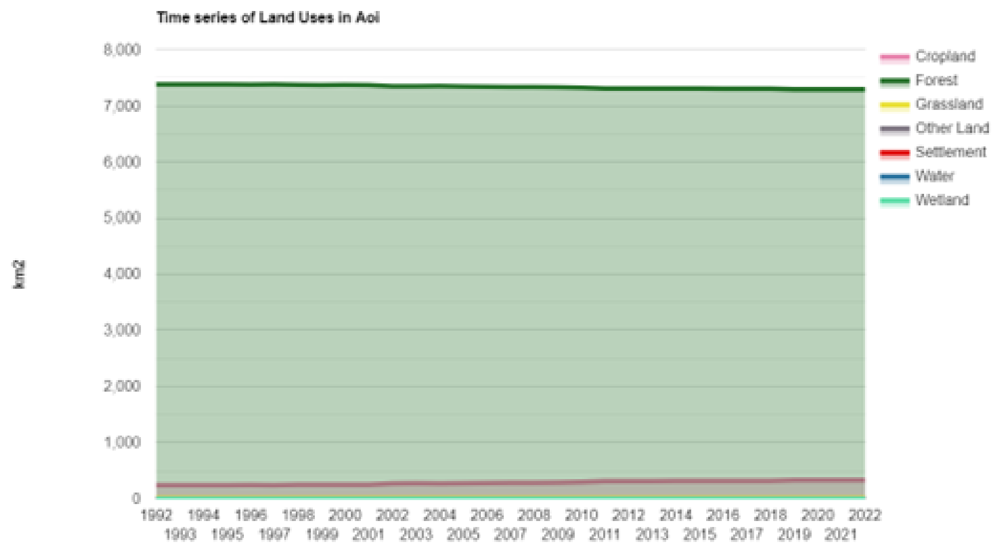


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, June 2016.

Protected areas and key biodiversity areas

Since none of the project activities are carried out in protected areas or key biodiversity areas, their land use-trend remains the same with the project. Figure 25 shows the land use trend in the protected areas.

Figure 25. Protected area land use trends, 1992–2021



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Natural capital

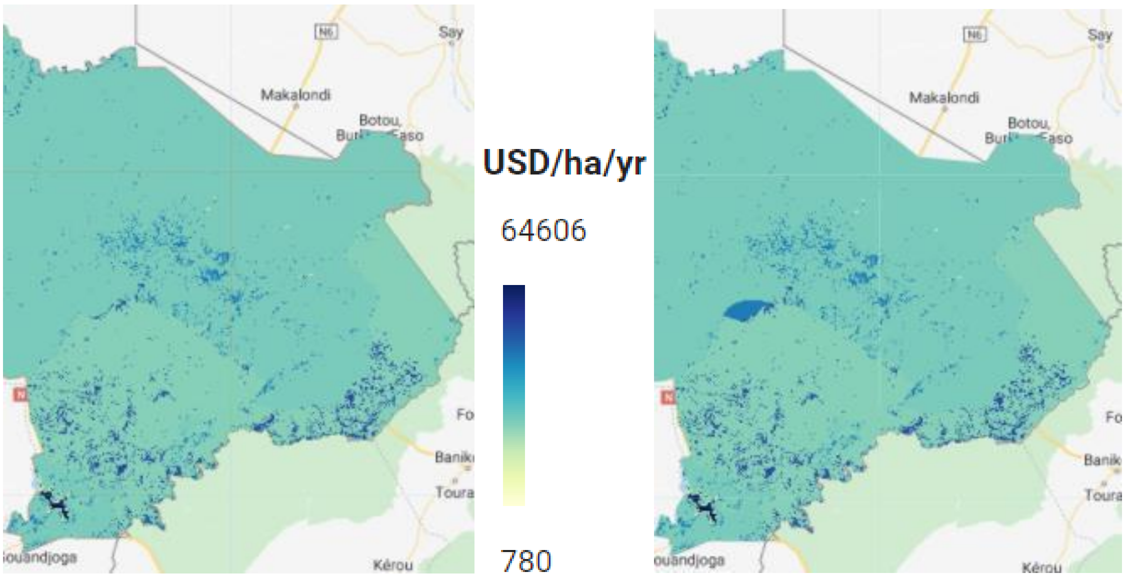
Using the constant baseline scenario as reference, the total value of the natural capital will increase by USD 16.54 million with the project. This increase can also mainly be attributed to the conversion of conventional agriculture to extensive agroforestry systems. Figure 26 shows the natural capital trend with the project and Figure 27 compares the natural capital maps of the baseline with the project scenario.

Figure 26. Natural capital trend, 1992–2022

Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Since ABC-Map uses data from 1992 to 2019 and the start date of the Neer-Tamba project was 2013, there is a time overlap of six years. ABC-Map is conceived so that project impacts are only shown from 2019 onwards; this explains why the red dotted line only appears in 2019.

Figure 27. Natural capital: baseline (left) versus project scenario (right)

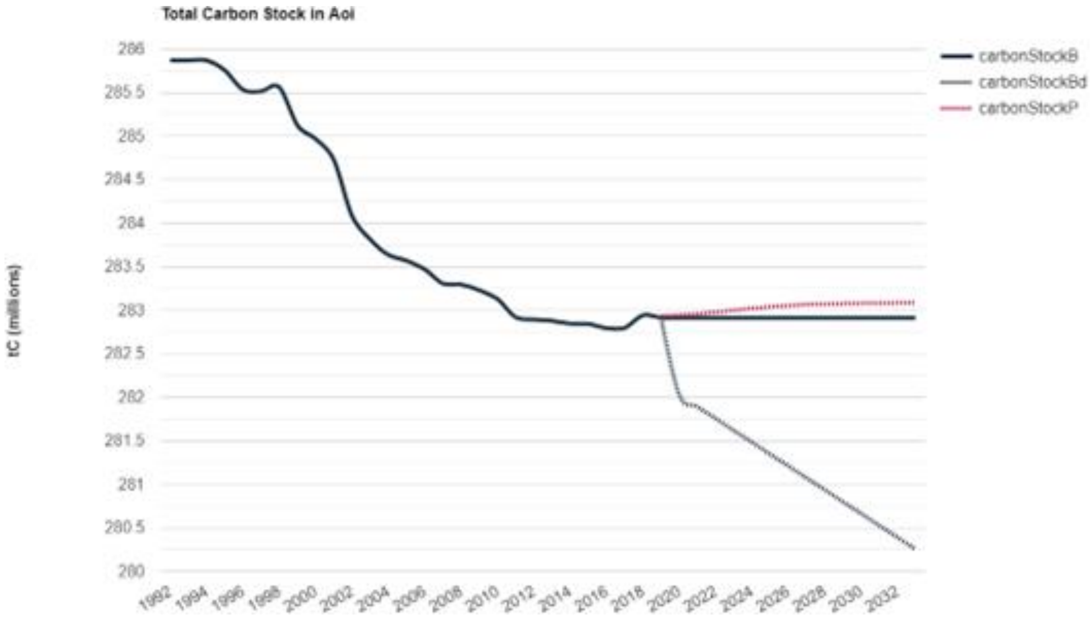


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, June 2016.

Carbon stock

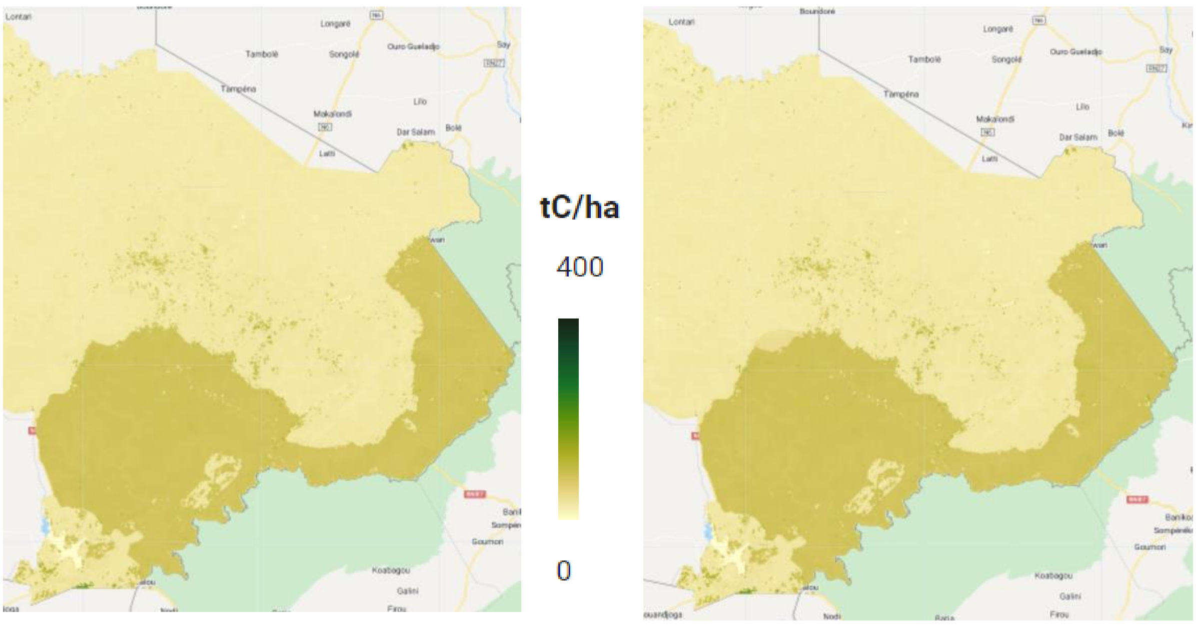
Using the constant baseline scenario as reference, the project will sequester - 27,556.38 tC over a period of 20 years (10 years of implementation of the project and 10 years of capitalization). Figure 28 provides detailed yearly results on carbon stock changes, and Figure 29 provides a comparison of the baseline (left) and project (right) carbon stock maps.

Figure 28. Carbon stock trends, 1992–2032



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.

