THE ROAD TO RESTORATION

A Guide to Identifying Priorities and Indicators for Monitoring Forest and Landscape Restoration

Food and Agriculture Organization of the United Nations

WORLD RESOURCES INSTITUTE

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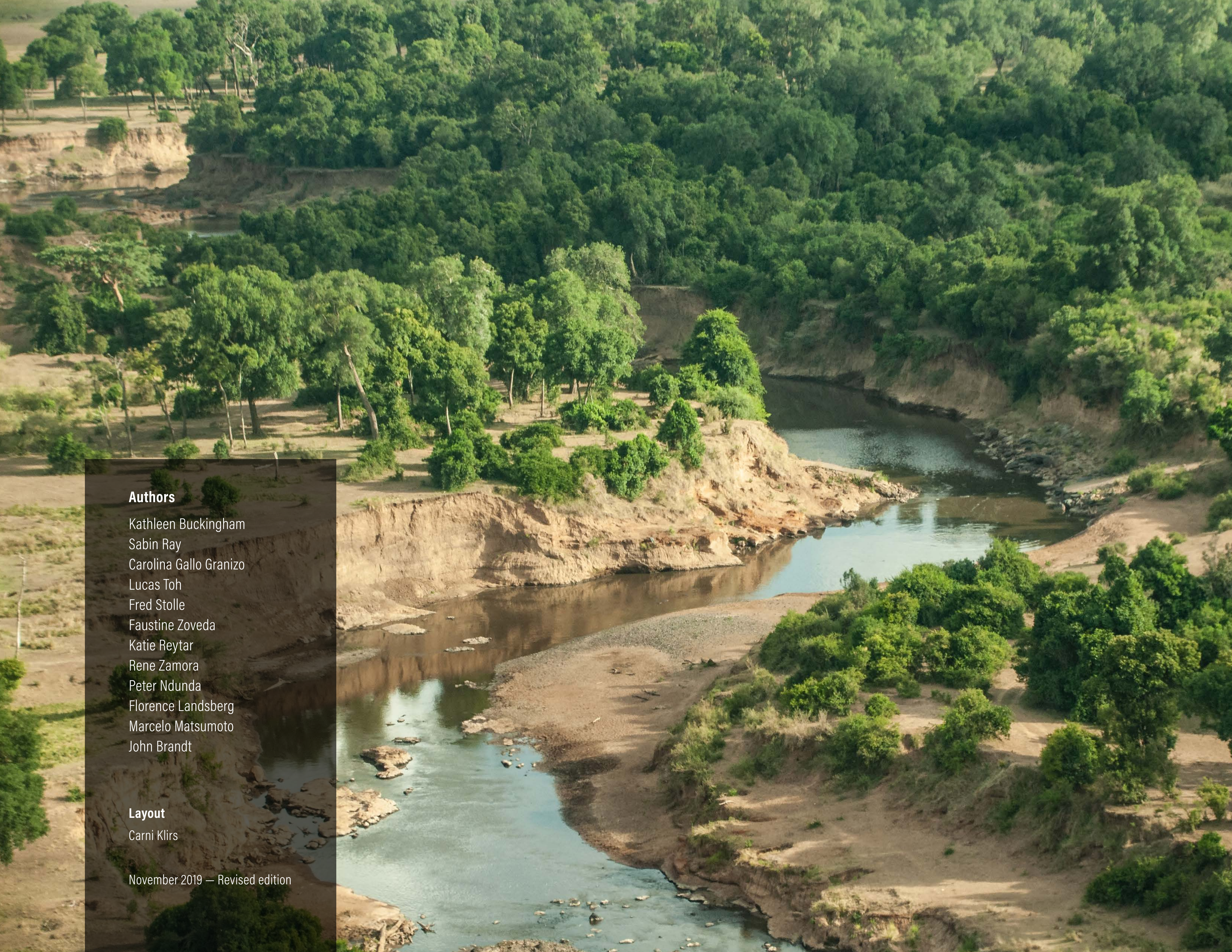

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GLOSSARY

Adaptive management: "An intentional approach to making decisions and adjustments in response to new information and changes in context" (USAID 2018).

Barriers to sustainability: Factors that impede successful restoration. These may include, but are not limited to, drivers of degradation. Barriers may include factors such as climate change that require strategies for mitigation or adaptation, or governance issues such as encroachment or illegal logging that require stronger regulation.

Baseline: An initial measurement from which the response to restoration activities can be demonstrated.

Goal: Result or achievement toward which effort is directed.

Goal-theme: Broad theme under which goals can fit (e.g., water, biodiversity, or climate).

Indicator: A measurable variable used to represent change or the attainment of a goal (e.g., increased crop yield). An indicator may be a composite measure, made up of multiple metrics.

Indicator framework: "An indicator framework is an organized way to view data from different sources. It is a simple and concise way to present data and help show the relevance and connection between different indicators" (Government of Canada 2017).

Metric: Specific variables used to measure change in a broader indicator (e.g., average crop yield per hectare, by crop type may be used to measure increased crop yield).

Monitoring: Process to assess progress toward specific goals that the restoration effort plans to achieve.

Land degradation: "Reduction or loss of the biological or economic productivity and complexity of land, resulting from land uses or from a process or combination of processes, including those that arise from human activities and habitation patterns (e.g., soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation)" (UNCCD 2016).

Land use: Characterized by human arrangements, activities, and inputs to produce, change, or maintain a certain land-cover type (FAO 2016).

Land-use change: Change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land-use change may have an impact on surface albedo, evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus impact climate locally or globally. In forestry, land-use change is not necessarily the same as land-cover change. Land cover is the observed biophysical cover of the earth's surface, whereas land use reflects the actions of people and their intentions (IPCC 2007).

Landscape: "A mosaic of two or more ecosystems that exchange organisms, energy, water, and nutrients" (SER 2002).

Restoration: Forest and landscape restoration is a process that aims to regain ecological functionality and enhance human well-being across degraded landscapes (Lamb 2014; Chazdon et al. 2015). Landscapes may be forested or non-forested.

Sustainability: The ability to be maintained at a certain rate or level. Sustainability is often considered to comprise three interconnected goals—environmental, social, and economic—that must be pursued if people and the natural world are to continue to thrive (Purvis et al. 2018).

EXECUTIVE **SUMMARY**

This guide aims to help stakeholders develop a monitoring system tailored to their needs by identifying indicators and metrics to monitor progress toward their set goals. It emphasizes the need to make choices and understand potential trade-offs and synergies when designing a restoration project.

