Monitoring land health in agriculture landscapes

Guidance note

Mercedes Muñoz Cañas

With contributions from Simon Julien, Ludovic Larbodière, Maria Ana Borges

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Introduction

Monitoring and metrics are key components of strategies for transitioning to sustainable agriculture. In fact, monitoring is particularly important to assess both the positive and negative impacts of agricultural production systems on biodiversity and ecosystems, enhance their beneficial effects, and safeguard the natural capital essential for the long-term sustainability of agriculture and food production.

Monitoring and metrics also enable tracking progress on targets that are set for the transition to sustainable agriculture as well as allowing for adaptive management of practices and interventions. Furthermore, the quality and coverage of monitoring will allow us to collectively assess whether we are on track to meet global 2030 goals.

A wide range of tools and indicators are used to monitor sustainable agriculture worldwide (See Annex I and II for a non-exhaustive list). A review of those tools revealed that none of them provide a complete view of all the impacts of agriculture on biodiversity and natural factors and that many are also developed for a specific scale and purpose (mainly farm or soil) with a gap identified in terms of linkages and aggregation to different levels (soil, farm, landscape and national).

Based on the above, IUCN developed the ***Land Health Monitoring Framework***, a framework for monitoring biodiversity at different levels in productive agroecosystems.

Land health is understood as 'the capacity of land, relative to its potential, to sustain delivery of ecosystem services'. Therefore, this guidance is focused on how to assess the *capacity of land* to deliver ecosystem services, which includes the biotic processes and the state of natural resources.

The Land Health Monitoring Framework (LHMF) is designed to support **the monitoring of biodiversity** on actions that drive positive change, such as transitions from conventional to sustainable agriculture, agricultural landscape restoration, and the implementation of Nature-based Solutions (NbS). It embeds monitoring within broader intervention cycles, enabling stakeholders to assess progress, adapt strategies, and refine practices based on robust evidence.

As a comprehensive and flexible framework, the LHMF is able to integrate a wide range of tools, metrics and indexes (listed in the annexes of the present document) – such as the Agrobiodiversity Index, the Cool Farm Tool, and the Global Farm Metric – enabling users to continue working with the approaches they are accustomed to, while addressing the limitations of these individual methods. These resources, often focused on specific dimensions like soil chemistry, field-level biodiversity, or landscape dynamics, are aligned and enhanced within the LHMF to ensure a holistic assessment of land health across scales. By bringing together resources from international organizations, public institutes, and research platforms, the LHMF enables a unified approach to land health monitoring, promoting sustainable land management and biodiversity conservation.

The IUCN framework enables selecting appropriate **indicators for monitoring biodiversity at 4 scales: field, farm, landscape, and national/global**. It is important to mention that the national/global level is not a formal scale for monitoring but rather a step that helps to set the context and tie monitoring processes to national commitments in an effort to ensure their relevance and wider contribution. It also helps to understand the spillover effects from one productive landscape to another.

The IUCN framework explicitly emphasizes the environmental pillar of sustainability, focusing in biodiversity and the state of natural resources. The present guidance does not provide guidance on social and economic dimensions. Even though we recognise that socioeconomic indicators could be useful to interpret the human context of the state of the environment, many indicators have been established to monitor them and can be used to complement the present guidance.

The framework, outlined in Figure 1, has initially been designed to serve IUCN projects and therefore to be used principally by project managers, often in collaboration with local and national authorities as well as private companies and farmers. The effectiveness of the framework must be assessed for its relevance to these different groups and positioned as an incentive for them to adopt, by highlighting why the knowledge achieved is key for their own benefit.

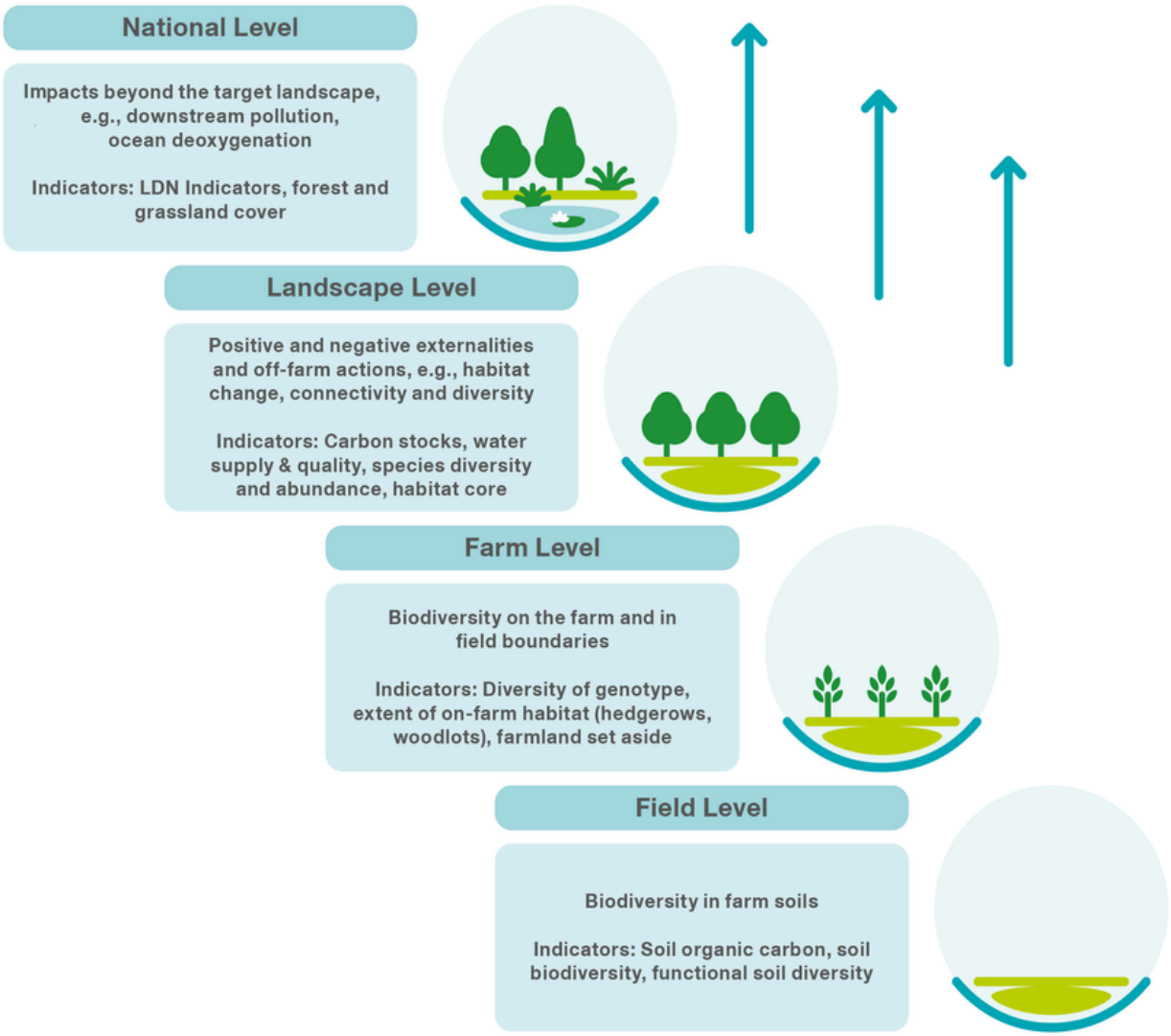


Figure 1. IUCN Land health monitoring framework.
Source: Dussán López, P. (2023)