Figure 29. Carbon stock trends: baseline 2019 (left) versus project scenario 2032 (right)

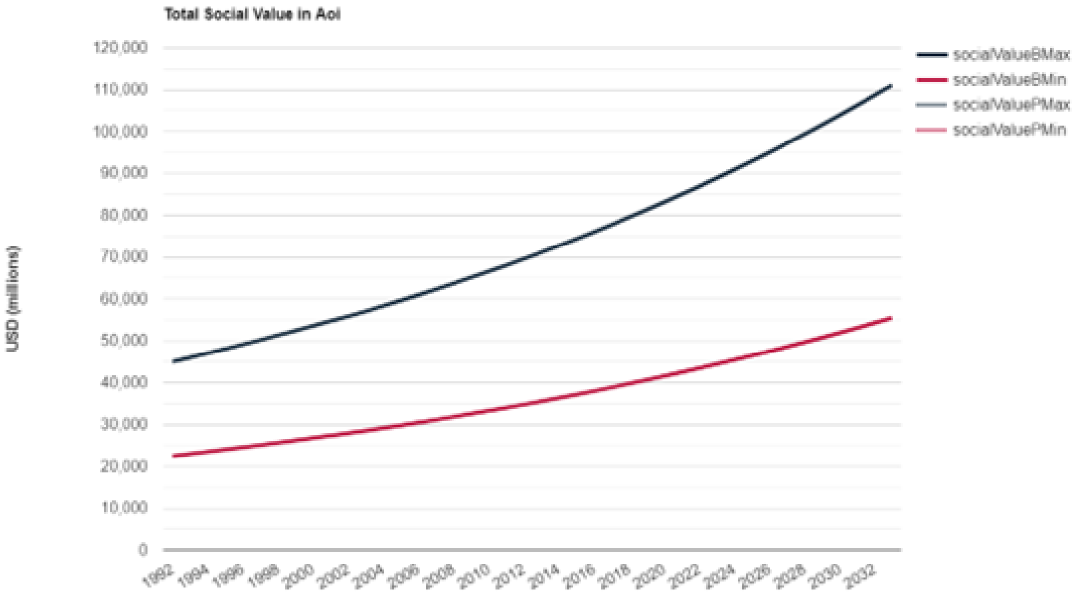


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, June 2016.

The social value of carbon

The changes in carbon stock will also affect the social value of carbon. The gained social value of carbon ranges between a lower bound of USD 33.57 million and an upper bound of USD 67.16 million over the 20-year period.

Figure 30. The social value of carbon, 1992–2032



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Case study 2 – Reduced Emissions through Climate Smart Agroforestry project in Viet Nam

Project title: Reduced Emissions through Climate Smart Agroforestry (RECAF)

Project duration: 12 years (2023–2034)

Total project budget: USD 121 000 000

Background

The Central Highlands and the southern coastal areas 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. Around 75 percent of Viet Nam's minority populations live in these two regions.

Project activity summary

Poverty, which is one of the most fundamental causes of undernutrition, 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 percent of the population, 73 percent of those living in poverty in 2016 were ethnic minority groups.

The areas of high incidence of poverty (i.e. the ratio of the poor to the 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 environmental goods and environmental from natural forests. Despite their dependence on forests, some rural people have also benefited from the clearance of forest cover through increased access to arable land and through the conversion of timber and other forest products into income and capital.

Project goal

The project's goal is to increase the resilience, nutrition and income of target groups through the sustainable management of forests and agriculture, and the 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.

Given that forest resources including timber and non-timber forest products, agroforestry practices and forest services (e.g. ecotourism, Payments for Ecosystem Services), and derived employment serve as crucial income and nutrition diversity sources for the rural poor, the main objective of the project is to reduce deforestation and forest degradation in the project zone.

Since the project is at the concept note stage, currently, no information is available on the exact activities (and area). While the project also focuses 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 7. RECAF project activity summary

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

Source: Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.

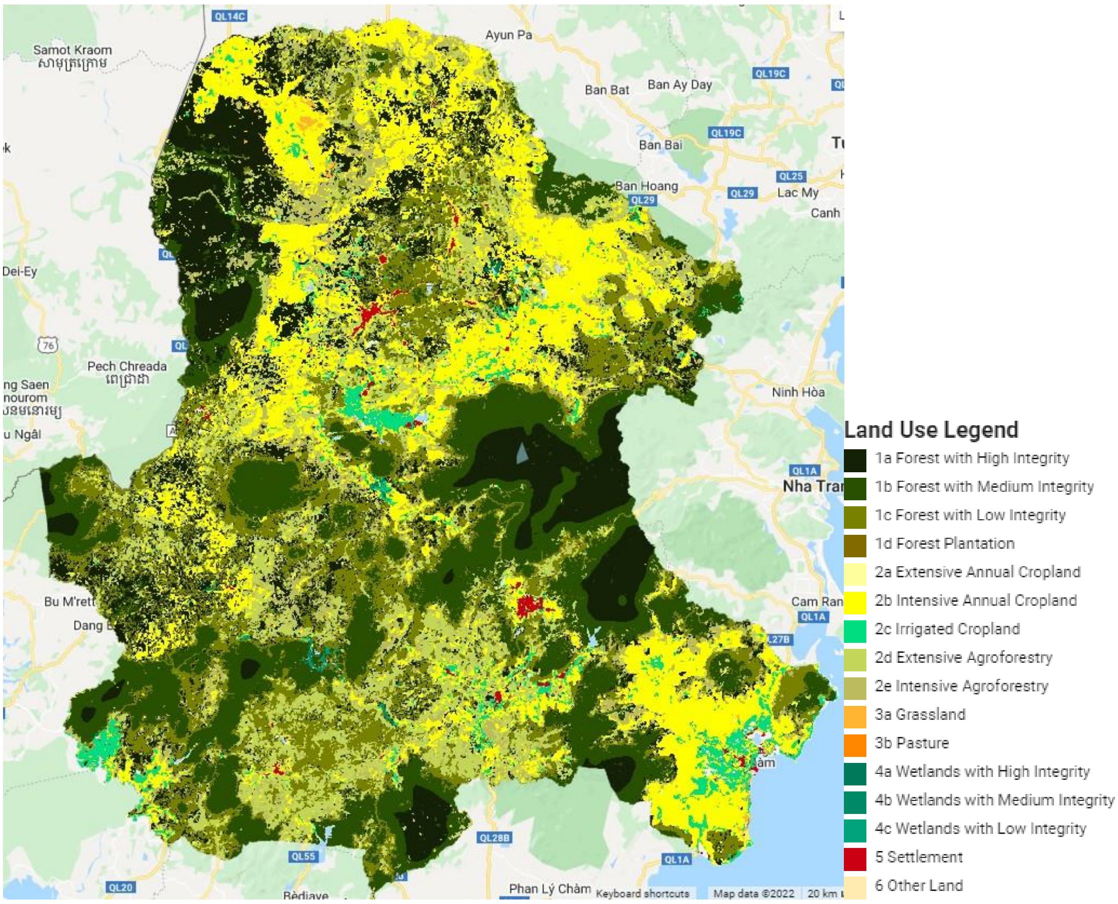
RECAF targets four provinces in the Central Highlands and South-Central region of Viet Nam, namely Dak Lak, Dak Nong, Lam Dong and Ninh Thuan. The broad target group for the project comprises around 60 000 smallholder producers and poor households, as well as indigenous communities actively engaged in 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 the high vulnerability of its most important economic sectors, i.e. industry and agriculture, Viet Nam has been listed by the World Bank as one of the five countries most highly affected by climate change.

From 1982, i.e. for over 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, which increased from five to almost nine days a year. The total annual precipitation is abundant and slightly increased from 1 843 mm to 1 977 mm.

The targeted provinces have a total area of 3 272 531 ha. With this large area, a spatial resolution of 300 m (i.e. the size of each pixel is 300 m x 300 m) was chosen. With this 300 m resolution, ABC-Map provides a land use map for 2019, as shown in Figure 31.

Figure 31. Baseline land use map



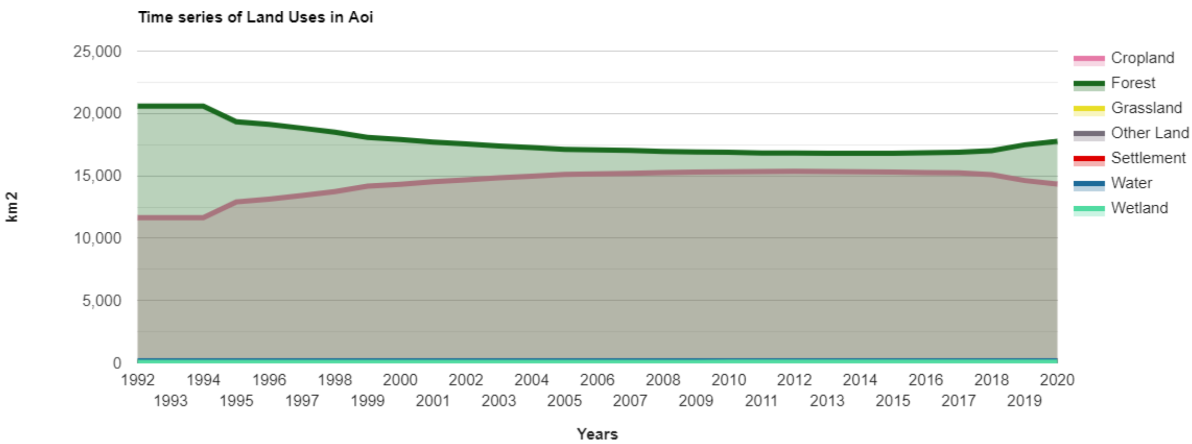
Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, January 2004.

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, which 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 32 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 detailed overview can be obtained of the exact changes between 1992 and 2020 (Table 8).

Most agricultural expansion can be attributed to agroforestry systems – mosaic cropland (>50 percent) / natural vegetation (tree, shrub, herbaceous cover) (<50 percent) and mosaic natural vegetation (tree, shrub, herbaceous cover, >50 percent) / cropland (<50 percent) – followed by annual cropland and flooded rice. Table 8 also shows that the greatest loss of forest was in the broadleaved, evergreen, closed to open (>15 percent) tree cover category, of 605 827 ha. A significant amount of forest of this category was lost to the mosaic tree and shrubs, (>50 percent) / herbaceous cover, (<50 percent). Although this is not a land use change per se in IPCC terms, it hints at 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, forest cover increases and cropland cover decreases. This increase, however, already starts slowing down in 2020.

Figure 32. Land use trends in the AoI, 1992–2020



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Table 8 shows a more detailed land use classification which compares the land uses and land use changes in ha and percent between 1992 and 2020.