HIGHLIGHTS

- This guide aims to help stakeholders develop a monitoring system tailored to their needs by identifying indicators and metrics to monitor progress toward their set goals.
- Measuring progress on restoration focuses on understanding the practitioner's goals for restoration and the themes they fall under, whether they be community, culture, food & products, water, energy, biodiversity, soil, or climate. The guide emphasizes the need to make choices and understand potential trade-offs and synergies when designing a restoration project.
- The guide walks users through seven questions considering goals and targets for restoration, land-use interventions, and barriers to sustainability. Through country examples, the guide identifies considerations regarding constraints and priorities, data access and availability. It also discusses suitable indicators and identifies how to create an index from those indicators.
- This guide does not intend to be prescriptive. It is a supportive starting point designed to help stakeholders focus on a specific landscape context. It provides different entry points for considering goals and targets such as biophysical and social factors, ecosystem goods and services, or goals under UN initiatives in order to allow a flexible approach.

RESTORATION IN CONTEXT

More than one billion people worldwide live in degraded areas. Land degradation reduces the productivity of land, threatening the economy and people's livelihoods. In addition, degradation can lead to reduced availability of food, water, and energy, and contribute to climate change (Sabogal et al. 2015).

Forest and landscape restoration (FLR) can counteract these challenges. Restoration is a process and set of practices to return vitality to the land. The Global Partnership on Forest and Landscape Restoration (GPFLR) emphasizes that restoration activities bring people together to identify, negotiate, and implement these practices. Restoration offers ecological, social, and economic benefits by improving the land with forests, trees, or vegetation.

Restoration is increasingly important on the international stage. The international environmental community has encouraged commitments to promote restoration and sustainable land management. As of September 2019, governments around the world have pledged to restore over 170.6 million hectares (Mha). Commitments have been garnered at the global and regional levels through a variety of initiatives. The following list is not exhaustive:

GLOBAL COMMITMENTS:[1]

- The **Bonn Challenge** targets the restoration of 150 Mha by 2020 and 350 Mha by 2030.
- The **UN Convention on Biological Diversity, Aichi Target 15** states that, by 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks will have been enhanced through conservation and restoration, including restoration of at least 15 percent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation, and combating desertification.[2]
- The **UN New York Declaration on Forests** aims for 350 Mha under restoration activities by 2030.

REGIONAL COMMITMENTS:

- In Latin America and the Caribbean, **Initiative 20x20** aims to begin restoration of 20 Mha by 2020.
- In Africa, the **African Forest Landscape Restoration Initiative (AFR100)** focuses on bringing 100 Mha under restoration by 2030.
- In the Mediterranean, the **Agadir Commitment** has a goal to start restoring 8 Mha by 2030.
- In the Asia-Pacific region, **Asia-Pacific Economic Cooperation (APEC)** has made a commitment to place 20 Mha under restoration by 2020.[3]

Restoration is a process, not an end goal. Although many organizations and researchers focus on ways to restore land, restoration may be used to pursue a wide range of different desired outcomes. For example, restoration can target watershed development, improved soil health for food security, and enhanced biodiversity conservation among other outcomes. Restoration usually aims to achieve both environmental and socio-economic objectives. Under the many existing commitments to restoration, the goals and impacts of actual restoration projects, programs, or initiatives can be very different across projects, countries, or jurisdictions.

WHY DO WE NEED TO MONITOR FOREST AND LANDSCAPE RESTORATION?

Countries and other jurisdictions monitor forest and landscape restoration for a variety of reasons, such as to:

- Ensure transparency and provide evidence of progress, achievements, and impact in relation to specific goals and objectives, including periodic assessments of who benefits and how from restoration interventions (pay for performance).
- Communicate positive results and outcomes and learn from negative results to encourage positive momentum, inspire replication, and transfer relevant knowledge.
- Guide and support project implementation and provide feedback, including continuous and collective learning for adaptive management.
- Enable investors to see progress toward their investment goals.
- Share evidence with restoration investors to enhance trust and foster additional investments for scaling up.
- Support robust monitoring of restoration impacts and regular reporting on progress toward achieving national, regional, and international commitments.

Monitoring restoration is different from monitoring deforestation; therefore it requires a different approach. Many countries have monitoring systems in place to detect deforestation. However, two unique attributes stand out regarding restoration monitoring. First, restoration is undertaken primarily in grasslands and agricultural regions rather than in forests. Detecting the dispersed trees in these landscapes requires expensive high-resolution satellite imagery. In addition, restoration is a slower process that might be able to show tree cover gain only after several years, whereas deforestation can occur rapidly and is easily observed. Restoration needs to be tracked over longer periods of time to detect changes and measure the impacts. Second, as mentioned, restoration can have other goals than the establishment of a closed canopy forest. The forest monitoring systems used in most countries are therefore not well suited to monitoring restoration. To detect and quantify restoration, we need distinct methods and tools.

WHO IS THIS GUIDE FOR?

This guide is intended to inform restoration practitioners working on landscape-level restoration initiatives. A landscape is defined as "a mosaic of two or more ecosystems that exchange organisms, energy, water and nutrients" (SER 2002). The landscape level applies best to those involved in restoration efforts on the ground.

The guide is useful to several types of practitioners. Organizations conducting restoration at the landscape level may want to understand whether restoration efforts are improving incomes in local communities. Landowners implementing restoration may monitor the results of their restoration efforts to improve next season's planting. Governments may focus on the impact of restoration on ecosystem services like water provision.

The guide provides additional guidance to practitioners using our accompanying web-based tool or app (under development). In many countries, the web-based tool or app may be more accessible than this guide.

WHY NOW?

There is a drive to turn restoration commitments into action. Since the Bonn Challenge was launched in 2011, the restoration movement has grown. This momentum has inspired a huge surge of government commitments to bring land under restoration. We have the commitments, but it is imperative

to act on those commitments and turn them into projects on the ground. In turn, we must be able to monitor change on the ground.

There is an opportunity to address the issue collectively, and to learn and adapt the process. Successful restoration at the global scale will require collaboration. In 2016, FAO initiated the Collaborative Roadmap for Restoration Monitoring, which brought together more than 70 experts from a wide variety of organizations.[4] The Collaborative Roadmap aims to encourage and support countries, implementers, and other relevant partners to monitor restoration outcomes. This guide forms part of the roadmap. The app and webtool will provide options to upload data to share with other practitioners so that they can learn from and adapt the process to their needs.