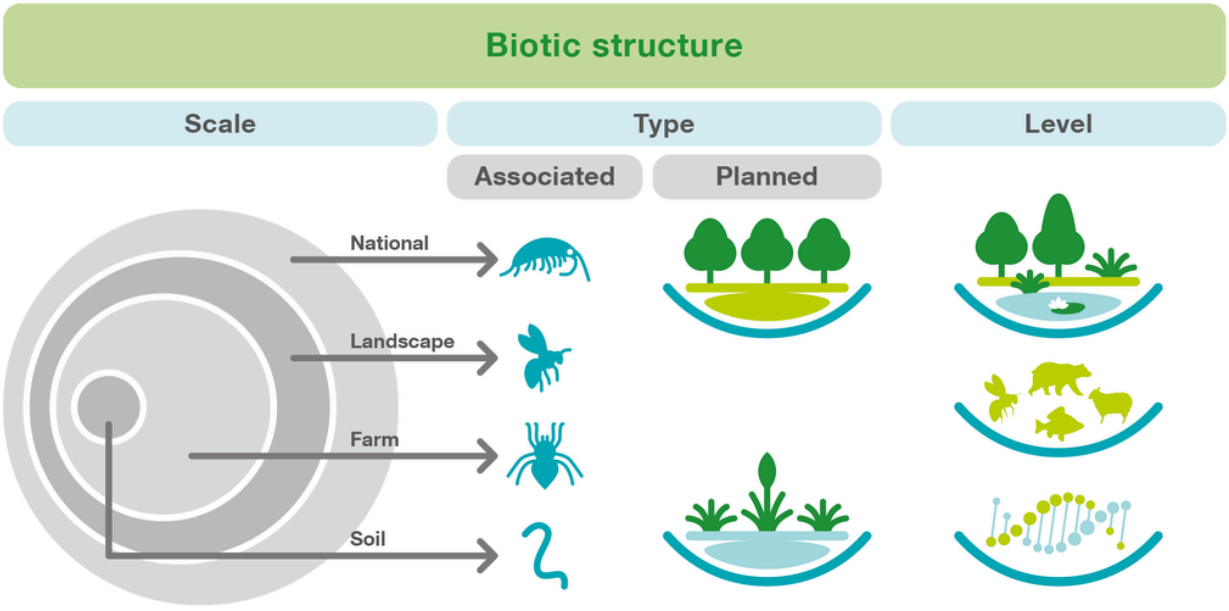


Figure 2. Three dimensions of the biotic structure: scale, type and level.
Source: Dussán López, P. (2023)

The four levels of the Land Health Monitoring Framework

1. **At soil/field level** we examine ***the soil biotic structure (field level),*** which includes the belowground biodiversity such as all kingdoms of living nature that inhabit the soil, i.e., the underground parts of plants, vertebrate and invertebrate animals, algae, and protozoans, fungi, and bacteria (Glazovsky & Zaitseva, 2009). In the present document, soil is used as an equivalent of field.

2. **At farm level** we examine how farming practices influence biodiversity, and by extension, the farm ecosystem functions that biodiversity is responsible for. In this context, it is to be noted that biodiversity conservation at the farm level is attained through practices that explicitly promote biodiversity and/or minimise the negative environmental impacts of agriculture. ***The farm biotic structure (farm level)***, includes the aboveground biodiversity such as domestic/wild animals and plants in an agricultural production unit as well as in the surroundings. The Figure 2 above outlines the three dimensions of the biotic structure.

3. **The landscape level** is where critical ecosystem functions are maintained, including those that support agriculture and livestock and those that are enjoyed outside the farming landscape. Sustainable agricultural landscapes should maintain or strengthen the biological and economic productivity and complexity of the landscape, which can be measured through ecosystem services and functions. At the landscape scale, it is necessary also to consider trade-offs between land uses in order to maintain the desired balance of ecosystem functionality. ***The landscape biotic structure (landscape level)*** encompasses land heterogeneity, the biodiversity that is not considered in the other two levels (farm and field) and the diversity of habitats in a predefined geographical area.

4. **The national level** includes biodiversity and natural resources in the sum of landscapes encircled by an administrative border (e.g., region, district, province, state, etc.). This scale includes the possible land-use spillovers within the country and between countries, as disturbances from farming practices impact the biotic structure beyond the farm itself and should be considered (e.g., biodiversity-friendly policies increase the habitat diversity in country A but encourage monoculture in country B). As mentioned before, this level does not constitute a formal scale to monitor but it is included as context to support decision-making and to gain a better understanding of the spillover effects from one productive landscape to another.

About the Guidance note for monitoring land health

This guidance note has been developed to provide a step-by-step process for monitoring land health in geographical areas where agriculture is the dominant land use. It helps navigate existing indexes and select the appropriate indicators at different levels.

Glossary

Aboveground biodiversity The diversity of living organisms found above the soil surface.

Agricultural biodiversity (**Agrobiodiversity**) 'All components of biological diversity of relevance to food and agriculture and that constitute an agroecosystem: the variety and variability of animals, plants and microorganisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agroecosystem' (CBD, 2000).

Agricultural ecosystems (**Agroecosystem**) 'Communities of plants and animals interacting with their physical and chemical environments that have been modified by people to produce food, fibre, fuel and other products for human consumption and processing' (Altieri, 2002).

Associated biodiversity Genetic variation of cultivars/livestock and wild plants/insects; species variation in crops/insects released for biocontrol and wild plants/insects; diversity of artificial and natural ecosystems.

Belowground biodiversity The diversity of the soil biota.

Biological diversity (**Biodiversity**): At the global level, it is 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems' (CBD, 2011).

Biotic structure The living organisms that shape the environment.