Table 8. ESA CCI land cover and changes

Land Use	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, needle-leaved, 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/brackish 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

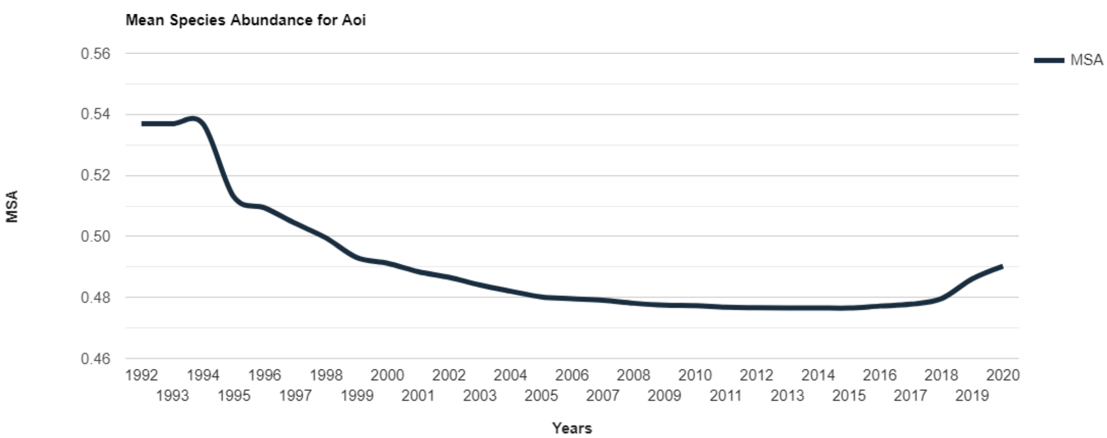
Source: Author's elaboration based on European Space Agency. 2017 Land Cover CCI Product User Guide Version 2.0. In: European Space Agency. Belgium.

Section 1. Baseline

Mean species abundance

The mean species abundance of the AoI is estimated at 0.49 (or 49 percent) for 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 (MSA value of 0.995) and infrastructure (MSA value of 0.998). Figure 33 shows the MSA trend 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 trend and the forest cover trend in this AoI, 99.67 percent of the variation of the MSA value can be explained by the variation of forest cover. This correlation also explains why the increase in forest cover leads to an increase in biodiversity intactness.

Figure 33. MSA trend in the AoI, 1992–2020

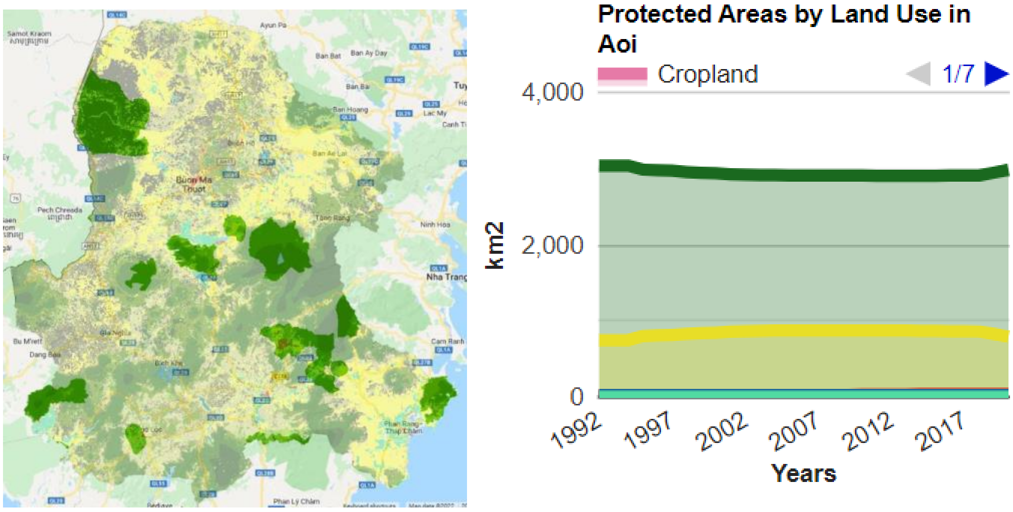


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.

Protected areas

As of 2020, the AoI has a total protected area of 3 840 km^2. Figure 34 shows that the protected areas are distributed across all of the provinces of the AoI. The protected areas coincide with large areas of the remaining high integrity forests. The variation of land uses is fairly small over time, which indicates that the provisions of the protected areas are adequately enforced.

Figure 34. Screenshot of results for protected areas (left) and land use trends within them (right), 1992–2017

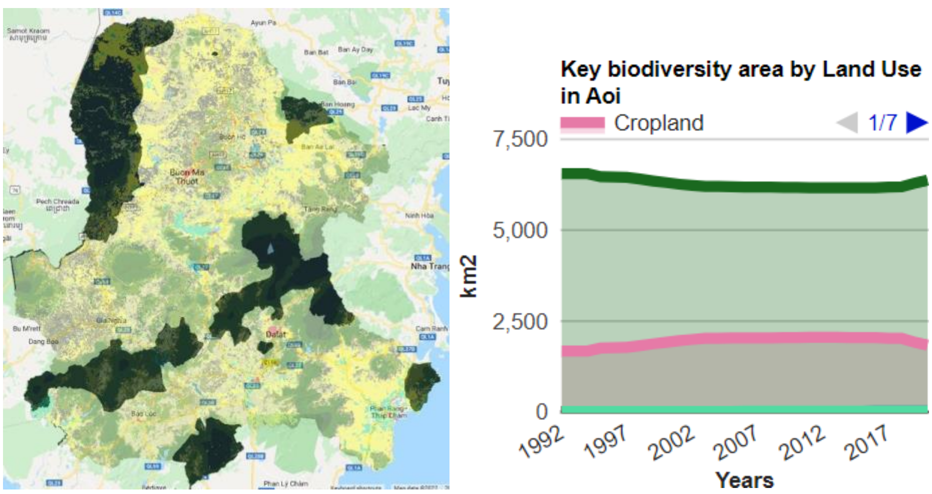


Source: ABC-Map screenshots, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, January 2004.

Key biodiversity areas

Most of the KBAs and protected areas coincide, with small variations in the centre-east and south-west of the AoI, as shown in Figure 35. This explains why the land use variation remains low (yet slightly higher in KBAs). It is worth noting, however, that the KBAs cover a significantly larger area (more than double that of the protected areas with a total surface of 8 263 km^2 as of 2020).

Figure 35. Screenshot of results for KBAs (left) and land use trends within them (right) 1992–2017

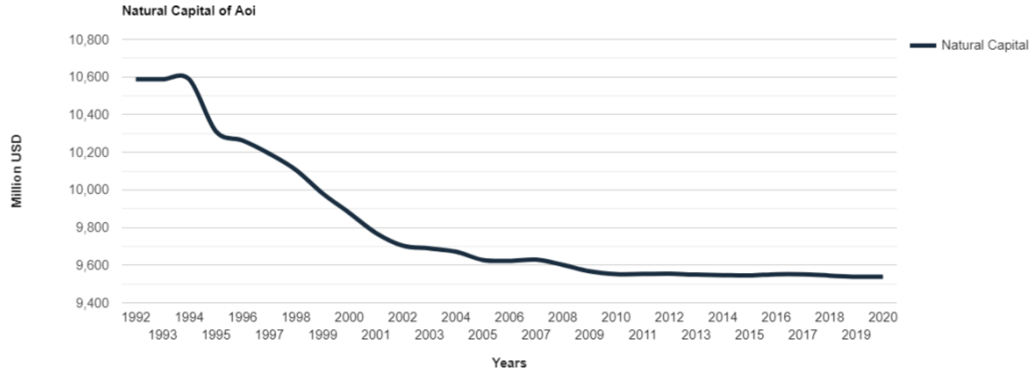


Source: ABC-Map screenshots, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, January 2004.

Natural capital

The natural capital of the AoI amounted to USD 9 538 521 000 in 2020. This corresponds to an average natural capital value of USD 2 914 per ha. Figure 36 shows the changes in the natural capital value from 1992 to 2020 in the AoI. Large parts of the AoI are located in a tropical moist or wet climate. ESVD estimates that tropical forests have higher average ecosystem values per ha per year since their ecosystem services are more highly valued by humans. This may be illustrated by carbon stock and sequestration rates. Tropical moist and wet forests sequester more carbon in the five carbon compartments: above- and below-ground biomass, litter, deadwood, and soils, than do temperate forests. The natural capital trend follows a dynamic similar to the MSA and land use trend, with a decrease until 2009, which then stabilized from 2010 to 2017 and slightly increased from 2018.

Figure 36. Natural capital trend in the AoI, 1992–2020

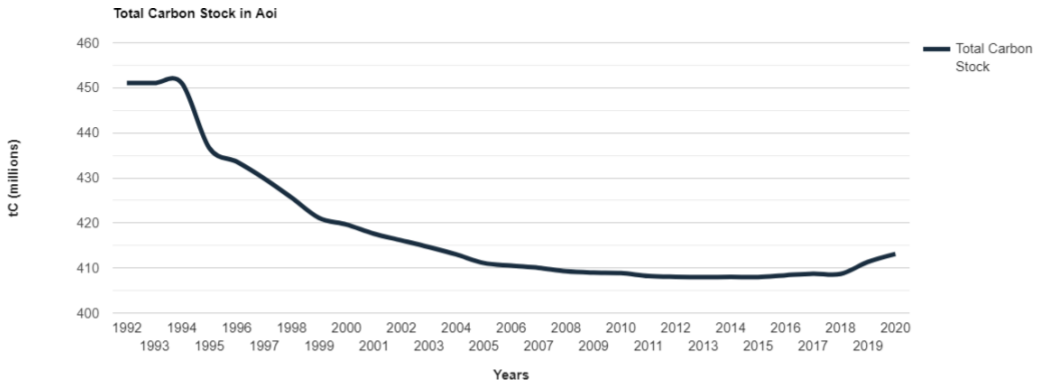


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Carbon stock

The variation of forest cover will necessarily also impact on the carbon stocks in the AoI. This explains why a very similar curve is observed between the changes in the forest cover and the carbon stocks. Figure 37 illustrates the trend in carbon stock from 1992 to 2020.

Figure 37. Carbon stock trend in the AoI, 1992–2020

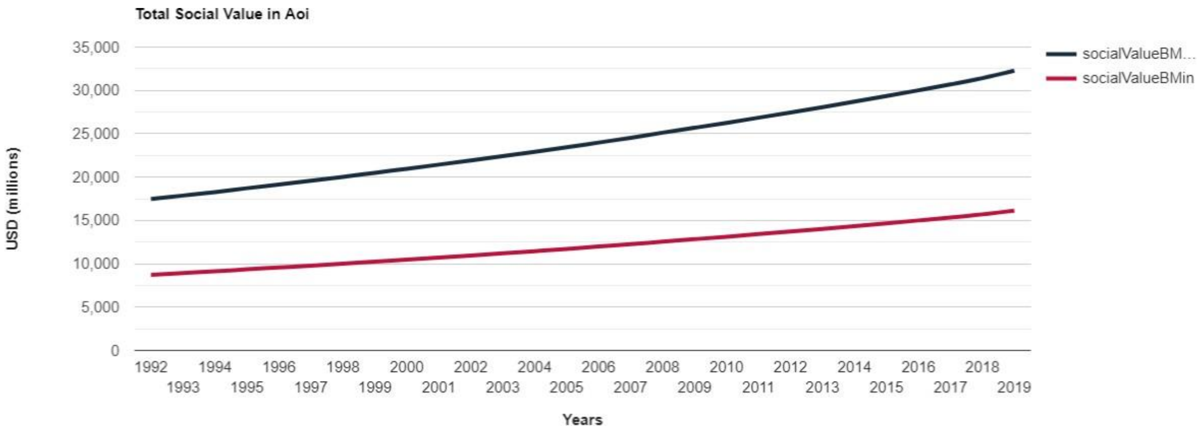


Source: ABC-Map screenshot, ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Social value of carbon

Based on the carbon prices (mentioned in case study 1) and the carbon stock values in the previous section, Figure 38 shows a minimum and maximum value of the carbon stock. The social value of carbon is estimated to range between USD 60 658 293 000 and USD 121 374 918 000 in 2020.