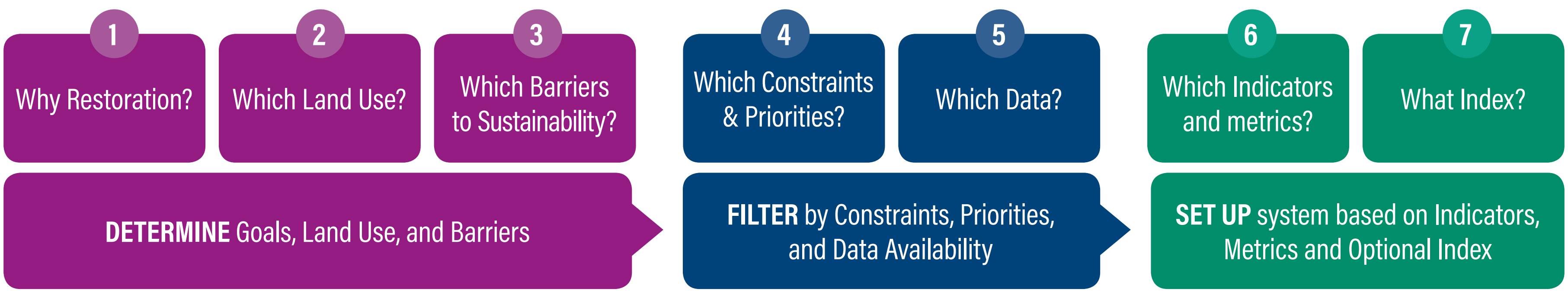
IDENTIFYING PRIORITIES AND INDICATORS FOR RESTORATION MONITORING: HOW TO USE THIS GUIDE

This guide walks practitioners through a three-step process to help them make decisions regarding restoration monitoring. Although much literature exists on monitoring specific restoration goals, this guide takes a novel approach by walking users through the considerations necessary to identify goals, priorities, and indicators before monitoring occurs. First, practitioners are asked to determine their own restoration goals, land-use patterns, and barriers to sustainability. Second, these choices are refined by filtering them through relevant constraints, data availability, and user priorities. Third, practitioners are then in a position to develop appropriate indicators and set up an indicator framework. Each step is guided by questions, seven in all (Figure ES-1). Practitioners can approach the first question from different perspectives, choosing to focus on biophysical and social factors, ecosystem goods and services, or goals under UN initiatives like the Sustainable Development Goals (SDGs), the Aichi Biodiversity Targets of the Convention on Biological Diversity (CBD), and the Land Degradation Neutrality indicators (LDN) of the Convention to Combat Desertification (UNCCD), rather than restoration goals.

This guide is intended to be used at the landscape level but can be adapted to suit local needs and different scales.[5]

The guide helps practitioners develop an indicator framework by identifying appropriate metrics and measures. Indicators are value-laden measures of development performance designed to track and calibrate progress (King 2016). Environmental indicators are used to synthesize knowledge

Figure ES-1 | Three Steps to Identify Priorities and Indicators for Restoration Monitoring



Source: Authors.

on environmental issues and highlight environmental trends. They also help to reduce complexity, provide important links between science and policy, and provide guidance to decision-makers responsible for environmental governance (Butt 2018). An indicator framework can provide a **management tool** to help countries develop implementation strategies and allocate resources accordingly to reach restoration goals. Tracking progress via indicators can act as a **report card** to measure progress toward restoration goals and help ensure the accountability of all stakeholders for achieving the goals (SDSN 2015).

Indicator frameworks attempt to simplify complex issues but this can lead to over-simplification. Moreover, indicators often make use of information that is currently available, rather than focusing on priority issues that may require different information (Seagar 2001). A lack of resources can lead to the use of proxy indicators,[6] which may lead to false assumptions regarding restoration outcomes, based on confusion between causation and correlation. Social indicators are often less accurate for monitoring social processes than physical indicators are for monitoring physical processes (Mayer et al. 2014). With these limitations in mind, this guide aims to help users prioritize their goals while being practical about the availability of resources.

Different types of data can feed into creating an indicator framework, depending on resource constraints and information needs. Some restoration programs may require relatively few cost-effective indicators, based on data that can be collected locally. Other programs, though, may integrate locally collected data with big data from satellite imagery and social media. This guide intends to lay the foundations for a more systematic deep-dive into the logistics of monitoring. Once practitioners have identified goals, constraints, priorities, and data availability, they will be able to create an appropriate indicator framework that takes into account the practicalities of available tools and approaches specific to their situation.

USER-TESTING THE GUIDE

After explaining the concepts, this guide uses country case studies to demonstrate how some practitioners have used the framework. This guide was created through an iterative process. The initial framework was designed with key stakeholders working in the field, then adapted and developed in light of country experiences. The case studies accompany each of the three steps to developing an indicator framework and illustrate the process that each country followed. These country examples offer a menu of potential indicators for measuring progress that other monitoring practitioners might find useful.

In **Malawi**, the government's restoration indicator framework focused on **measuring progress on the goals identified in the national forest landscape restoration strategy**, allowing for a more seamless integration of the monitoring framework with ongoing national work.

In Ethiopia, establishing a monitoring system for tree-based landscape restoration started by identifying the ways in which trees and forests could contribute to economic, social, and environmental goals at the local, regional, and national levels. The monitoring system focused on the ecosystem services that would deliver these contributions and identifying which specific restoration options (e.g., restocking of degraded natural forest, agroforestry, commercial plantations, buffer zone to waterbodies) would best supply these services.

In **Kenya**, stakeholders brought together by the Kenya Water Towers Agency[7] created an inclusive working group from various sectors. The group emphasized the need for **collaboration in designing the indicators and weighting their importance in relation to the country's priorities.** In addition, Kenya strongly emphasized development of an **integrated** monitoring framework that would allow for a coordinated and consistent scientific monitoring approach to tracking the status of the water towers across the various sectors and stakeholders.

In **El Salvador**, the Ministry of Environment's interest in understanding whether the measurements showed intended progress on their priority issues led to the creation of a restoration index. The restoration index provides decision support to government authorities to facilitate the implementation of restoration activities and their associated impacts.