Ecosystem functions 'Ecosystem functioning reflects the collective life activities of plants, animals, and microbes and the effects these activities (e.g., feeding, growing, moving, excreting waste) have on the physical and chemical conditions of their environment. Ecosystem functions (sometimes also referred to as ecosystem processes or ecological processes) are an integral part of biodiversity, and can thus be broadly defined as the biological, geochemical and physical processes that take place or occur within an ecosystem' (GEOBON).

Ecosystem services 'The set of ecosystem functions that are useful to humans' (Kremen, 2005). According to the 2005 Millennium Ecosystem Assessment (MEA), ecosystem services can be divided into four categories: provisioning services like food, fibre, and fuel; supporting services such as nutrient cycling, soil formation and habitat provision; regulating services including climate regulation, water, and disease and pest control; and cultural services such as aesthetic, spiritual or recreational experiences (MEA, 2005).

Glossary

Farm The economic unit of an agroecosystem. An area of land and its buildings, used for growing crops and/or rearing animals.

Farming System A farming system is defined as a population of individual farm systems that have broadly similar resource basis, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate (Dixon et al., 2001).

Functional biodiversity Biodiversity that provides ecosystem functions and services to agricultural landscapes.

Land health 'The capacity of land, relative to its potential, to sustain delivery of ecosystem services' (Shepherd et al., 2015).

Landscape A socio-ecological system that consists of a mosaic of natural and/or human modified ecosystems, with a characteristic configuration of topography, vegetation, land use, and settlements that is influenced by the ecological, historical, economic and cultural processes and activities of the area. Depending on the management objectives of the stakeholders, landscape boundaries may be discrete or fuzzy, and may correspond to watershed boundaries, distinct land features, and/or jurisdictional boundaries, or cross-cut such demarcations. A landscape may encompass areas from hundreds to tens of thousands of square kilometres (Scherr et al., 2013).

Nature-based Solutions Nature-based Solutions address societal challenges through actions to protect, sustainably manage, and restore natural and modified ecosystems, benefiting people and nature at the same time (IUCN).

Planned biodiversity Biodiversity voluntarily introduced by the farmer.

Sustainable agriculture 'The management and conservation of the natural resource base, and the orientation of technological change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Sustainable agriculture conserves land, water, and plant and animal genetic resources, and is environmentally non-degrading, technically appropriate, economically viable and socially acceptable' (FAO, 1988).

STEPS to assess land health

The steps to assess land health are outlined in Figure 3. The details of each step are explained in the following sections.

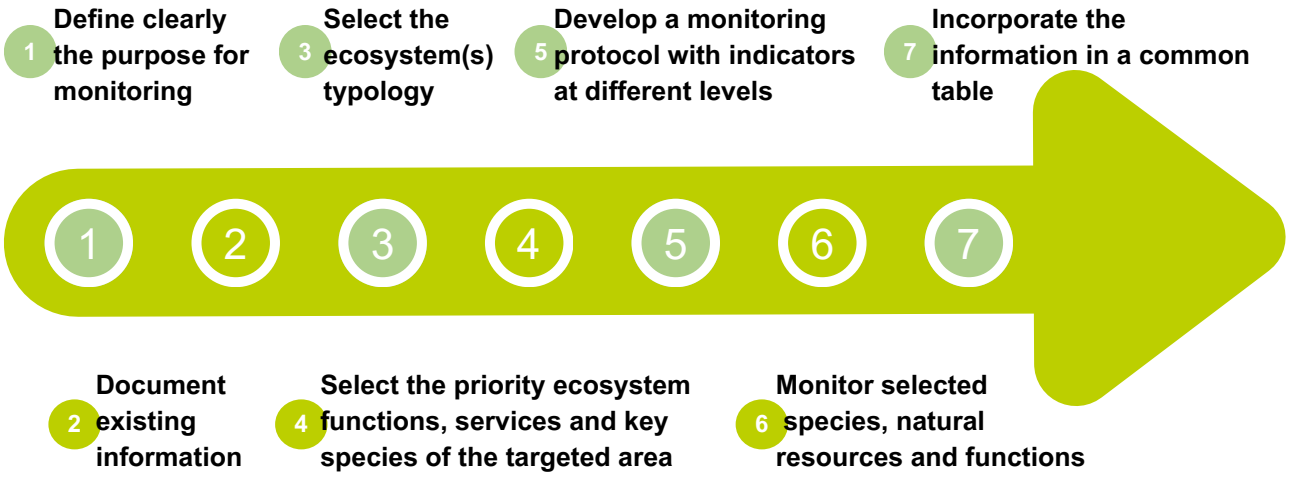


Figure 3. Illustration of step-by-step land health assessment.
Source: Prepared by the authors.

1. Define clearly the objective and purpose for monitoring

The first step consists in defining the objective of the monitoring, what is intended to be achieved (for instance, in a degraded landscape, certain ecosystem functions participating to restoring soil fertility, or improving water quality, could be priorities; the goal could include the development of targeted Nature-based Solutions using the NbS Agriculture Guidance (under development. For NbS criteria, see Annex III)).

Once the purpose of the monitoring has been made clear, it is crucial to gather as much information about the history and the baseline of the state of the agricultural landscape of interest. The impact on ecosystem services delivered to farm production and society should be understood by identifying the threats to biodiversity, the drivers of biodiversity losses, and the ecosystem dependencies. This will help the understanding of the actions needed to put in place to reach the objective(s).

The goal is to set clear objectives and commitments by understanding the land historical use, along with the current state of its biodiversity and ecosystems at the different levels.

In this step we would need to clearly define:

- The objective(s) of the monitoring
- The area concerned (and specific levels for monitoring)
- The historical use of the land
- The targeted production/cropping system(s) and season(s)
- Value chains of relevance
- Land uses (for landscape level)
- Farm systems in place (or towards which to move)
- The needs for the monitoring, with a particular emphasis on the ecosystem functions that need to be preserved (this would be the priority issues that are faced in the landscape, e.g., soil fertility, acidity, salinity, erosion, water quality, etc.) to guide the selection of indicators.

Tips

- Check with local agricultural experts/advisors. While national and regional information (such as statistics) can be useful for a more general context, information obtained closest to the farms is often more precise than the one from higher levels.

- It is important to take into account the heterogeneity in management practices and geographical locations when designing a monitoring plan.

2. Document existing information

After defining the area and the objectives of the monitoring, the next step is to document the information and data that is already available at different levels (if the data that is available is old, new data should be gathered). This will help to better define the indicators that will be needed through a gap analysis.