Figure 38. The social value of carbon in the AoI, 1992–2020



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Section 2. Project intervention

Since the project is at the concept note stage, there is not yet information on its exact activities and area of intervention. Yet, while the project might also focus on the introduction of agroforestry systems and climate-smart agriculture practices in annual cropland, its main goal is to halt deforestation and forest degradation. Accordingly, REDD+ will be mainstreamed in 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.

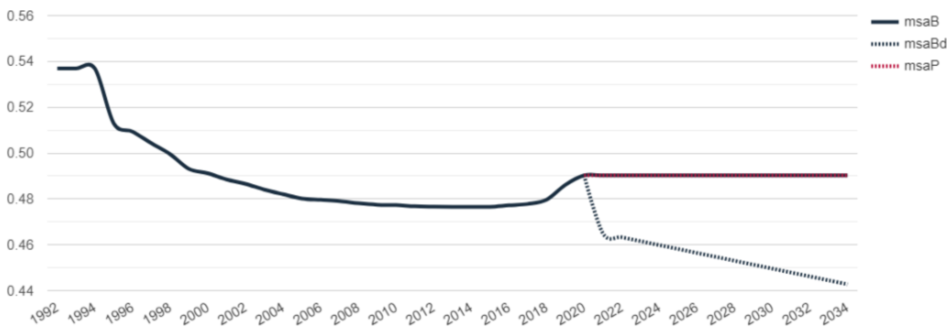
For this reason, here the only assumption that has been made for the project assessment is that the project will halt all further degradation. In this case study, the project impact is derived from the difference between the project scenario (or the conservation scenario) and the dynamic baseline, which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

ABC-Map land uses do not change in the current situation and under the project scenario, which explains why a project land use map is not shown.

Mean species abundance

With the implementation of the project, the mean species abundance would remain constant, i.e. 49 percent of the biodiversity would remain intact. Yet, in a dynamic baseline scenario (using past trends), the MSA would decrease to 44.3 percent. The project would therefore prevent the loss of 4.7 percent. This corresponds to a total area of 1 538 km^2 of avoided biodiversity loss. Figure 41 illustrates both the project scenario (red dotted line) and the dynamic baseline (blue dotted line).

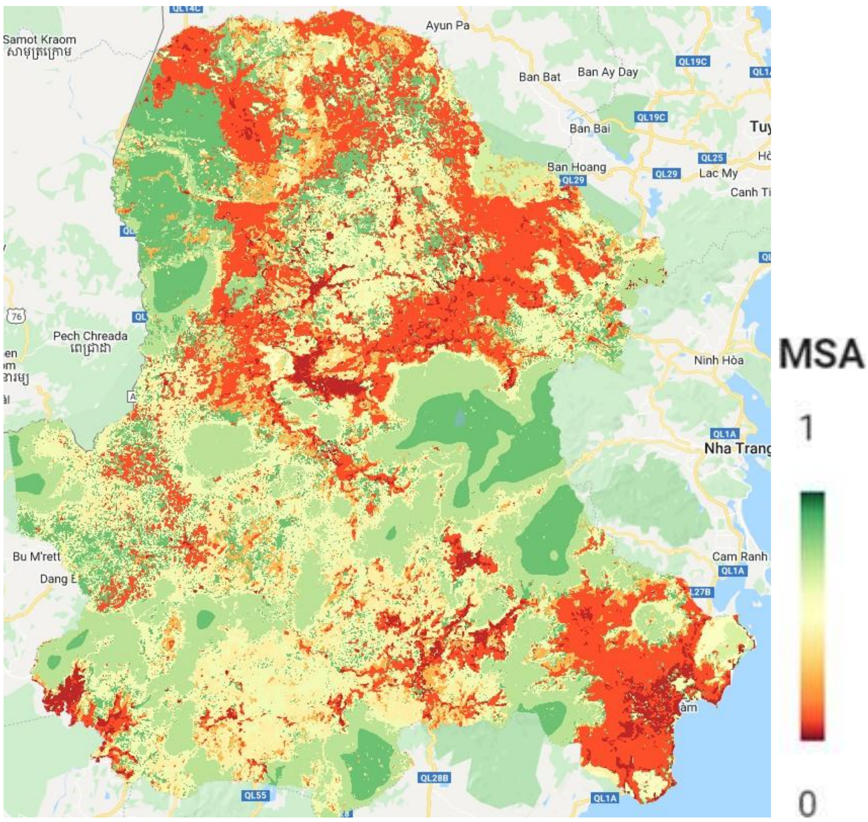
Figure 39. MSA trends with the project scenario, 1992–2034



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

ABC-Map only provides a map for the project scenario and the constant baseline scenario since it would be impossible to predict the exact location of future land use changes and land use management changes. Figure 39 therefore only shows the project scenario.

Figure 40. MSA map with the project

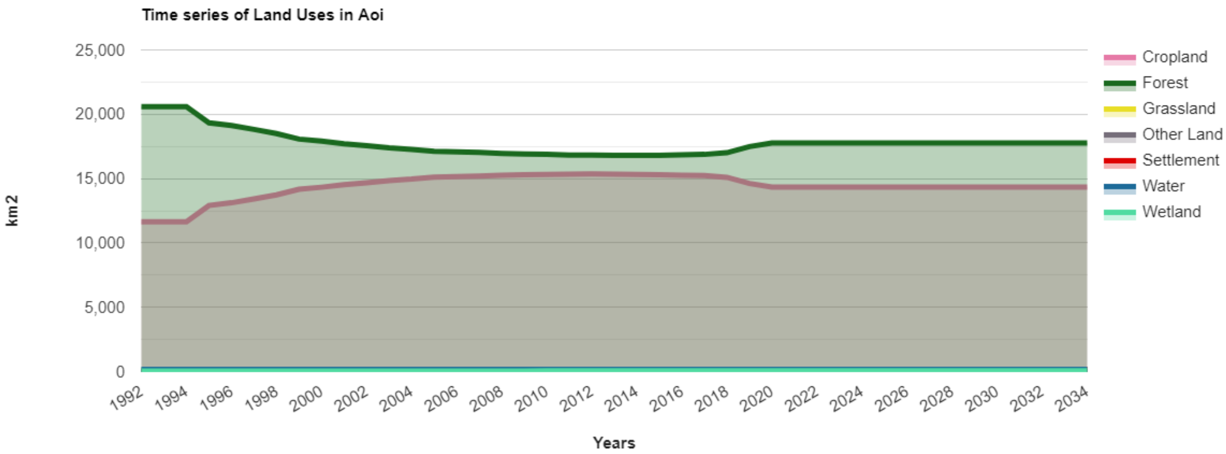


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, January 2004.

Protected areas and key biodiversity areas

Figure 41 shows the land use trend in the protected areas with the project. Since there are no land use changes, the land use distribution shows no variation from 2023 onwards.

Figure 41. Protected area land use trends, 1992–2034

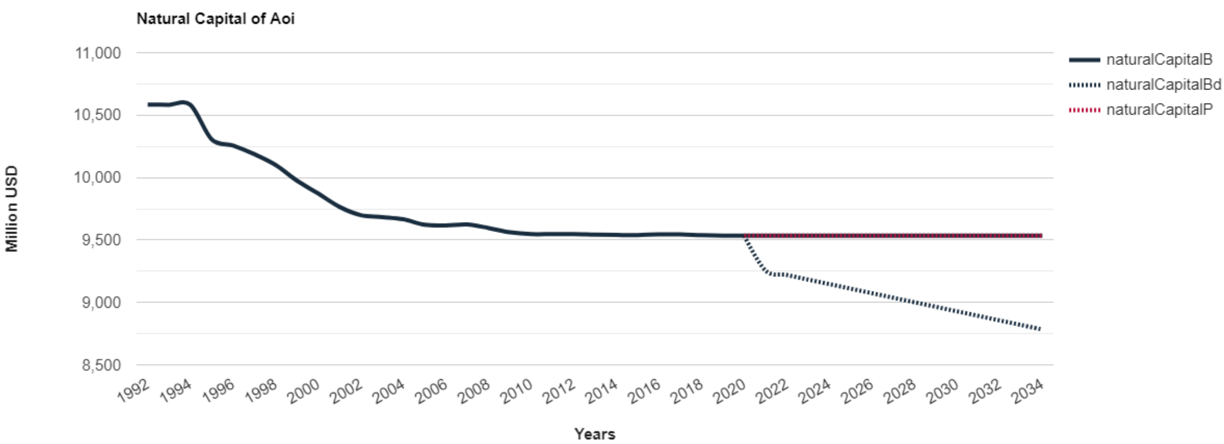


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.

Natural capital

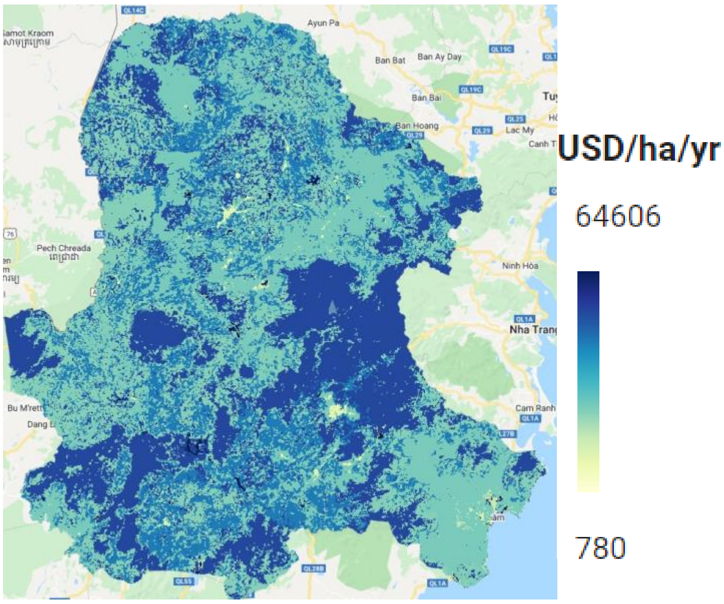
While the natural capital value is expected not to increase or decrease with the project, the natural capital value would be decreasing in a dynamic baseline scenario. The natural capital loss would amount to a total of USD 714.74 million without the project. Figure 42 shows the natural capital evolution with and without the project, and Figure 43 shows a natural capital map of the project scenario.