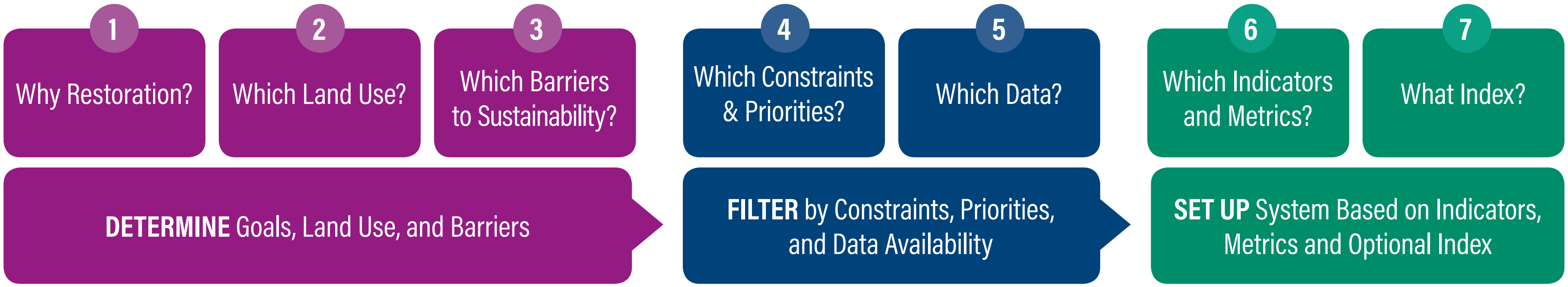

FATORES MOTIVACIONAIS
PARA RESTAURAÇÃO
ECONOMIA
CLIMA
SOLO
ÁGUA
COMUNIDADE
INVESTIMENTO
MITIGAÇÃO
ADAPTAÇÃO
CARBONO
QUALIDADE
ESTABILIDADE
MANEJO
CRESCIMENTO
QUALIDADE
USO DA TERRA
DENSIDADE
MANEJO
MANEJO
QUANTIDADE
QUALIDADE
QUALIDADE
CONECTIVIDADE
CONSERVAÇÃO
DIREITOS
PUNIÇÃO
INCENTIVO
ORIENTAÇÃO
CFFV

CHAPTER 1:

IDENTIFY PRIORITIES AND INDICATORS FOR RESTORATION MONITORING

When restoring land, you need to make choices. These choices center on what your desired outcomes from restoring the land are. Before creating a monitoring system, you need to make choices on how you are going to measure progress toward your goals using indicators. These choices will be essential in creating a manageable set of measurements that can be sustained over the long term.

Figure 1 | Three Steps to Identify Priorities and Indicators for Restoration Monitoring



Source: Authors.

To start, you should consider your local restoration context and identify your desired outcomes. Clarifying these outcomes will make it easier to identify indicators and shape the monitoring system.

The guide uses a three-step approach to identify priorities and indicators for restoration monitoring. In the first step, you determine your goals, identify current and desired land-use patterns, and define the principal barriers to change. In the second step, you filter the choices on the basis of resource constraints and your priorities for changes in the landscape. In the third step, you use the foregoing decisions as criteria to help identify indicators. The three steps are guided by seven questions (Figure 1).

Practitioners can approach the first question from different perspectives, choosing to focus on biophysical and social factors, ecosystem goods and services, or the United Nations conventions, rather than restoration goals.

INTRODUCING GOAL-THEMES, SUB-THEMES, INDICATORS, AND METRICS

This guide aims to simplify indicator identification by selecting **goal-themes**, such as “water,” “food & products,” and “biodiversity,” and suggesting sub-themes within each goal-theme. For example, the “food & products” goal-theme might comprise sub-themes such as “yield,” “market,” and “finance” (Figure 2). Sub-themes are intended to highlight the focal areas that indicators should address.

The goal- and sub-themes presented in this guide are not prescriptive, but can help you narrow down the large number of choices involved in restoration implementation.

Indicators and **metrics** track progress toward restoration goals by measuring changes in specific outcomes of interest. More specifically, **indicators** (e.g. crop yield or products harvested) are yardsticks used to represent change or progress toward the attainment of a goal. Indicators might consist of a single measure (e.g., percentage of a given land area under tree canopy cover) or a composite measure made up of several discrete measures (e.g., increased crop yield might be measured based

on yields per hectare of several different crops). **Metrics** are discrete measures—variables that can be measured at defined intervals to determine the change in status of the indicator (e.g., volume of products harvested per year, or average crop yield per hectare, by crop type, can be used to determine overall crop yield).

A sub-theme might be measured by multiple indicators, and an indicator might be measured using multiple metrics. However, for the sake of simplicity, we show only one indicator per sub-theme, and only one metric per indicator in this guide.

OUR APPROACH

An important focus of our approach is ensuring inclusion and sustainability. Five principles underpin this guide:

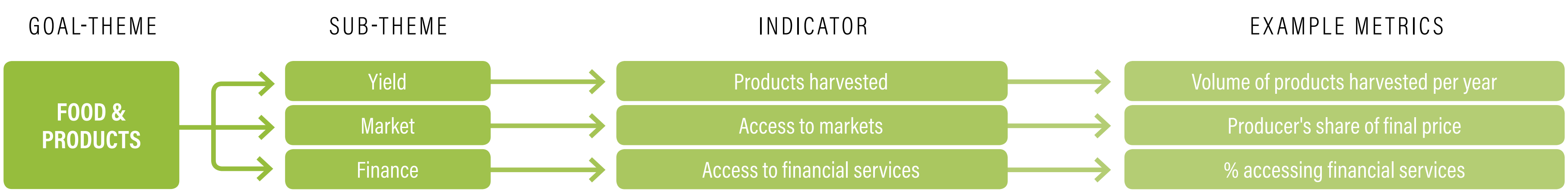
- **LANDSCAPE-LEVEL FOCUS:** Promoting restoration monitoring at the landscape level
- **COMPREHENSIVE SYSTEM:** Incorporating biophysical, social, economic, and governance measures
- **PARTICIPATORY APPROACH:** Including a variety of stakeholders in the restoration monitoring process to determine the most relevant and comprehensive measurements for a specific context
- **BALANCE TRADE-OFFS:** Making choices based on context-driven constraints to ensure the monitoring system is realistic and sustainable
- **DATA INTEGRATION:** Integrating different kinds of data—qualitative and quantitative, micro and macro level—into a single system

This guide encourages an adaptive management process. Adaptive management is an intentional approach to decision-making and adjusting in response to new information and changes in context (USAID 2018). Adaptive management is an important learning process in restoration efforts to ensure long-term success.

The guide is a starting point, meant to be adapted to the local context by practitioners. To ensure that the guide is as effective as possible when used in a specific restoration process, we suggest that practitioners take the following preliminary steps:

1. **REVIEW EXISTING INFORMATION** on monitoring and data-collection activities at various scales in the restoration focus area.
2. **CONSULT STAKEHOLDERS** to confirm restoration targets, identify potential indicators, and review existing monitoring activities and protocols.
3. **IDENTIFY INDICATORS ALREADY BEING MONITORED** to minimize additional work.