The following table can be used to document existing monitoring plans and indicators that are used and/or have been used in the selected agriculture landscape, in order to identify and to take note of gaps on monitoring for which local solutions are currently absent. Part of this preliminary assessment should be to document any relevant indicators that are already institutionalised in the country (e.g., within Ministries of Agriculture, or under national reporting against sustainable development goals (SDGs), etc.) and also to identify technical capacities necessary (such as specialist knowledge for species identification) or constraints (such as access to laboratory equipment) for the required monitoring. In this process, it is important to strike a balance between local knowledge and broader, regional perspectives.

Level	**Indicators / monitoring tools proposed in the existing agricultural landscape**	**Established indicators / tools accessible to project implementer**	**Gaps* where additional tools / indicators are required**	**Technical capacities**
Field				
Farm				
Landscape				
National				
Other				

**Is monitoring missing in any of those levels? Are indicators targeted in each of the levels? If not, please say so in the relevant cell.*

Additional comments

Please write below any other information that could be useful for the purpose of the work but does not fit in the table above.

Tips

- Targeted information can be collected from many sources, but the most reliable is usually the household interview.
- The adoption of bottom-up approach, addressing biodiversity information gaps by starting at the smallest scale and moving to the largest, could reduce information gaps in larger dimensional scales.

3. Select the ecosystem(s) typology

Step three consists in defining the targeted agroecosystem. This step is needed to identify links between ecosystem types and natural resources or biodiversity that may facilitate the choice of indicators in the future steps.

1. Define the ecosystem(s) that align(s) the most to your selected area. The IUCN Global Ecosystem Typology (Keith et al., 2020) might provide a basis for monitoring environmental outcomes per Ecosystem Functional Group (EFG). The typology encompasses five realms representing all parts of the biosphere, passing through 25 biomes and 110 ecosystem functional groups. From these ecosystem functional groups, approximately 40 support agricultural activities. For example, for extensive livestock production areas, the ecosystem type would be one of the Grassland EFG.

2. Define the main characteristics of your area linked to the EFG(s) to which it belongs (ecological traits, possible threats, main practices, biodiversity, etc.)

3. Define the current state of the selected area in terms of conservation status, the desired level to reach and the changes that need to be made (complete the information gathered in “Step 1. Define clearly the objective and purpose for monitoring” accordingly).

4. Review all the gathered information and verify if the selected EFG is the one that aligns the most with the selected area.

Tip

In some selected landscapes, the agriculture system consists in a mosaic of EFGs (combining, for example, a productive forest, areas of cereal production and pastures for livestock).
In such situations, select the most relevant/important ones, or just the dominant one, according to the monitoring objectives; all the while keeping in mind the trade-offs between convenience (less complexity when selecting only one or two EFGs) and precision (a more accurate picture of the landscape will be obtained if all relevant EFGs are selected).

4. Select the priority ecosystem functions, services and key species of the targeted area

This step is divided in two parts. The first part (4.1) aims to explain how to find the main functions, services and species at each of the 4 levels of the Land health framework.
The second part (4.2) consists in organizing a series of meetings with experts and relevant stakeholders in order to obtain the final list of functions, services and species that should be monitored (examples are available in Annex V).

Tip
For this step, leveraging academic approaches and/or working in collaboration with academic structures could be important. Concepts and models from academic research can enhance the understanding of the relationship between ecosystem functions and biodiversity. Exploring concepts like "structural stability of ecosystems," "matrices of presence and absence," "co-occurrence and interactions," and "predator-prey dynamics" (especially relevant in agriculture), could be useful for the targeted objective. While these analyses may be complex, their results can provide valuable insights to assist farmers in integrating ecological principles into their production systems effectively.

4.1. Select the related indicators at each scale

Under step 4, the four levels (national, landscape, farm and soil/field) are targeted. Below is information providing guidance on how to select the related functions, services and indicators at each of those 4 levels.

A non-exhaustive review of indicators and indexes used nowadays has been conducted, and it is available as Annex for potential use.

A. National/Global level* - **Documenting existing information and national/international commitments**

**There will be inevitable challenges of attribution at this level that should be addressed through qualitative assessment and analysis of the relationship between local level changes and national level indicators.*

The national level includes biodiversity and natural resources in the sum of landscapes encircled by an administrative border (e.g., region, district, province, state, etc.). This level of analysis includes the possible land-use spill-overs within the country and between countries. Disturbances from farming practices impact the biotic structure beyond the farm itself and should be considered (e.g., biodiversity-friendly policies increase the habitat diversity in country A but encourage monoculture in country B). As mentioned before, this level does not constitute a formal scale to monitor but it is included as context to support decision-making and to gain a better understanding of the spill-over effects from one productive landscape to another. Therefore, no selection of indicators is expected here.

Instead, the different political commitments made by the country/countries in which the landscape is situated should be reviewed (this step should be complementing the work performed in “Step 2. documenting existing information”).

The aim behind the research done at the national/global level is to link the work of the other three levels with the conventions and agreements of the country/countries where the monitored landscape is situated (see Annex IV for sites where to search for global information). Concretely, this is done through:

1. Adding to the results found in step 2 any other additional information of commitments from the region or country relevant for the selected area.

2. Reviewing the main policies in relation to agriculture, biodiversity and ecosystems protection. The websites that should be consulted for this review include the ones of the Ministries in charge of agriculture and livestock, ecological transition and environment.

Tips

- The work done on the national/global level should allow to track relevant agreements and conventions related to agriculture on the wider environment and biodiversity aspects. SDG and Nationally Determined Contributions (NDCs) indicators provide one possible option for national level monitoring.
- As an example, national level information could include established SDG indicators of Land Degradation Neutrality (land productivity, land cover changes and soil organic carbon). The review of the existing documents should also help to track potential spillover effects of agriculture projects, for example if more sustainable agriculture practices would result in severe gross yields reductions and thus in agricultural expansion in other landscapes or countries.
- Reviewing the ministerial webpages related to agriculture and environment could provide additional information about the commitments of the country.

B. Landscape level* - **Selecting biodiversity and the ecosystem typology, functions and services**

**This level requires GIS analysis.*

The landscape level is where critical ecosystem functions are maintained, including those that support agriculture and those that are enjoyed outside the farming landscape. Sustainable agricultural landscapes should maintain or strengthen the complexity of landscape (i.e. the various elements proven to be beneficial to ecosystem health and resilience, such as rivers, forests, etc.) as well as its biological and economic productivity, which can be measured through ecosystem services and functions. At the landscape scale, it is necessary also to consider trade-offs between land uses in order to maintain the desired balance of ecosystem functionality.

The landscape biotic structure (landscape level), encompasses land heterogeneity and biodiversity that isn't considered in the other following two levels (farm and soil/field) and the diversity of habitats in a predefined geographical area. Landscape level aims to monitor the structure of the selected agroecosystem, measuring the habitat diversity (composition and configuration).