Figure 42. Natural capital trends, 1992–2034



Source: Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance.* IFAD (International Fund for Agricultural Development), Rome, Italy.

Figure 43. Natural capital with the project

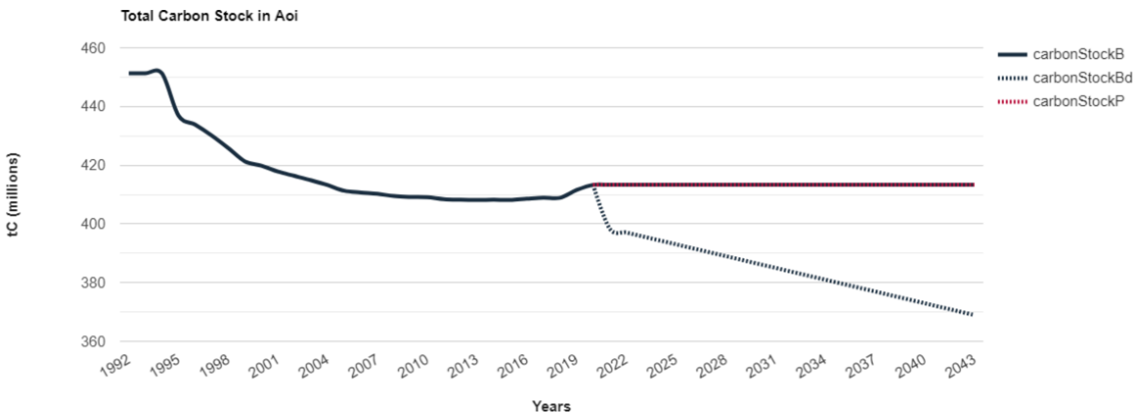


Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, January 2004.

Carbon stocks

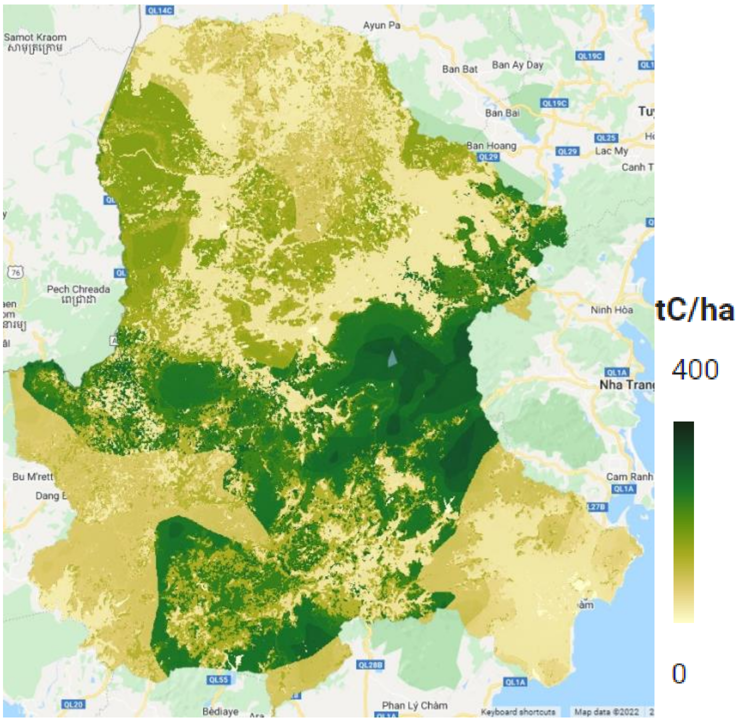
Carbon stocks are automatically calculated over a 20-year span, in accordance with IPCC guidelines (soils are considered to be in equilibrium after 20 years). In a dynamic baseline scenario, a total of 415 335 ha of forest and a carbon stock of 44.37 million tC would be depleted from 2023 to 2043. This corresponds to -162 704 668 tCO_2-e. of potentially avoided emissions with the project. Figure 44 provides detailed yearly results on carbon stock changes, and Figure 45 provides a map for the carbon stocks in the project situation.

Figure 44. Carbon stock trends, 1992–2043



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.

Figure 45. Carbon stock with the project



Source: ABC-Map screenshot, Audebert, P., Brierley, I. & Azzu, N. 2022. *Biodiversity Core Indicator Comprehensive Guidance*. IFAD (International Fund for Agricultural Development), Rome, Italy.
Conforms to the UN World map, January 2004.

The social value of carbon

ABC-Map only provides the social value of carbon for the constant baseline and project scenarios (and not the dynamic baseline). Yet, when calculating the preserved social value of carbon, it would range between a lower bound of USD 10 876 million and USD 21 763 million.

Future developments

ABC Map was conceived as a dynamic tool that will be continuously updated with new features, updated datasets and indicators. New indicators added depending on the user' needs and feedback.

Some of the features and improvements being developed will address most of the current limitations of ABC-Map:

- improved performance to allow for analysis of larger areas and at the national level; and
- the addition of the option for the user to upload custom project area boundaries and custom land cover maps. To this end, ABC-Map will be integrated with the System for Earth Observation, Data Access, Processing and Analysis for Land Monitoring, a tool developed by FAO which allows for the creation of more accurate land cover maps.

Other developments currently planned include a new and more intuitive interface that improves ease of use and offer new features and functionalities over time. This new interface will also allow to use ABC-Map on handheld devices.

The adaptation section:

- Integration with the Climate Risk Toolbox: FAO developed an indicator that gathers information on different risk components to help identify climate risk hotspots in a given location and food system of interest. This toolbox will be integrated into ABC-Map to allow the user to assess projects' exposure to climate risks.

The biodiversity section:

- Improved ESVD values: The ESVD is continually updated, with 5 000 studies in the process of review to supplement the ESVD. FAO is collaborating with Foundation for Sustainable Development to finalize the development of models that include ESVD values and geo-referenced data. These updated values from the ESVD will be integrated into ABC-Map to improve the accuracy of the natural capital indicator.
- New indicators including genetic, ecosystems and species: FAO is working in partnership with researchers and biodiversity specialists at the Foundation for Sustainable Development to develop indicators that encompass the three commonly discussed levels of biodiversity (i.e. genetic diversity, species diversity and ecosystem diversity). These indicators will be aligned with FAO goals to measure the impact or contribution of food production systems on biodiversity.
- Updating GLOBIO to the latest available version.

The carbon section:

- There will be further integration of the NEXT methodology and features into ABC-Map over time. Initially, the focus for integration will be on:
    - the progressive inclusion of GHG fluxes from organic soils among other activities as a result of land use changes and or changes in management practices; and
    - the disaggregation of emissions by GHG type and carbon pool.

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Annex I – Mapping of land use categories in ABC-MAP and GLOBIO v3.5

IPCC Land Use	ABC-Map Land Uses	GLOBIO Land Use 3.5	MSA3.5
Forest	Forest + High Integrity	Natural	1
	Forest + Medium Integrity	Reduced Impact Logging	0,85
	Forest + Low Integrity	Selective logging (Lightly used forest)	0,7
	Shrubland + High Integrity		
	Shrubland + Medium Integrity		
	Shrubland + Low Integrity		
	Plantation + High Integrity		
	Plantation + Medium Integrity		
	Plantation + Low Integrity	Forest - Plantation	0,3
Cropland, annual	no tillage + low input	Extensive cropland (Low-input agriculture)	0,3
	no tillage + medium input	Intensive cropland	0,1
	no tillage + high input without manure		
	no tillage + high input with manure		
	reduced tillage + low input		
	reduced tillage + medium input		
	reduced tillage + high input without manure		
	reduced tillage + high input with manure		
	full tillage + low input		
	full tillage + medium input		
	full tillage + high input without manure		
	full tillage + high input with manure		
Cropland, flooded rice	Non-flooded pre-season < 180 days + Irrigated, continuously flooded + Straw left on field	Irrigated cropland	0,05
	Non-flooded pre-season < 180 days + Irrigated, continuously flooded + Straw burnt		
	Non-flooded pre-season < 180 days + Irrigated, continuously flooded + Straw exported		
	Non-flooded pre-season < 180 days + Irrigated, continuously flooded + Straw incorporated <30 days before cultivation		

Non-flooded pre-season < 180 days + Irrigated, continuously flooded + Straw incorporated >30 days before cultivation		
Non-flooded pre-season < 180 days + Irrigated, continuously flooded + Compost		
Non-flooded pre-season < 180 days + Irrigated, continuously flooded + Farm yard green manure		
Non-flooded pre-season < 180 days + Irrigated, continuously flooded + Green manure		
Non-flooded pre-season < 180 days + Irrigated, single drainage + Straw left on field		
Non-flooded pre-season < 180 days + Irrigated, single drainage + Straw burnt		
Non-flooded pre-season < 180 days + Irrigated, single drainage + Straw exported		
Non-flooded pre-season < 180 days + Irrigated, single drainage + Straw incorporated <30 days before cultivation		
Non-flooded pre-season < 180 days + Irrigated, single drainage + Straw incorporated >30 days before cultivation		
Non-flooded pre-season < 180 days + Irrigated, single drainage + Compost		
Non-flooded pre-season < 180 days + Irrigated, single drainage + Farm yard green manure		
Non-flooded pre-season < 180 days + Irrigated, single drainage + Green manure		
Non-flooded pre-season < 180 days + Irrigated, multiple drainage + Straw left on field		
Non-flooded pre-season < 180 days + Irrigated, multiple drainage + Straw burnt		
Non-flooded pre-season < 180 days + Irrigated, multiple drainage + Straw exported		
Non-flooded pre-season < 180 days + Irrigated, multiple drainage + Straw incorporated <30 days before cultivation		
Non-flooded pre-season < 180 days + Irrigated, multiple drainage + Straw incorporated >30 days before cultivation		
Non-flooded pre-season < 180 days + Irrigated, multiple drainage + Compost		
Non-flooded pre-season < 180 days + Irrigated, multiple drainage + Farm yard green manure		
Non-flooded pre-season < 180 days + Irrigated, multiple drainage + Green manure		
Non-flooded pre-season < 180 days + Rainfed, regular rainfed + Straw left on field	Intensive cropland	0,1
Non-flooded pre-season < 180 days + Rainfed, regular rainfed + Straw burnt		
Non-flooded pre-season < 180 days + Rainfed, regular rainfed + Straw exported		
Non-flooded pre-season < 180 days + Rainfed, regular rainfed + Straw incorporated <30 days before cultivation		