Figure 2 | Example of Indicators, Metrics, and Sub-themes



Source: Authors.

INTERNATIONAL CASE STUDIES

The guide benefits from the experience of four national restoration efforts that serve as case studies. The work in these countries is ongoing, and offers illustrative examples of how different national governments co-created, iterated on, and adapted an earlier version of the guide to begin building their indicator frameworks for monitoring restoration. Each of these countries has become a global restoration leader with commitments to one or more of the following global initiatives:

- Bonn Challenge: a global effort to restore 150 million hectares (Mha) by 2020
- Aichi Targets to restore 15 percent of land by 2020
- New York Declaration on Forests: a global effort aiming for 350 million hectares of land under restoration activities by 2030
- Initiative 20x20: a country-led effort seeking to change the dynamics of land degradation in Latin America and the Caribbean by bringing 20 Mha into restoration by 2020
- African Forest Landscape Restoration Initiative (AFR100): a country-led effort to bring 100 Mha in Africa under restoration by 2030.
- Additonal information about the four case studies is provided in Table 1

Table 1 | Overview of Restoration Efforts in El Salvador, Ethiopia, Kenya, and Malawi

COUNTRY	NATIONAL RESTORATION COMMITMENT	NATIONAL RESTORATION STRATEGIES	NATIONAL RESTORATION ASSESSMENTS	NATIONAL PRIORITIES FOR RESTORATION	GOVERNMENT LIAISON FOR MONITORING
El Salvador	■ 1 Mha, or 48% of land area committed in 2012 ■ Committed to Bonn Challenge, New York Declaration on Forests, and Initiative 20x20	National Program for the Restoration of Ecosystems and Landscapes (MARN 2013)	Included in the National Restoration Strategy	■ Mitigate and adapt to climate change ■ Increase carbon stocks ■ Protect biodiversity ■ Improve livelihoods of people living in priority landscapes ■ Improve water flow and quality in main rivers ■ Increase local economic opportunities	The Environment Observatory
Ethiopia	■ 15 Mha, or 15% of land area committed in 2014 ■ Committed to Bonn Challenge, New York Declaration on Forests, and AFR100	Pending	National Potential and Priority Maps for Tree-Based Landscape Restoration in Ethiopia (MEFCC 2018)	■ Reverse forest degradation and deforestation ■ Increase agricultural and pastoral productivity ■ Prevent sedimentation of water bodies ■ Decrease occurrence of flooding and landslides ■ Mitigate and adapt to climate change ■ Reverse habitat fragmentation and loss of biodiversity	Ethiopia's Environment, Forest, and Climate Change Commission (EFCCC)
Kenya	■ 5.1 Mha, or 9% of land area committed in 2016 ■ Committed to Bonn Challenge, New York Declaration on Forests, and AFR100	Development in progress	Technical Report on the National Assessment of Forest and Landscape Restoration Opportunities in Kenya (2016)	■ Increase water quality and supply ■ Improve forest cover ■ Enhance climate change mitigation and resilience ■ Improve livelihoods of communities ■ Improve economic growth	Kenya Water Towers Agency (KWTA)
Malawi	■ 2Mha, or 21% of land area committed in 2016 ■ Committed to Bonn Challenge, New York Declaration on Forests, and AFR100	National Forest Landscape Restoration Strategy (GoM 2017b)	National Forest Landscape Restoration Opportunities Assessment (GoM 2017a)	■ Improve food security ■ Increase energy resources ■ Increase climate resilience ■ Improve water quality and supply ■ Conserve and restore biodiversity ■ Ensure gender equity and equality ■ Alleviate poverty	Malawi's Department of Forestry, within the Ministry of Natural Resources, Energy, and Mining

Source: Authors.

CHAPTER 2:

DETERMINE GOALS, LAND USE, AND BARRIERS

It is important to start by asking why restoration is needed in the first place. First, the goals of the project need to be established. Once it is clear why you are establishing a restoration effort, then you can identify which land uses are present and how restoration interventions will affect them. With these factors established, you should identify the barriers to sustainability and understand how to eliminate them. These barriers may have caused the degradation the restoration aims to overcome. Without adequate attention, they may prevent project success.

IDENTIFY THE GOALS OF YOUR RESTORATION EFFORT

Restoration is a process, not an end goal, and stakeholders restore land to meet a variety of goals. The first question you should ask is why restoration is being undertaken. The answers may involve improving water management in a watershed, increasing the number of trees in a woodlot for energy use, or increasing soil fertility to enable greater food production, for example. The aim of the guide is to allow practitioners to approach restoration from the perspective that speaks to them, whether enhancing ecosystem services, contributing to the Sustainable Development Goals (SDGs), or improving biophysical and socio-economic conditions. The Restoration Monitoring Wheel (Figure 3) is a simple entry point, but the guide and web tool allow users to choose their own entry points.

SELECT THE GOALS YOU WANT TO MONITOR

Eight common goal-themes of restoration are summarized in Table 2. These goal-themes represent topics found in restoration literature and emphasized in conversations with restoration stakeholders (more information on how we identified these goal-themes can be found in Appendices A and B). The goal-themes may help stakeholders identify specific goals.

Table 2 | A Summary of Restoration Goal-Themes

GOAL-THEMES	FOCUS	RATIONALE
CULTURE	Local cultural practices, stakeholder values, and land-use rights	The knowledge, value, and tenure systems of many communities are linked to how they interact with physical landscapes. It is important to consider how revitalizing a landscape will affect the local culture.
COMMUNITY	Income, equity, and health	Restoration expands the livelihood options available to communities, creating economic opportunity and improving well-being.
FOOD & PRODUCTS	Restoration product yield, market value, and available financing	Healthy landscapes are more productive. Local people benefit from higher yields of forestry products, non-timber forest products, and crops.
CLIMATE	Resilience, adaptation, and mitigation	Forests and trees sequester carbon in biomass and soils, helping to mitigate climate change. Landscapes need resilience and adaptation measures to protect against current and future pressures from climate change.
SOIL	Improved soil-related land-use management, soil stability, and soil quality	The restoration of root systems, understory growth, and leaf litter help stabilize the soil, increase organic matter, and promote nutrient cycling.
WATER	Improved water-related land-use management, water quantity, and water quality	Vegetation reduces surface runoff and erosion, thereby controlling the amount of sediment and pollution that flows through the watershed. Restoration can improve water quality and quantity. Restoration can also include reshaping the land to retain more water.
ENERGY	Woodfuel management, energy scarcity, and energy quantity	Restoration interventions can help provide sustainable sources of energy such as woodfuel. The need for woodfuel is an important driver of deforestation in some regions. Alternative and sustainable sources of energy are also needed.
BIODIVERSITY	Natural habitat protection, habitat connectivity, and biodiversity quality through abundance of flora and fauna	Restoration creates and enlarges habitats and connects fragmented landscapes, improving the ecological conditions for plant and animal species. Direct introduction of species diversity can also constitute restoration.