The questions that need to be solved at landscape level are:

a) Which biodiversity is delivering the selected functions and ecosystem services at landscape level?
b) Which natural resources are linked to those functions and should be monitored?

Concretely, these are the steps that should be taken:

1. Perform a literature review and use GIS tools to define the different habitats that are part of the selected area.
2. Select the key ecosystem functions and services and link them to the natural resources (e.g., catchment boundary, land use, farming systems).
3. Select, at landscape level, the key species that are maintaining those functions (e.g., pollinator-friendly vegetation, plants participating to soil stabilization and erosion control, trees acting as windbreak, etc.).

Tips

- Select the natural resources and related biodiversity in off-farm habitat (forests, rivers, wetlands etc.). This could include indicators of land cover change (e.g., habitat change) or indicators of pollution or other hazards.
- Include other structural elements that will impact biodiversity, such as connectivity, size of plots, diversity in production systems and habitats.
- It is important to note that the data needs should be well-calibrated and carefully analysed, considering that information validation at the local level depends on specific models.

It is important to remember that this stage of monitoring landscape level indicators may face challenges of differentiation in extensive grazing systems where field boundaries do not formally exist. This needs to be documented as part of the evaluation and may lead to a blurring of levels C (farm) and B (landscape).

Examples of indicators that can be used and their full description are included as annex

C. Farm level - **Selecting the aboveground groups (planned and associated)**

At farm level we examine how farming practices influence biodiversity, including soil ecosystem functions. Biodiversity can be conserved at the farm level through practices that explicitly promote biodiversity and/or minimise the negative impacts of agriculture (e.g. minimum tillage, cover crops, agroforestry, organic inputs instead of synthetic ones, etc.).

The farm biotic structure (farm level) includes the aboveground biodiversity, such as domestic/wild animals and plants, in an agricultural production unit and the surroundings. The ecosystem services and ecosystem functions of an agricultural landscape and farm are linked with the below and aboveground biodiversity that could be found in the selected agroecosystem.

As a very simplified example:

Aboveground group

- *Keystone species*: vascular plants, bees, spiders, butterflies, birds and bats.
- *Ecosystem functions*: seed dispersion, pollination, predation, pest and disease control.

The questions that need to be solved at farm level are:

a) Which functions need to be preserved to support/enable/ensure sustainable farming practices?
b) Which aboveground biodiversity and natural resources are delivering those functions at farm level and should be monitored?

Concretely, these are the steps that should be taken:

1. Select the key functions at farm level that need to be preserved for resilient farming.
2. Select the key species at farm level that are maintaining those functions.

Tips

- Many conventional indicators of agrobiodiversity focus on the farm level, including genetic diversity of livestock, crops and trees, presence of pollinators, natural predators, etc.
- Farm level indicators could include indicators of perennial vegetation cover and diversity (especially on grazing lands), extent and health of field boundaries, protection of unproductive areas of farmland (wetlands, woodlands, etc.) on the farm. However, this should be differentiated from similar features that are off-farm but in the farming landscape (see level B, landscape).
- Certain parameters could be affected by seasonal and climatic variations, therefore clearly select the season of the year most appropriate to measure your indicator.

Examples of indicators that can be used and their full description are included as annex

D. Soil/Field level* - **Selecting the belowground groups (planted and associated)**

**This level may require some lab analysis.*

At soil/field level we examine ***the soil biotic structure (field level)***, which includes the belowground biodiversity such as all kingdoms of living nature that inhabit the soil, i.e., the underground parts of plants, vertebrate and invertebrate animals, algae and protozoans, fungi and bacteria (Glazovsky & Zaitseva, 2009). In the present document, soil is used as an equivalent of field.

As a reminder, ecosystem services and ecosystem functions of an agricultural landscape and farm are linked with the below and aboveground biodiversity that could be found in the selected agroecosystem.

<u>As a very simplified example:</u>

Belowground group

- *Keystone species*: earthworms.
- *Ecosystem functions*: decomposition of organic matter, maintenance of soil structure and regulation of soil hydrological processes, mineralization and nutrient cycling, plant growth control, detoxification of pollutants, and plant pest biological suppression.

The questions that need to be solved at soil/field level are:

a) Which soil functions need to be preserved maintain soil health and support/enable/ensure sustainable farming?
b) Which belowground biodiversity (planned and associated) is delivering those functions?

Concretely, these are the steps that should be taken:

1. Select the key functions at soil/field level that need to be preserved for resilient farming.
2. Select the key species at soil/field level that are maintaining those functions.

Tips

- Field monitoring should include a set of soil species that are recognized as good indicators of soil health in the area (e.g., earthworms, nematodes, fungi, carabs, ants, termites, dung beetles, etc.).
- Field level monitoring should include soil organic matter/soil organic carbon as an important indicator to track the performance of sustainable agriculture, since it directly correlates with the levels of soil biodiversity and a number of important soil-based ecosystem services, such as carbon sequestration, soil moisture retention, and water supply.

- Field level monitoring should include some physical and chemical indicators of soil health (aggregate, water capacity, surface structure, erosion, salinity, soil moisture, acidity, nutrient content, heavy metals, etc.) prioritized according to the key challenges experienced locally. Several of the parameters should be measured at the same time.

- Most of time, soils' characteristics vary along the slope in the landscape (toposequence). Normally, farmers are aware of these differences and allocate their cropping systems accordingly. However non soil scientists may not be aware of these differences. It is important to use soil maps to have clear understanding of the biophysical environment.

- Certain parameters could be affected by seasonal and climatic variations, therefore clearly select the season of the year most appropriate to measure your indicator.

Examples of indicators that can be used and their full description are included as annex

4.2. List of functions, services and key species to be monitored: Selection of indicators

Based on results of step 3, and the A, B, C, D analysis of step 4.1, a list of the main ecosystem functions and services that need to be targeted will have been obtained.

That list of preselected ecosystem functions and services - including the review of the available information collected in steps 1, 2 and 3 - should be presented to a group of experts selected by IUCN. The members of the group of experts will be brought together by selecting subject matter experts to validate, complete, and advise on how to measure the list of priority ecosystem functions and services of the selected area based on the results presented. Once the group of experts is assembled, IUCN will moderate the discussion amongst its members.

The final validation of the preselected ecosystem functions and services by the group of experts should be made through meetings convened by IUCN with relevant stakeholders (farmers, conservation experts, soil specialists, public authorities) able to provide input on the most relevant way to proceed for the agricultural landscape(s) in question.

Discussions should cover the four scales of the monitoring framework (field, farm, landscape and national*). **This validation will include the national level to relate the work with the national priorities and to reduce the risks of spillover effects*.