Non-flooded pre-season < 180 days + Rainfed, regular rainfed + Straw incorporated >30 days before cultivation		
Non-flooded pre-season < 180 days + Rainfed, regular rainfed + Compost		
Non-flooded pre-season < 180 days + Rainfed, regular rainfed + Farm yard green manure		
Non-flooded pre-season < 180 days + Rainfed, regular rainfed + Green manure		
Non-flooded pre-season < 180 days + Rainfed, drought prone + Straw left on field	Extensive cropland (Low-input agriculture)	0,3
Non-flooded pre-season < 180 days + Rainfed, drought prone + Straw burnt	Intensive cropland	0,1
Non-flooded pre-season < 180 days + Rainfed, drought prone + Straw exported		
Non-flooded pre-season < 180 days + Rainfed, drought prone + Straw incorporated <30 days before cultivation		
Non-flooded pre-season < 180 days + Rainfed, drought prone + Straw incorporated >30 days before cultivation		
Non-flooded pre-season < 180 days + Rainfed, drought prone + Compost		
Non-flooded pre-season < 180 days + Rainfed, drought prone + Farm yard green manure		
Non-flooded pre-season < 180 days + Rainfed, drought prone + Green manure		
Non-flooded pre-season < 180 days + Rainfed, deep water + Straw left on field	Extensive cropland (Low-input agriculture)	0,3
Non-flooded pre-season < 180 days + Rainfed, deep water + Straw burnt	Intensive cropland	0,1
Non-flooded pre-season < 180 days + Rainfed, deep water + Straw exported		
Non-flooded pre-season < 180 days + Rainfed, deep water + Straw incorporated <30 days before cultivation		
Non-flooded pre-season < 180 days + Rainfed, deep water + Straw incorporated >30 days before cultivation		
Non-flooded pre-season < 180 days + Rainfed, deep water + Compost		
Non-flooded pre-season < 180 days + Rainfed, deep water + Farm yard green manure		
Non-flooded pre-season < 180 days + Rainfed, deep water + Green manure		
Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Straw left on field	Irrigated cropland	0,05
Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Straw burnt		
Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Straw exported		
Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Straw incorporated <30 days before cultivation		

Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Straw incorporated >30 days before cultivation		
Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Compost		
Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Farm yard green manure		
Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Green manure		
Non-flooded pre-season > 180 days + Irrigated, single drainage + Straw left on field		
Non-flooded pre-season > 180 days + Irrigated, single drainage + Straw burnt		
Non-flooded pre-season > 180 days + Irrigated, single drainage + Straw exported		
Non-flooded pre-season > 180 days + Irrigated, single drainage + Straw incorporated <30 days before cultivation		
Non-flooded pre-season > 180 days + Irrigated, single drainage + Straw incorporated >30 days before cultivation		
Non-flooded pre-season > 180 days + Irrigated, single drainage + Compost		
Non-flooded pre-season > 180 days + Irrigated, single drainage + Farm yard green manure		
Non-flooded pre-season > 180 days + Irrigated, single drainage + Green manure		
Non-flooded pre-season > 180 days + Irrigated, multiple drainage + Straw left on field		
Non-flooded pre-season > 180 days + Irrigated, multiple drainage + Straw burnt		
Non-flooded pre-season > 180 days + Irrigated, multiple drainage + Straw exported		
Non-flooded pre-season > 180 days + Irrigated, multiple drainage + Straw incorporated <30 days before cultivation		
Non-flooded pre-season > 180 days + Irrigated, multiple drainage + Straw incorporated >30 days before cultivation		
Non-flooded pre-season > 180 days + Irrigated, multiple drainage + Compost		
Non-flooded pre-season > 180 days + Irrigated, multiple drainage + Farm yard green manure		
Non-flooded pre-season > 180 days + Irrigated, multiple drainage + Green manure		
Non-flooded pre-season > 180 days + Rainfed, regular rainfed + Straw left on field	Intensive cropland	0,1
Non-flooded pre-season > 180 days + Rainfed, regular rainfed + Straw burnt		
Non-flooded pre-season > 180 days + Rainfed, regular rainfed + Straw exported		
Non-flooded pre-season > 180 days + Rainfed, regular rainfed + Straw incorporated <30 days before cultivation		

Non-flooded pre-season > 180 days + Rainfed, regular rainfed + Straw incorporated >30 days before cultivation		
Non-flooded pre-season > 180 days + Rainfed, regular rainfed + Compost		
Non-flooded pre-season > 180 days + Rainfed, regular rainfed + Farm yard green manure		
Non-flooded pre-season > 180 days + Rainfed, regular rainfed + Green manure		
Non-flooded pre-season > 180 days + Rainfed, drought prone + Straw left on field	Extensive cropland (Low-input agriculture)	0,3
Non-flooded pre-season > 180 days + Rainfed, drought prone + Straw burnt	Intensive cropland	0,1
Non-flooded pre-season > 180 days + Rainfed, drought prone + Straw exported		
Non-flooded pre-season > 180 days + Rainfed, drought prone + Straw incorporated <30 days before cultivation		
Non-flooded pre-season > 180 days + Rainfed, drought prone + Straw incorporated >30 days before cultivation		
Non-flooded pre-season > 180 days + Rainfed, drought prone + Compost		
Non-flooded pre-season > 180 days + Rainfed, drought prone + Farm yard green manure		
Non-flooded pre-season > 180 days + Rainfed, drought prone + Green manure		
Non-flooded pre-season > 180 days + Rainfed, deep water + Straw left on field	Extensive cropland (Low-input agriculture)	
Non-flooded pre-season > 180 days + Rainfed, deep water + Straw burnt	Intensive cropland	
Non-flooded pre-season > 180 days + Rainfed, deep water + Straw exported		
Non-flooded pre-season > 180 days + Rainfed, deep water + Straw incorporated <30 days before cultivation		
Non-flooded pre-season > 180 days + Rainfed, deep water + Straw incorporated >30 days before cultivation		
Non-flooded pre-season > 180 days + Rainfed, deep water + Compost		
Non-flooded pre-season > 180 days + Rainfed, deep water + Farm yard green manure		
Non-flooded pre-season > 180 days + Rainfed, deep water + Green manure		
Flooded pre-season > 30 days + Irrigated, continuously flooded + Straw left on field	Irrigated cropland	0,05
Flooded pre-season > 30 days + Irrigated, continuously flooded + Straw burnt		
Flooded pre-season > 30 days + Irrigated, continuously flooded + Straw exported		
Flooded pre-season > 30 days + Irrigated, continuously flooded + Straw incorporated <30 days before cultivation		
Flooded pre-season > 30 days + Irrigated, continuously flooded + Straw incorporated >30 days before cultivation		

Flooded pre-season > 30 days + Irrigated, continuously flooded + Compost		
Flooded pre-season > 30 days + Irrigated, continuously flooded + Farm yard green manure		
Flooded pre-season > 30 days + Irrigated, continuously flooded + Green manure		
Flooded pre-season > 30 days + Irrigated, single drainage + Straw left on field		
Flooded pre-season > 30 days + Irrigated, single drainage + Straw burnt		
Flooded pre-season > 30 days + Irrigated, single drainage + Straw exported		
Flooded pre-season > 30 days + Irrigated, single drainage + Straw incorporated <30 days before cultivation		
Flooded pre-season > 30 days + Irrigated, single drainage + Straw incorporated >30 days before cultivation		
Flooded pre-season > 30 days + Irrigated, single drainage + Compost		
Flooded pre-season > 30 days + Irrigated, single drainage + Farm yard green manure		
Flooded pre-season > 30 days + Irrigated, single drainage + Green manure		
Flooded pre-season > 30 days + Irrigated, multiple drainage + Straw left on field		
Flooded pre-season > 30 days + Irrigated, multiple drainage + Straw burnt		
Flooded pre-season > 30 days + Irrigated, multiple drainage + Straw exported		
Flooded pre-season > 30 days + Irrigated, multiple drainage + Straw incorporated <30 days before cultivation		
Flooded pre-season > 30 days + Irrigated, multiple drainage + Straw incorporated >30 days before cultivation		
Flooded pre-season > 30 days + Irrigated, multiple drainage + Compost		
Flooded pre-season > 30 days + Irrigated, multiple drainage + Farm yard green manure		
Flooded pre-season > 30 days + Irrigated, multiple drainage + Green manure		
Flooded pre-season > 30 days + Rainfed, regular rainfed + Straw left on field	Intensive cropland	0,1
Flooded pre-season > 30 days + Rainfed, regular rainfed + Straw burnt		
Flooded pre-season > 30 days + Rainfed, regular rainfed + Straw exported		
Flooded pre-season > 30 days + Rainfed, regular rainfed + Straw incorporated <30 days before cultivation		
Flooded pre-season > 30 days + Rainfed, regular rainfed + Straw incorporated >30 days before cultivation		
Flooded pre-season > 30 days + Rainfed, regular rainfed + Compost		

Flooded pre-season > 30 days + Rainfed, regular rainfed + Farm yard green manure		
Flooded pre-season > 30 days + Rainfed, regular rainfed + Green manure		
Flooded pre-season > 30 days + Rainfed, drought prone + Straw left on field	Extensive cropland (Low-input agriculture)	0,3
Flooded pre-season > 30 days + Rainfed, drought prone + Straw burnt	Intensive cropland	0,1
Flooded pre-season > 30 days + Rainfed, drought prone + Straw exported		
Flooded pre-season > 30 days + Rainfed, drought prone + Straw incorporated <30 days before cultivation		
Flooded pre-season > 30 days + Rainfed, drought prone + Straw incorporated >30 days before cultivation		
Flooded pre-season > 30 days + Rainfed, drought prone + Compost		
Flooded pre-season > 30 days + Rainfed, drought prone + Farm yard green manure		
Flooded pre-season > 30 days + Rainfed, drought prone + Green manure		
Flooded pre-season > 30 days + Rainfed, deep water + Straw left on field	Extensive cropland (Low-input agriculture)	0,3
Flooded pre-season > 30 days + Rainfed, deep water + Straw burnt	Intensive cropland	0,1
Flooded pre-season > 30 days + Rainfed, deep water + Straw exported		
Flooded pre-season > 30 days + Rainfed, deep water + Straw incorporated <30 days before cultivation		
Flooded pre-season > 30 days + Rainfed, deep water + Straw incorporated >30 days before cultivation		
Flooded pre-season > 30 days + Rainfed, deep water + Compost		
Flooded pre-season > 30 days + Rainfed, deep water + Farm yard green manure		
Flooded pre-season > 30 days + Rainfed, deep water + Green manure		
Flooded pre-season < 30 days + Irrigated, continuously flooded + Straw left on field	Irrigated cropland	0,05
Flooded pre-season < 30 days + Irrigated, continuously flooded + Straw burnt		
Flooded pre-season < 30 days + Irrigated, continuously flooded + Straw exported		
Flooded pre-season < 30 days + Irrigated, continuously flooded + Straw incorporated <30 days before cultivation		
Flooded pre-season < 30 days + Irrigated, continuously flooded + Straw incorporated >30 days before cultivation		
Flooded pre-season < 30 days + Irrigated, continuously flooded + Compost		
Flooded pre-season < 30 days + Irrigated, continuously flooded + Farm yard green manure		