Source: Authors.

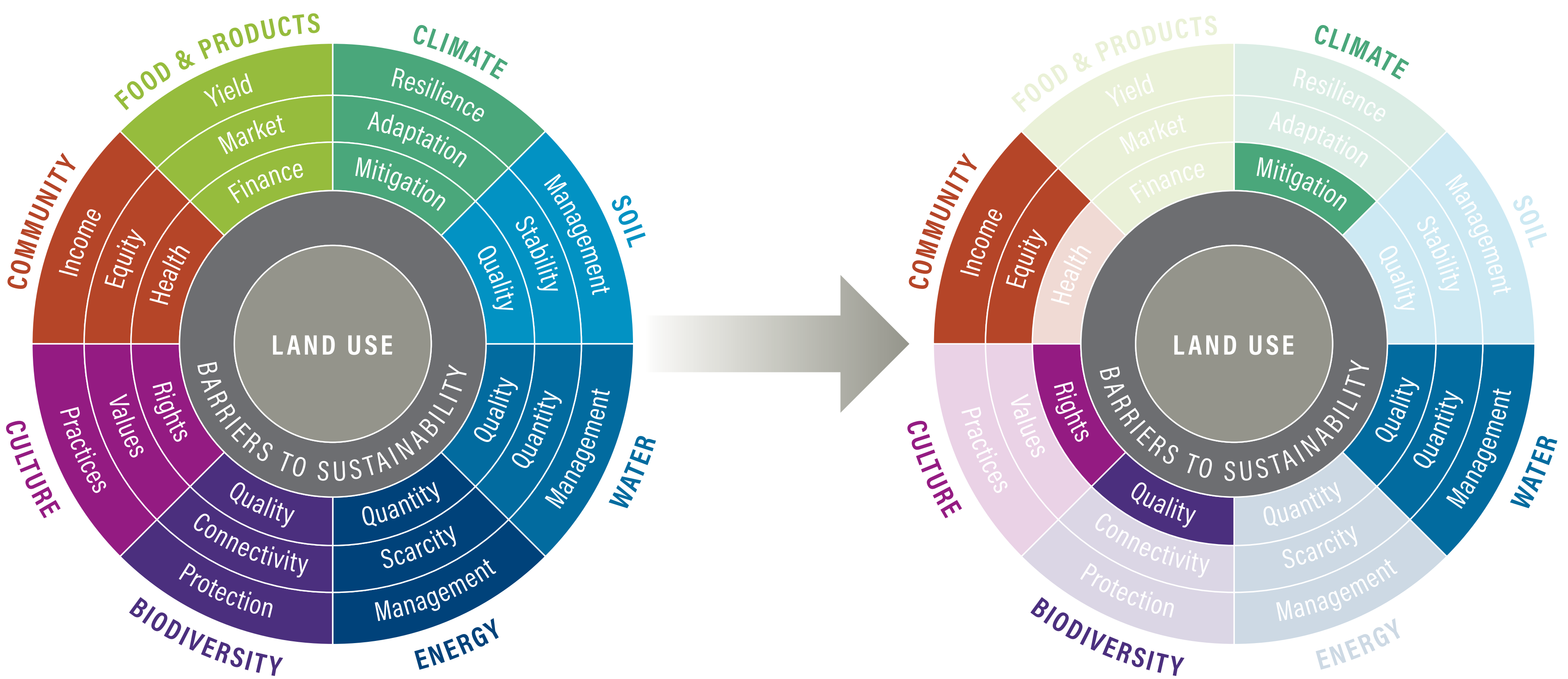
Alternatively, stakeholders may already have specific goals that can fit into these categories.

These eight goal-themes are visualized in the outer ring of the Restoration Monitoring Wheel (Figure 3). The wheel can help identify the main areas to monitor and is especially useful in a workshop setting. By choosing broad themes, stakeholders may be led to identify more specific goals for their restoration effort.

SELECT THE SUB-THEME YOU WANT TO MONITOR

Inside each goal-theme is a second circle of sub-themes. Sub-themes represent more specific objectives relating to a broader restoration goal, and not all sub-themes may be applicable to a restoration effort. For example, if "water" is a main thematic goal of your restoration effort, stakeholders could choose between the sub-themes associated with that goal, according to which of them are most relevant to improving water resources in their local context: water quantity, water quality, or water-related land-use management.[8] This could help to create a goal such as to increase water availability in the watershed, for example. The different sub-themes highlight a variety of biophysical, social, economic, and governance factors.

Figure 3 | Determining Goal- and Sub-Themes Using the Restoration Monitoring Wheel



Source: Authors.

In the center of the wheel are the issues of land use and barriers to sustainability, both core elements that must be considered in any restoration effort. "Land use" focuses on land management to increase vegetation through restoration. Without improved land management, the restoration effort will not be able to accomplish its other intended goals. "Barriers to sustainability" can impede significant, impactful progress. Examples could include the presence of free grazing animals or lack of legal controls against illegal harvesting. It is important to address barriers that support the continuation of business-as-usual practices or that prevent amelioration of the drivers of degradation.

After selecting the most important sub-themes for your restoration effort, re-examine your choices. A comprehensive approach to monitoring is critical to effectively manage and monitor restoration. We encourage you to select multiple goal-themes and a variety of sub-themes to ensure long-term sustainability of the restoration effort. Since restoration efforts often involve impacts on the local community, we suggest selecting sub-themes within community-focused goals such as "culture," "food & products," and "community" (Box 1). These themes should be fleshed out to identify goals such as "increase area of community woodlots." A more specific target could be identified as "increase area of community woodlots to 200,000 ha by 2020."

Box 1 | An Inclusive Vision for Restoration

Restoration can bring many benefits to communities. By creating new livelihood opportunities, restoration has the potential to raise incomes, generate employment, and strengthen resilience. However, if not carefully managed, these benefits may not be equitably shared by all segments of society. Women, children, migrants, and Indigenous Peoples are at particular risk of being marginalized. For example, under "Culture," monitoring the "use of knowledge, practices, and innovations" focuses on whether restoration interventions respect the existing traditions of local communities. Under "Community," the indicator "restoration benefits for women and minorities" aims to identify and measure specific restoration outcomes that create benefits for women and minority groups.