On those meetings IUCN will share the results obtained in previous steps and the functions and services preselected with the group of experts and will discuss with the relevant stakeholders to decide which of them are the most appropriate, adapting the results to the reality of the working area. The result will be a short list of the main functions and services that should be preserved, protected or restored for the selected area.

Ecosystem functions (example):

Functions	Processes maintained related to biodiversity and ecosystems
Soil formation	Organic matter accumulation/decomposition and mineralization
Pollination	Dispersal of pollen
Water regulation	Water infiltration, retention, and purification
Primary productivity	Photosynthesis and biomass accumulation

Building on all the above information, the final part of this step will be to list the species and the natural resources to be monitored.

Continuing with the previous table and as a very simplified example:

Functions	Processes maintained	Keystone indicators	Scale
Soil formation	Organic matter accumulation / decomposition and mineralization	Earthworms	Field
Pollination	Dispersal of pollen	Pollinator species	Farm
Water regulation	Water infiltration, retention, and purification	Land cover (vascular plants)	Landscape, farm and field
Primary productivity	Photosynthesis and biomass accumulation	Vegetation cover, NPP (Net Primary Production)	Landscape, farm, and field

Finally select the tools, indices and indicators most appropriate for that monitoring (**a non-exhaustive list of indicators and indexes is included as annex**). The table of functional indicators selected should be provided separately.

As an example, a hypothetical summary of the functions and biodiversity to be measured in a landscape (tools extracted and available to monitor selected species or functions are included as annex).

	Description	Indicators (examples)	Tools (examples)
Level 1: Field	Biodiversity in farm soils	Soil organic carbon, soil biodiversity, functional soil diversity	SOC measurement, Visual soil assessment, SIREN
Level 2: Farm	Biodiversity on the farm and within field boundaries	Diversity of genotype, extent of on-farm habitat (hedgerows, woodlots), farmland set-aside	LDSF, Biobio, cool farm tool, Grassland health index (ecological health index) Butterfly monitoring scheme
Level 3: Landscape	Positive and negative externalities and off-farm actions, e.g., habitat change, connectivity and diversity	Carbon stocks, water supply & quality, species diversity and abundance, habitat cover	ROAM, STAR, LDSF, cool farm tool, HNV, Structural complexity index
Level 4: National / Global	Impacts beyond the target landscape, e.g. downstream pollution, ocean deoxygenation, displaced deforestation, telecoupling	LDN indicators, forest and grassland cover	National SDG data sets, geoFootprint

5. Develop a monitoring protocol with indicators at different levels

After identifying the ecosystem functions and services that need to be preserved, and the list of the key species associated to them, the next step consists in developing a monitoring protocol that includes all the indicators selected at the different levels.

This protocol must be based on the results of all the previous steps and needs to measure the biotic structure within 3 (landscape, farm and field) of the 4 scales of the framework. For this step, one of the challenges is to establish connectivity between indicators at different levels. Focusing on the biodiversity linked with ecosystem functions and services of interest at different scales ensures an optimal pathway for its preservation and/or enhancement; hence the importance of monitoring at each level.

While specific monitoring protocols will vary, a typical framework may include:

- Frequency of monitoring (e.g., seasonal vs. continuous data collection).
- Sampling strategy (e.g., fixed plots, transects, remote sensing applications).
- Data collection methods (e.g., in-field observations, drone imagery, participatory monitoring).

Tips

- It may be necessary to adapt protocols to the stakeholder group conducting the monitoring to enhance inclusivity.
- Search for political and academic alignments around monitoring practices to strengthen the objectives of the guide and make them more robust.

6. Monitor selected species, natural resources and functions

After developing the monitoring framework, step number 6 consists in proceeding with the monitoring. To that end, it is necessary to define how the monitoring will be conducted. This step requires balancing scientific rigor with practical feasibility, ensuring that:

- Data collection is sufficiently robust for meaningful analysis.
- The level of effort is aligned with the team's technical capacity.

At this stage, IUCN can assist with capacity building, expert guidance, and methodological refinement, ensuring that the team involved in the monitoring process selects the most effective and realistic approach for their context.

Tips

- Data may not be available for the selected indicators, so a more detailed monitoring may be needed.
- The use of citizen science could be a valuable tool for this step.

7. Incorporate the information in a common table

For keeping track of the monitoring of the different groups and functions, in step number 7, a common table developed by IUCN will provide results in a standardised manner. This table should be developed through consultations with different stakeholders and experts. The aim of this final step is to share the results of all the sites in a similar way. This facilitates comparability, scaling and integration into broader conservation efforts.

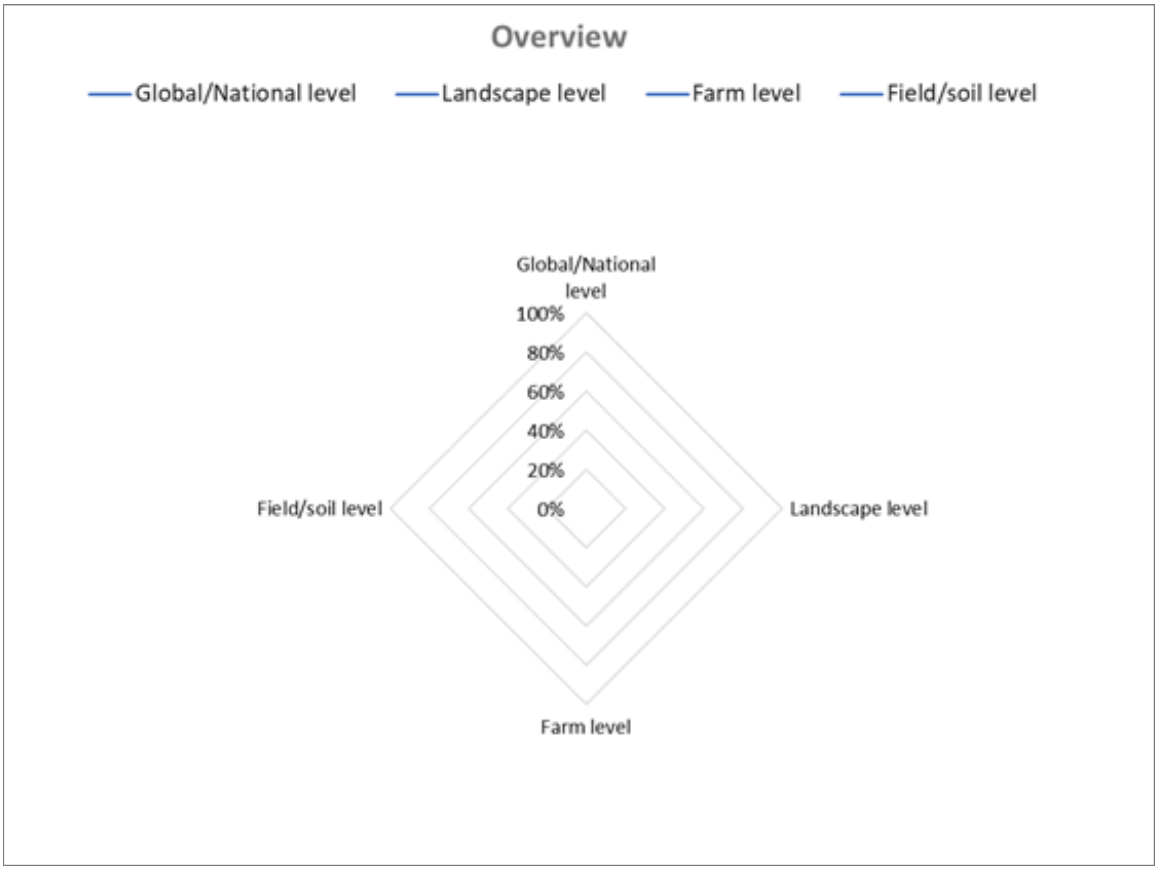
At this stage, key challenges include:

- Ensuring compatibility with existing monitoring frameworks (e.g., SDG indicators, national biodiversity reporting).
- Making results accessible and actionable for decision-makers and stakeholders.
- Maintaining continuity in long-term monitoring efforts.

As an example:

		Measurement level	Functions	Indicators
Biodiversity and ecosystem integrity	**1.1**	National/Global level		
	1.2	Landscape level		
	1.3	Farm level		
	1.4	Soil/Field level		

	Nº of sites	Functions targeted	Services targeted
National/Global level			
Landscape level			
Farm level			
Soil/Field level			



<u>To know more about the indicators and tools, please review the annexes</u>

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Annex I. Existing tools

- Agrobiodiversity Index
- Holistic Agricultural Diversity Index
- Multidimensional Biodiversity Index (MBI)
- SIREN-Project
- Cool Farm Tool
- Agroecosystemic Resilience Index
- Farm Sustainability Tool (FaST Platform)
- geoFootprint
- Sustainable Rural Development Index
- BIOBIO (Indicators for biodiversity in organic and low-input farming systems)
- Healthy Farm Index
- Indice de Agrobiodiversidad
- Swiss Agricutural Life Cycle Assessment (SALCA) - subcategory biodiversity
- Indicator Reporting on the Integration of Environmental concerns in Agricultural (IRENA)
- Global Farm Metric

Annex II. Existing indicators

International organizations

- IUCN tools: Species threat abatement and restoration (STAR) metric; Global standard of Nature-based solutions; Red List of ecosystems; global ecosystem typology; Guidelines for planning and monitoring corporate biodiversity performance
- UNCCD: Good Practice Guidance for SDG Indicator 15.3.1 "Proportion of land that is degraded over total land area"
- FAO: Global Soil Organic Carbon Map; Visual soil assessment for annual crops (VSA)
- UNEP: Multidimensional Biodiversity Index; The Aligning Biodiversity Measures for Business
- OECD: Agri-environmental indicators

Public institutes

- Joint Research Centre of the European Commission: Global Soil Biodiversity Maps
- Directorate-General for Agriculture and Rural Development (European Commission): Common Agricultural Policy Indicators – Biodiversity; FaST
- European Environment Agency (European Commission): Pan-European High-Resolution Layers, the Copernicus Land Monitoring Service.
- Norwegian Institute of Bioeconomy Research: Norway The Norwegian Agricultural Environmental Monitoring Programme (JOVA)
- Agrobioscope (Switzerland): ALL-EMA Agricultural Species and Habitats
- L'Agence de la transition écologique (France) : Les bio-indicateurs de l'état des sols
- CEEweb (NGOs network in Central and Eastern Europe). Sustainable Rural Development Index (EU funded project)

Research platforms

- EBONE project (18 research institutions in 16 mainly European countries): Selection of biodiversity indicators
- Biobio project (15 research institutions in 14 mainly European countries): Biobio indicators for Biodiversity (EU-funded project).
- Life Biorgest (six research institutions from Spain and France): Indice de biodiversidad potencial (EU-funded project).
- Hercules project (13 research institutions from 11 European countries): Indicator database (EU-funded project).
- Food & biodiversity (seven research institutions from four European countries): Biodiversity Performance Tool (EU-funded project).
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Research institutions

- Cornell University: Comprehensive Assessment of Soil Health
- World Resources Institute: Aqueduct;NDC Partnership
- University of Colorado Boulder: LandPKS
- Universidad Nacional de Colombia: Agroecosystemic Resilience Index (AgRI)

Multi-stakeholder initiatives

- Alliance Bioversity International and CIAT: The Agrobiodiversity Index
- CGIAR, WAC: Farmland Biodiversity Score
- A global coalition led by Rainforest alliance, Verra and Conservation International: Landscale
- A global alliance of 100+ actors: Cool Farm Alliance
- A partnership of 25 actors led by Quantis: GeoFootprint
- The Climate, Community & Biodiversity Alliance (a five NGOs partnership): Sustainable Landscapes Rating Tool

Participative science platforms

- Vigie-Nature: Observatoire Agricole de la biodiversité
- Ecobiosoil: L'Observatoire Participatif des Vers de Terre

Academic collaboration

- 56 affiliated institutions: Soil nematode abundance at a global scale
- 134 affiliated institutions: Global distribution of earthworm diversity
- Nine affiliated institutions: A global atlas of the dominant bacteria found in soil
- Ten affiliated institutions: Global fungal distribution.
- Three affiliated institutions: The healthy farm index
- Two affiliated institutions: Indice de Agrobiodiversidad
- Three affiliated institutions: Holistic Agricultural Diversity Index