Flooded pre-season < 30 days + Irrigated, continuously flooded + Green manure		
Flooded pre-season < 30 days + Irrigated, single drainage + Straw left on field		
Flooded pre-season < 30 days + Irrigated, single drainage + Straw burnt		
Flooded pre-season < 30 days + Irrigated, single drainage + Straw exported		
Flooded pre-season < 30 days + Irrigated, single drainage + Straw incorporated <30 days before cultivation		
Flooded pre-season < 30 days + Irrigated, single drainage + Straw incorporated >30 days before cultivation		
Flooded pre-season < 30 days + Irrigated, single drainage + Compost		
Flooded pre-season < 30 days + Irrigated, single drainage + Farm yard green manure		
Flooded pre-season < 30 days + Irrigated, single drainage + Green manure		
Flooded pre-season < 30 days + Irrigated, multiple drainage + Straw left on field		
Flooded pre-season < 30 days + Irrigated, multiple drainage + Straw burnt		
Flooded pre-season < 30 days + Irrigated, multiple drainage + Straw exported		
Flooded pre-season < 30 days + Irrigated, multiple drainage + Straw incorporated <30 days before cultivation		
Flooded pre-season < 30 days + Irrigated, multiple drainage + Straw incorporated >30 days before cultivation		
Flooded pre-season < 30 days + Irrigated, multiple drainage + Compost		
Flooded pre-season < 30 days + Irrigated, multiple drainage + Farm yard green manure		
Flooded pre-season < 30 days + Irrigated, multiple drainage + Green manure		
Flooded pre-season < 30 days + Rainfed, regular rainfed + Straw left on field	Intensive cropland	0,1
Flooded pre-season < 30 days + Rainfed, regular rainfed + Straw burnt		
Flooded pre-season < 30 days + Rainfed, regular rainfed + Straw exported		
Flooded pre-season < 30 days + Rainfed, regular rainfed + Straw incorporated <30 days before cultivation		
Flooded pre-season < 30 days + Rainfed, regular rainfed + Straw incorporated >30 days before cultivation		
Flooded pre-season < 30 days + Rainfed, regular rainfed + Compost		
Flooded pre-season < 30 days + Rainfed, regular rainfed + Farm yard green manure		
Flooded pre-season < 30 days + Rainfed, regular rainfed + Green manure		

	Flooded pre-season < 30 days + Rainfed, drought prone + Straw left on field	Extensive cropland (Low-input agriculture)	0,3
	Flooded pre-season < 30 days + Rainfed, drought prone + Straw burnt	Intensive cropland	0,1
	Flooded pre-season < 30 days + Rainfed, drought prone + Straw exported		
	Flooded pre-season < 30 days + Rainfed, drought prone + Straw incorporated <30 days before cultivation		
	Flooded pre-season < 30 days + Rainfed, drought prone + Straw incorporated >30 days before cultivation		
	Flooded pre-season < 30 days + Rainfed, drought prone + Compost		
	Flooded pre-season < 30 days + Rainfed, drought prone + Farm yard green manure		
	Flooded pre-season < 30 days + Rainfed, drought prone + Green manure		
	Flooded pre-season < 30 days + Rainfed, deep water + Straw left on field	Extensive cropland (Low-input agriculture)	0,3
	Flooded pre-season < 30 days + Rainfed, deep water + Straw burnt	Intensive cropland	0,1
	Flooded pre-season < 30 days + Rainfed, deep water + Straw exported		
	Flooded pre-season < 30 days + Rainfed, deep water + Straw incorporated <30 days before cultivation		
	Flooded pre-season < 30 days + Rainfed, deep water + Straw incorporated >30 days before cultivation		
	Flooded pre-season < 30 days + Rainfed, deep water + Compost		
	Flooded pre-season < 30 days + Rainfed, deep water + Farm yard green manure		
	Flooded pre-season < 30 days + Rainfed, deep water + Green manure		
Cropland, perennial	Monoculture, Oil palm + no tillage + low input	Woody biofuels and perennial crops	0,3
	Monoculture, Oil palm + no tillage + medium input		
	Monoculture, Oil palm + no tillage + high input without manure		
	Monoculture, Oil palm + no tillage + high input with manure		
	Monoculture, Oil palm + reduced tillage + low input		
	Monoculture, Oil palm + reduced tillage + medium input		
	Monoculture, Oil palm + reduced tillage + high input without manure		
	Monoculture, Oil palm + reduced tillage + high input with manure		
	Monoculture, Oil palm + full tillage + low input		
	Monoculture, Oil palm + full tillage + medium input		
	Monoculture, Oil palm + full tillage + high input without manure		

	Monoculture, Oil palm + full tillage + high input with manure		
	Monoculture, Olive + no tillage + low input		
	Monoculture, Olive + no tillage + medium input		
	Monoculture, Olive + no tillage + high input without manure		
	Monoculture, Olive + no tillage + high input with manure		
	Monoculture, Olive + reduced tillage + low input		
	Monoculture, Olive + reduced tillage + medium input		
	Monoculture, Olive + reduced tillage + high input without manure		
	Monoculture, Olive + reduced tillage + high input with manure		
	Monoculture, Olive + full tillage + low input		
	Monoculture, Olive + full tillage + medium input		
	Monoculture, Olive + full tillage + high input without manure		
	Monoculture, Olive + full tillage + high input with manure		
	Monoculture, Orchard + no tillage + low input		
	Monoculture, Orchard + no tillage + medium input		
	Monoculture, Orchard + no tillage + high input without manure		
	Monoculture, Orchard + no tillage + high input with manure		
	Monoculture, Orchard + reduced tillage + low input		
	Monoculture, Orchard + reduced tillage + medium input		
	Monoculture, Orchard + reduced tillage + high input without manure		
	Monoculture, Orchard + reduced tillage + high input with manure		
	Monoculture, Orchard + full tillage + low input		
	Monoculture, Orchard + full tillage + medium input		
	Monoculture, Orchard + full tillage + high input without manure		
	Monoculture, Orchard + full tillage + high input with manure		
	Monoculture, Rubber hevea + no tillage + low input		
	Monoculture, Rubber hevea + no tillage + medium input		
	Monoculture, Rubber hevea + no tillage + high input without manure		
	Monoculture, Rubber hevea + no tillage + high input with manure		
	Monoculture, Rubber hevea + reduced tillage + low input		
	Monoculture, Rubber hevea + reduced tillage + medium input		

	Monoculture, Rubber hevea + reduced tillage + high input without manure		
	Monoculture, Rubber hevea + reduced tillage + high input with manure		
	Monoculture, Rubber hevea + full tillage + low input		
	Monoculture, Rubber hevea + full tillage + medium input		
	Monoculture, Rubber hevea + full tillage + high input without manure		
	Monoculture, Rubber hevea + full tillage + high input with manure		
	Monoculture, Short rotation + no tillage + low input		
	Monoculture, Short rotation + no tillage + medium input		
	Monoculture, Short rotation + no tillage + high input without manure		
	Monoculture, Short rotation + no tillage + high input with manure		
	Monoculture, Short rotation + reduced tillage + low input		
	Monoculture, Short rotation + reduced tillage + medium input		
	Monoculture, Short rotation + reduced tillage + high input without manure		
	Monoculture, Short rotation + reduced tillage + high input with manure		
	Monoculture, Short rotation + full tillage + low input		
	Monoculture, Short rotation + full tillage + medium input		
	Monoculture, Short rotation + full tillage + high input without manure		
	Monoculture, Short rotation + full tillage + high input with manure		
	Monoculture, Tea camelia + no tillage + low input		
	Monoculture, Tea camelia + no tillage + medium input		
	Monoculture, Tea camelia + no tillage + high input without manure		
	Monoculture, Tea camelia + no tillage + high input with manure		
	Monoculture, Tea camelia + reduced tillage + low input		
	Monoculture, Tea camelia + reduced tillage + medium input		
	Monoculture, Tea camelia + reduced tillage + high input without manure		
	Monoculture, Tea camelia + reduced tillage + high input with manure		
	Monoculture, Tea camelia + full tillage + low input		
	Monoculture, Tea camelia + full tillage + medium input		
	Monoculture, Tea camelia + full tillage + high input without manure		

	Monoculture, Tea camelia + full tillage + high input with manure		
	Monoculture, Vine + no tillage + low input		
	Monoculture, Vine + no tillage + medium input		
	Monoculture, Vine + no tillage + high input without manure		
	Monoculture, Vine + no tillage + high input with manure		
	Monoculture, Vine + reduced tillage + low input		
	Monoculture, Vine + reduced tillage + medium input		
	Monoculture, Vine + reduced tillage + high input without manure		
	Monoculture, Vine + reduced tillage + high input with manure		
	Monoculture, Vine + full tillage + low input		
	Monoculture, Vine + full tillage + medium input		
	Monoculture, Vine + full tillage + high input without manure		
	Monoculture, Vine + full tillage + high input with manure		
	Alley cropping + no tillage + low input	Agroforestry	0,5
	Alley cropping + no tillage + medium input		
	Alley cropping + no tillage + high input without manure		
	Alley cropping + no tillage + high input with manure		
	Alley cropping + reduced tillage + low input		
	Alley cropping + reduced tillage + medium input		
	Alley cropping + reduced tillage + high input without manure		
	Alley cropping + reduced tillage + high input with manure		
	Alley cropping + full tillage + low input		
	Alley cropping + full tillage + medium input		
	Alley cropping + full tillage + high input without manure		
	Alley cropping + full tillage + high input with manure		
	Perennial fallow + no tillage + low input		
	Perennial fallow + no tillage + medium input		
	Perennial fallow + no tillage + high input without manure		
	Perennial fallow + no tillage + high input with manure		
	Perennial fallow + reduced tillage + low input		
	Perennial fallow + reduced tillage + medium input		
	Perennial fallow + reduced tillage + high input without manure		
	Perennial fallow + reduced tillage + high input with manure		
	Cropland, perennial - Perennial fallow + full tillage + low input		
	Perennial fallow + full tillage + medium input		
	Perennial fallow + full tillage + high input without manure		