But we cannot stop at monitoring these indicators. Where appropriate, all data collected should be disaggregated by gender, age, and ethnic background. Monitoring restoration impacts along these lines will raise early warning signals for any inequalities that a restoration intervention could exacerbate. For instance, disaggregating data for "income from restoration-related activities" and "land tenure security" may help practitioners identify whether a lack of tenure security is preventing certain marginalized groups from benefiting from higher incomes.

While the Restoration Monitoring Wheel has no start or end point, when the goals are displayed in this guidebook, we choose to start with "Culture" and "Community" in order to emphasize the social aspects of restoration. Biophysical elements are often taken for granted in restoration, whereas social elements get less attention.

However, you should consider the feasibility of measuring all of these different goals. Here, prioritization is essential and you may want to rank the most important goals and sub-themes. Too many goals can make it too costly to measure all aspects. Too few goals can lead to an indicator framework that does not offer a comprehensive picture of the restoration effort.

For each goal's sub-theme that you select, you will need an indicator and corresponding metrics to track the progress of your restoration effort against that goal. Figure 4 presents indicator options that could be appropriate for a generic landscape. These indicators were selected with regard to their ease, affordability, data quality, comprehensiveness, and sensitivity to restoration interventions. Appendix D offers a longer list of indicators and examples of metrics for each goal. These indicators are intended to be a starting point for discussions and adapted as needed.

> If you have already selected the goals of your restoration effort, use the wheel to check whether the goals selected offer a holistic monitoring approach.

SETTING RESTORATION GOALS AND TARGETS

Goals represent the guiding principles of restoration interventions. For example, a goal may be to improve food security. Targets must be set to make goals actionable; they provide milestones by which to measure progress and they define the focus areas for indicators

Figure 4 | Indicator Options to Measure Restoration Goals

GOAL-THEME	SUB-THEME	INDICATOR	EXAMPLE METRICS
CULTURE	Practices	Sacred land or cultural site protection	Area of cultural/sacred land protected
	Values	Perception of restoration	% engaging in restoration actvities
	Rights	Land and natural resource tenure	% with perceived land tenure security
COMMUNITY	Income	Economic benefits from restoration	% income from restoration related activities
	Equity	Restoration benefits for women & minorities	Yield of non-timber forest products
	Health	Improvements in nutrition	% of people experiencing food shortage
FOOD & PRODUCTS	Yield	Products harvested	Volume of products harvested per year
	Market	Access to markets	Producer's share of final price
	Finance	Access to financial services	% accessing financial services
CLIMATE	Mitigation	Biomass and carbon sequestration	Aboveground biomass stock per hectare
	Adaptation	Impact of shocks and stresses	% of people experiencing food shortage
	Resilience	Capacity to deal with shocks & stresses	Existence of local risk reduction strategies
SOIL	Quality	Soil health	Faunal density and richness
	Stability	Soil compaction and permeability	Infiltration and percolation rate
	Management	Use of soil conservation practices	% of farmers using practices
WATER	Quality	Sediment in water	Sediment level in reservoir
	Quantity	Water balance	Streamflow & baseflow (hydrograph)
	Management	Use of water conservation practices	% of farmers using practices
ENERGY	Quantity	Quantity of woodfuel produced	Quantity of woodfuel produced per year
	Scarcity	Extent of energy needs being met	Energy burden (expenditure)
	Management	Sustainable sourcing of energy	% of households with access to sustainable energy
BIODIVERSITY	Quality	Community composition	Abundance of indicator species
	Connectivity	Connection between habitats	Mean nearest distance between habitat patches
	Protection	Protected area coverage	Area of key biodiversity areas protected

Source: Authors.

and metrics. If indicators are tracked over a period of time, they can be used to determine a trend. The simplest way to determine trends is to start with a reference point—a baseline. Baselines are starting points for measuring change from a certain state or date. With a clear baseline and a clear target, you can measure the distance between the current environmental or social situation and the desired future situation (Moldan et al. 2012). For example, a target may be to achieve at least 10 percent tree cover on 80 percent of cropland by 2030.

This guide uses broad goal-themes for illustrative purposes, but the user, wherever possible, should translate the themes into concrete goals and targets to tailor the restoration effort to local needs.

INTEGRATING SYNERGIES AND TRADE-OFFS IN DECISION-MAKING

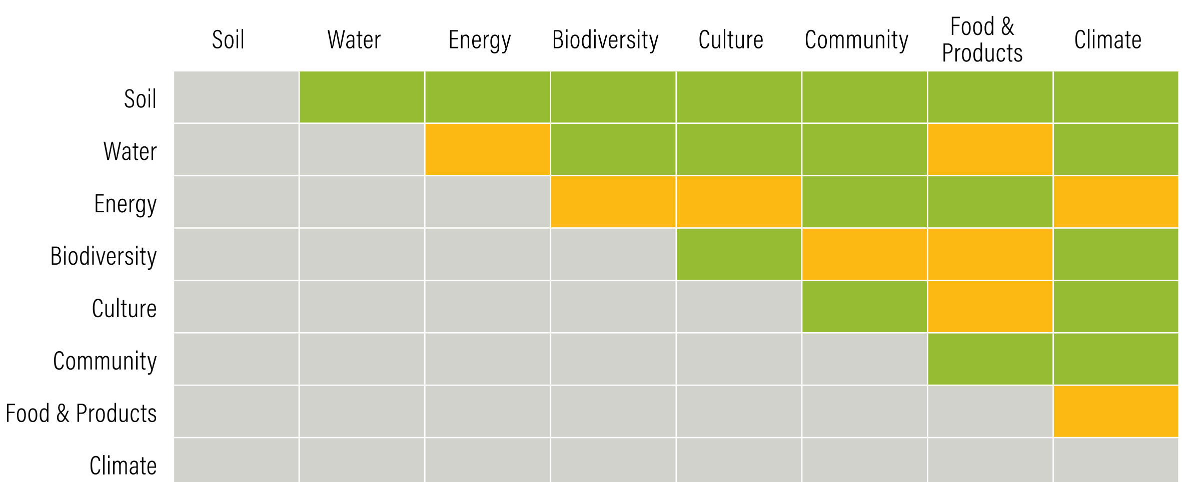
The choices made when restoring land can lead to both negative trade-offs or positive synergies. This divergence depends on whether goals are complementary or in conflict. Restoration is not always a win-win course of action. Restoration activities that lead to the successful achievement of one goal may have a negative impact on another goal. The key is to anticipate the trade-offs and decide how to proceed accordingly. Acceptable gains and losses need to be assessed and weighed. Different stakeholder groups may have different priorities and goals and they may not be aligned. Conflicting goals may be unavoidable—they may be the reality in any given landscape, and multistakeholder decision-making processes must work within this reality.