Annex III. NbS criteria

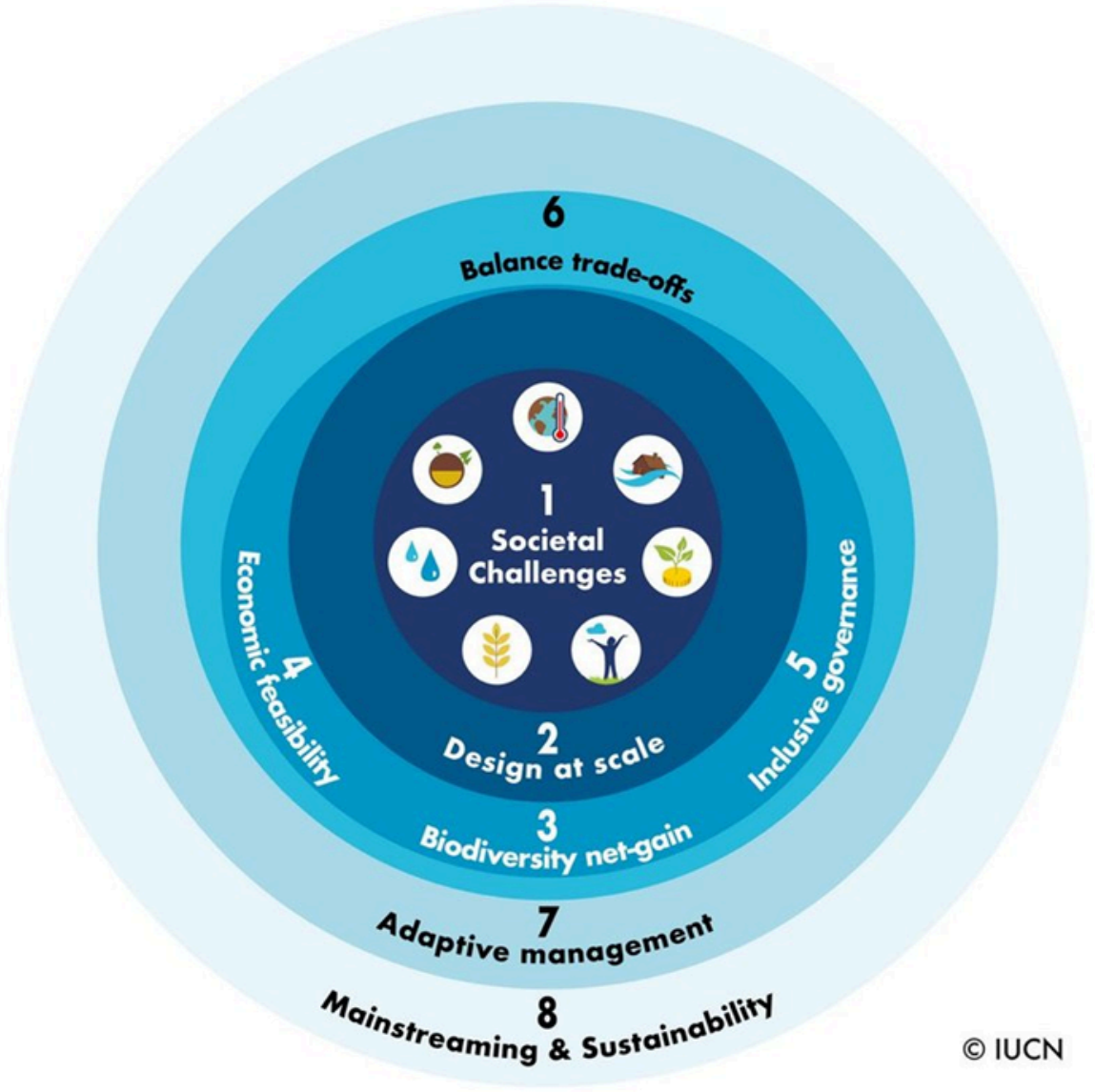

Figure A.III-1. The eight Criteria that make up the IUCN Global Standard for NbS are all interconnected.
Source: IUCN (2020)

For more detailed information please see the IUCN Global Standard for Nature-based Solutions.

Annex IV. Sites to search for global information

1. United Nations Environment Programme (UNEP) - unep.org
UNEP provides a wealth of information on global environmental policies, agreements, and indicators.

2. World Bank Environmental and Social Policies - worldbank.org
The World Bank offers information on environmental policies and indicators related to sustainability and development.

3. International Union for Conservation of Nature (IUCN) - iucn.org
IUCN provides insights into global conservation commitments, strategies, and indicators.

4. Global Environmental Facility (GEF) - thegef.org
GEF focuses on funding environmental projects and offers information on global environmental goals and indicators.

5. UN Framework Convention on Climate Change (UNFCCC) - unfccc.int
The UNFCCC site includes information on international climate agreements, commitments, and related indicators.

6. Convention on Biological Diversity (CBD) - cbd.int
The CBD site provides resources on global biodiversity commitments, strategies, and indicators.

7. European Environment Agency (EEA) - eea.europa.eu
The EEA offers data and reports on environmental indicators and policies within Europe and globally.

8. Global Reporting Initiative (GRI) - globalreporting.org
GRI focuses on sustainability reporting and provides guidelines and indicators for environmental performance.

9. Organisation for Economic Co-operation and Development (OECD) Environment - oecd.org/env
The OECD provides data and reports on environmental policies and indicators from member countries.

Annex V. Ecosystem services with ecosystem functions

1. Ecosystem Functions: These are the natural processes and interactions that occur within an ecosystem. They include processes such as nutrient cycling, primary production, soil formation, and pollination. Essentially, ecosystem functions are the underlying biological, chemical, and physical processes that sustain an ecosystem.

2. Ecosystem Services: These are the benefits that humans derive from ecosystem functions. They include things like clean air and water, food production, climate regulation, and recreational opportunities. Ecosystem services are essentially the practical outputs of ecosystem functions that contribute to human well-being.

Linkage

Ecosystem functions are the foundation of ecosystem services. Without the underlying functions, such as nutrient cycling or pollination, the services that humans rely on would not be possible. For example, the function of pollination by bees (an ecosystem function) directly supports the service of crop production (an ecosystem service). Similarly, the function of water filtration by wetlands (an ecosystem function) supports the service of providing clean drinking water (an ecosystem service).

Examples of measures to be taken to improve ecosystem functions and services :

1. Protect Pollinator Habitats:

Evidence: Studies have shown that maintaining diverse and healthy habitats for pollinators like bees and butterflies improves crop yields and biodiversity.
Recommendation: Create and maintain pollinator-friendly habitats, such as wildflower meadows and hedgerows, to support pollination services and improve agricultural productivity.

2. Promote Sustainable Agriculture:

Evidence: Agricultural practices that maintain soil health and biodiversity enhance ecosystem functions like nutrient cycling and pest control.
Recommendation: Implement practices such as crop rotation, organic farming, and agroforestry to improve soil health, reduce the need for chemical inputs, and support ecosystem functions. The use of cover crops and reduced tillage has been shown to improve soil fertility and structure.

3. Promote Integrated Water Resource Management:

Evidence: Integrated management approaches consider the interconnections between water sources, land use, and ecosystem health.
Recommendation: Implement integrated water resource management (IWRM) strategies to balance water use with ecosystem needs.

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