	Perennial fallow + full tillage + high input with manure		
	Hedgerow + no tillage + low input		
	Hedgerow + no tillage + medium input		
	Hedgerow + no tillage + high input without manure		
	Hedgerow + no tillage + high input with manure		
	Hedgerow + reduced tillage + low input		
	Hedgerow + reduced tillage + medium input		
	Hedgerow + reduced tillage + high input without manure		
	Hedgerow + reduced tillage + high input with manure		
	Hedgerow + full tillage + low input		
	Hedgerow + full tillage + medium input		
	Hedgerow + full tillage + high input without manure		
	Hedgerow + full tillage + high input with manure		
	Multistrata + no tillage + low input		
	Multistrata + no tillage + medium input		
	Multistrata + no tillage + high input without manure		
	Multistrata + no tillage + high input with manure		
	Multistrata + reduced tillage + low input		
	Multistrata + reduced tillage + medium input		
	Multistrata + reduced tillage + high input without manure		
	Multistrata + reduced tillage + high input with manure		
	Multistrata + full tillage + low input		
	Multistrata + full tillage + medium input		
	Multistrata + full tillage + high input without manure		
	Multistrata + full tillage + high input with manure		
	Parkland + no tillage + low input		
	Parkland + no tillage + medium input		
	Parkland + no tillage + high input without manure		
	Parkland + no tillage + high input with manure		
	Parkland + reduced tillage + low input		
	Parkland + reduced tillage + medium input		
	Parkland + reduced tillage + high input without manure		
	Parkland + reduced tillage + high input with manure		
	Parkland + full tillage + low input		
	Parkland + full tillage + medium input		
	Parkland + full tillage + high input without manure		
	Parkland + full tillage + high input with manure		
	Shaded perennial + no tillage + low input		
	Shaded perennial + no tillage + medium input		
	Shaded perennial + no tillage + high input without manure		
	Shaded perennial + no tillage + high input with manure		

	Shaded perennial + reduced tillage + low input		
	Shaded perennial + reduced tillage + medium input		
	Shaded perennial + reduced tillage + high input without manure		
	Shaded perennial + reduced tillage + high input with manure		
	Shaded perennial + full tillage + low input		
	Shaded perennial + full tillage + medium input		
	Shaded perennial + full tillage + high input without manure		
	Shaded perennial + full tillage + high input with manure		
	Silvoarable + no tillage + low input		
	Silvoarable + no tillage + medium input		
	Silvoarable + no tillage + high input without manure		
	Silvoarable + no tillage + high input with manure		
	Silvoarable + reduced tillage + low input		
	Silvoarable + reduced tillage + medium input		
	Silvoarable + reduced tillage + high input without manure		
	Silvoarable + reduced tillage + high input with manure		
	Silvoarable + full tillage + low input		
	Silvoarable + full tillage + medium input		
	Silvoarable + full tillage + high input without manure		
	Silvoarable + full tillage + high input with manure		
	Silvopasture + no tillage + low input		
	Silvopasture + no tillage + medium input		
	Silvopasture + no tillage + high input without manure		
	Silvopasture + no tillage + high input with manure		
	Silvopasture + reduced tillage + low input		
	Silvopasture + reduced tillage + medium input		
	Silvopasture + reduced tillage + high input without manure		
	Silvopasture + reduced tillage + high input with manure		
	Silvopasture + full tillage + low input		
	Silvopasture + full tillage + medium input		
	Silvopasture + full tillage + high input without manure		
	Silvopasture + full tillage + high input with manure		
Grassland	Improved with two inputs	Pasture – moderately to intensively used	0,6
	Improved with one input		
	Natural	Natural grassland	1
	High Intensity Grazing	Pasture – moderately to intensively used	0,6
	Severely Degraded		
Wetland	Mangrove - High Integrity		
	Mangrove - Medium Integrity		

	Mangrove - Low Integrity		
	Forest - High Integrity		
	Forest - Medium Integrity		
	Forest - Low Integrity		
	Annual Cropland - High Integrity		
	Annual Cropland - Medium Integrity		
	Annual Cropland - Low Integrity		
	Flooded Rice - High Integrity		
	Flooded Rice - Medium Integrity		
	Flooded Rice - Low Integrity		
	Perennial Cropland Monoculture - High Integrity		
	Perennial Cropland Monoculture - Medium Integrity		
	Perennial Cropland Monoculture - Low Integrity		
	Perennial Cropland Agroforestry - High Integrity		
	Perennial Cropland Agroforestry - Medium Integrity		
	Perennial Cropland Agroforestry - Low Integrity		
	Grassland - High Integrity	Natural	1
	Grassland - Medium Integrity	Reduced Impact Logging	0,85
	Grassland - Low Integrity	Selective logging (Lightly used forest)	0,7
Settlement	Urban Green	Urban areas	0,05
	Settlement		
Other Land	Water	Bare area	
	Other Land		

Annex II – Conversion table for land cover datasets and ABC-Map

Table 1. CCI LC

ESA CCI 300m Land Cover Classes	IPCC	ABC-Map
Cropland rainfed	Cropland, annual	Reduced tillage + medium input
Cropland rainfed- Herbaceous cover		
Cropland rainfed- Tree or shrub cover	Cropland, perennial	Monoculture, Orchard + reduced tillage + medium input
Cropland irrigated or post-flooding	Cropland, flooded rice	Non-flooded pre-season > 180 days + Irrigated, continuously flooded + Straw left on field
Mosaic cropland (>50%) / natural vegetation (Tree, shrub, herbaceous cover) (<50%)	Cropland, perennial	Monoculture, Orchard + reduced tillage + medium input
Mosaic natural vegetation (Tree, shrub, herbaceous cover) (>50%) / cropland (<50%)		Silvopasture + reduced tillage + medium input
Tree cover, broadleaved, evergreen, closed to open (>15%)	Forest	Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, broadleaved, deciduous, closed to open (>15%)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, broadleaved, deciduous, closed to open (>15%)- Tree cover, broadleaved, deciduous, closed (>40%)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, broadleaved, deciduous, closed to open (>15%)- Tree cover, broadleaved, deciduous, open (15-40%)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, needleleaved, evergreen, closed to open (>15%)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, needleleaved, evergreen, closed to open (>15%)- Tree cover, needleleaved, evergreen, closed (>40%)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, needleleaved, evergreen, closed to open (>15%)- Tree cover, needleleaved, evergreen, open (15-40%)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
		Forest + High Integrity*

Tree cover, needleleaved, deciduous, closed to open (>15%)		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, needleleaved, deciduous, closed to open (>15%)- Tree cover, needleleaved, deciduous, closed (>40%)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, needleleaved, deciduous, closed to open (>15%)- Tree cover, needleleaved, deciduous, open (15-40%)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Tree cover, mixed leaf type (broadleaved and needleleaved)		Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Mosaic T and shrub (>50%) / herbaceous cover (<50%)		Shrubland + High Integrity*
		Shrubland + Medium Integrity*
		Shrubland + Low Integrity*
Mosaic herbaceous cover (>50%) / T and shrub (<50%)	Grassland	Natural
Shrubland	Forest	Shrubland + High Integrity*
		Shrubland + Medium Integrity*
		Shrubland + Low Integrity*
Shrubland- Shrubland evergreen		Shrubland + High Integrity*
		Shrubland + Medium Integrity*
		Shrubland + Low Integrity*
Shrubland- Shrubland deciduous		Shrubland + High Integrity*
		Shrubland + Medium Integrity*
		Shrubland + Low Integrity*
Grassland	Grassland	Natural
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)		
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)- Sparse tree (<15%)		
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)- Sparse shrub (<15%)		
Sparse vegetation (tree, shrub, herbaceous cover) (<15%)- Sparse herbaceous cover (<15%)		
Tree cover, flooded, fresh or brakish water	Wetland	Forest - High Integrity*
		Forest - Medium Integrity*
		Forest - Low Integrity*
Tree cover, flooded, saline water		Forest - High Integrity*
		Forest - Medium Integrity*
		Forest - Low Integrity*

Shrub or herbaceous cover, flooded, fresh/saline/brakish water		Grassland - High Integrity*
		Grassland - Medium Integrity*
		Grassland - Low Integrity*
Urban areas	Settlement	Settlement
Bare areas	Other Land	Other Land
Bare areas- Consolidated bare areas		
Bare areas- Unconsolidated bare areas		
Permanent snow and ice		
Water bodies		Water

* Integrity is derevided from...

TABLE 2. ESA AFRICA

ESA Africa 20m	IPCC	ABC-Map
Trees cover areas	Forest	Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Shrubs cover areas	Forest	Shrubland + High Integrity*
		Shrubland + Medium Integrity*
		Shrubland + Low Integrity*
Grassland	Grassland	Natural
Cropland	Cropland, annual	Reduced tillage + medium input
Vegetation aquatic or regularly flooded	Wetland	Grassland - High Integrity*
		Grassland - Medium Integrity*
		Low Integrity*
Sparse vegetation	Other Land	Other Land
Bare areas		
Built up areas	Settlement	Settlement
Snow and/or ice	Other Land	Other Land
Open water	Other Land	Water

* Integrity is derevided from...

TABLE 3. ESA MESOAMERICA

ESA Mesoamerica 10m Land Cover Classes	IPCC	ABC-Map
Trees cover areas	Forest	Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Shrubs cover areas	Forest	Shrubland + High Integrity*
		Shrubland + Medium Integrity*
		Shrubland + Low Integrity*
Grassland	Grassland	Natural
Cropland	Cropland, annual	Reduced tillage + medium input
Vegetation aquatic or regularly flooded	Wetland	Grassland - High Integrity*
		Grassland - Medium Integrity*
		Grassland - Low Integrity*
Sparse vegetation	Other Land	Other Land
Bare areas		
Built up areas	Settlement	Settlement
Snow and/or ice	Other Land	Other Land
Open water		Water

* Integrity is derevided from...

TABLE 4. ESA EUROPE

ESA Europe 10m Land Cover Classes	IPCC	ABC-Map
Artificial surfaces and constructions	Settlement	Settlement
Cultivated areas	Cropland, annual	Reduced tillage + medium input
Vineyards	Cropland, perennial	Monoculture, Vine + no tillage + medium input
Broadleaf tree cover	Forest	Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Coniferous tree cover	Forest	Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Sclerophyllous vegetation	Forest	Forest + High Integrity*
		Forest + Medium Integrity*
		Forest + Low Integrity*
Herbaceous vegetation	Grassland	Natural
Moors and Heathland	Forest	Shrubland + High Integrity*
		Shrubland + Medium Integrity*
		Shrubland + Low Integrity*
Marshes	Wetland	Grassland - High Integrity*
		Grassland - Medium Integrity*
		Grassland - Low Integrity*
Peatbogs	Wetland	Grassland - High Integrity*
		Grassland - Medium Integrity*
		Grassland - Low Integrity*
Natural material surfaces	Other Land	Other Land
Permanent snow covered surfaces		
Water bodies	Other Land	Water

* Integrity is derevided from...

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