Trade-offs and synergies are key considerations. For example, a restoration project that focuses on increasing fuelwood energy must pay attention to potential impacts on water restoration efforts. Equally, practitioners should consider whether increasing production of timber or non-timber forest products might hinder the climate goal of sequestering carbon. Beyond commodity and plantation management, studies have shown that restoration can deplete water under some interventions (Maron and Cockfiled 2008), so practitioners should not assume mutually beneficial relationships among restoration activities or ignore possible trade-offs.

Figure 5 illustrates, in simplified form, how restoration goals may complement or conflict with each other. For example, "energy" and "biodiversity" may conflict, whereas "biodiversity" and "climate" may be complementary. Our intention is not to suggest that all goal-theme interventions may have negative trade-offs, but the figure highlights potential conflicts that could arise when making choices.

Various tools can help you understand trade-offs in land-use decisions, notably InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs). InVEST uses geospatial data to model climate benefits from carbon storage and sequestration; watershed services, including erosion control, water yield, and avoided nutrient pollution; habitat quality for biodiversity; and the tradeoffs and synergies among multiple services and economic activities.

Figure 5 | Synergies and Trade-offs When Choosing Goals



Note: Green indicates complementarity in goal-themes, and orange indicates the risk of conflicts or trade-offs.
Source: Authors.

QUESTION 2. WHICH LAND USE?

Identify which land uses are present in your landscape and how the restoration intervention will affect them. Identifying land uses reveals how restoration alters the physical composition of the landscape. The Intergovernmental Panel on Climate Change (IPCC) defines six land-use categories: forest land, cropland, grassland, wetland, settlement, and other land. These are very broad categories, and you can replace them with more locally relevant land uses. However, much data collection is carried out using these broad IPCC categories. As landscapes often involve a mosaic of land uses, more than one category may be relevant.

Based on your restoration goals, you should consider whether the restoration intervention will seek to change the type of land use (e.g., move from cropland to forest land), or improve certain qualities of the land while maintaining the same land-use category (e.g., improve cropland by increasing vegetation). Figure 6 shows the six possible outcomes in each land-use category.

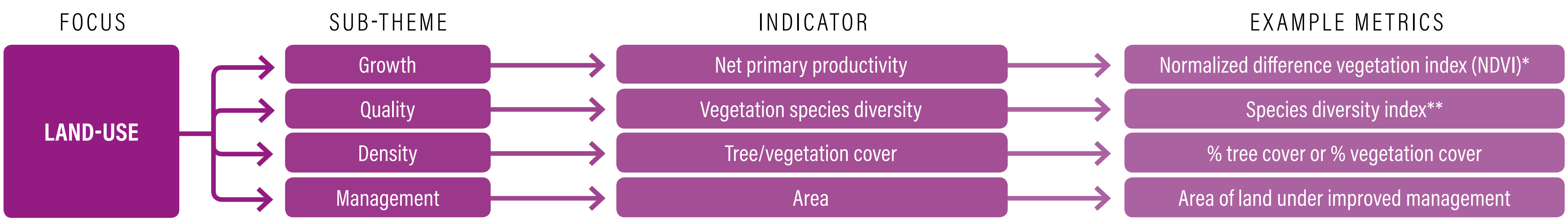
To see whether the restoration intervention has successfully improved outcomes within one land-use category, you may want to consider measuring four sub-themes: vegetation growth, vegetation quality, vegetation density, and land-use management. Figure 7 shows specific examples of indicators and relevant metrics.

Figure 6 | Identifying Land Use and Measuring Land-Use Change

LAND USE	LAND-USE CHANGE					
FOREST LAND	FOREST LAND → FOREST LAND	CROPLAND → FOREST LAND	GRASSLAND → FOREST LAND	WETLAND → FOREST LAND	SETTLEMENT → FOREST LAND	OTHER LAND → FOREST LAND
CROPLAND	FOREST LAND → CROPLAND	CROPLAND → CROPLAND	GRASSLAND → CROPLAND	WETLAND → CROPLAND	SETTLEMENT → CROPLAND	OTHER LAND → CROPLAND
GRASSLAND	FOREST LAND → GRASSLAND	CROPLAND → GRASSLAND	GRASSLAND → GRASSLAND	WETLAND → GRASSLAND	SETTLEMENT → GRASSLAND	OTHER LAND → GRASSLAND
WETLAND	FOREST LAND → WETLAND	CROPLAND → WETLAND	GRASSLAND → WETLAND	WETLAND → WETLAND	SETTLEMENT → WETLAND	OTHER LAND → WETLAND
SETTLEMENT	FOREST LAND → SETTLEMENT	CROPLAND → SETTLEMENT	GRASSLAND → SETTLEMENT	WETLAND → SETTLEMENT	SETTLEMENT → SETTLEMENT	OTHER LAND → SETTLEMENT
OTHER LAND	FOREST LAND → OTHER LAND	CROPLAND → OTHER LAND	GRASSLAND → OTHER LAND	WETLAND → OTHER LAND	SETTLEMENT → OTHER LAND	OTHER LAND → OTHER LAND

Source: Authors.

Figure 7 | Monitoring Restoration Interventions within the Same Land-Use Category



Note: *as proxy for Net Primary Producitvity
** assumes species inventory is a given
Source: Authors.

The indicators in Figure 7 are general indicators that encompass most restoration interventions. However, certain land-use categories will require more specialized monitoring. For example, although both peatland and mangroves fall into one of the six IPCC-defined categories (wetland and forest land), they require unique restoration interventions, and thus different measurements. Peatlands, for example, must be rewetted before replanting begins. Mangrove restoration requires the natural structure of a coastline to be restored if mangrove seedlings are to thrive. In unique cases, additional indicators may need to be incorporated to monitor improved land use. In other cases, these general indicators may be sufficient, but the ideal target or direction of change may differ. For example, in semi-arid landscapes, a relatively low value for percentage of tree cover would be ideal to achieve productivity benefits without overdrawing water supplies (Ilstedt et al. 2016).

If you have already determined your current and future land-use categories, the indicators shown in Figure 4 can be adjusted to reflect the desired changes within each category.

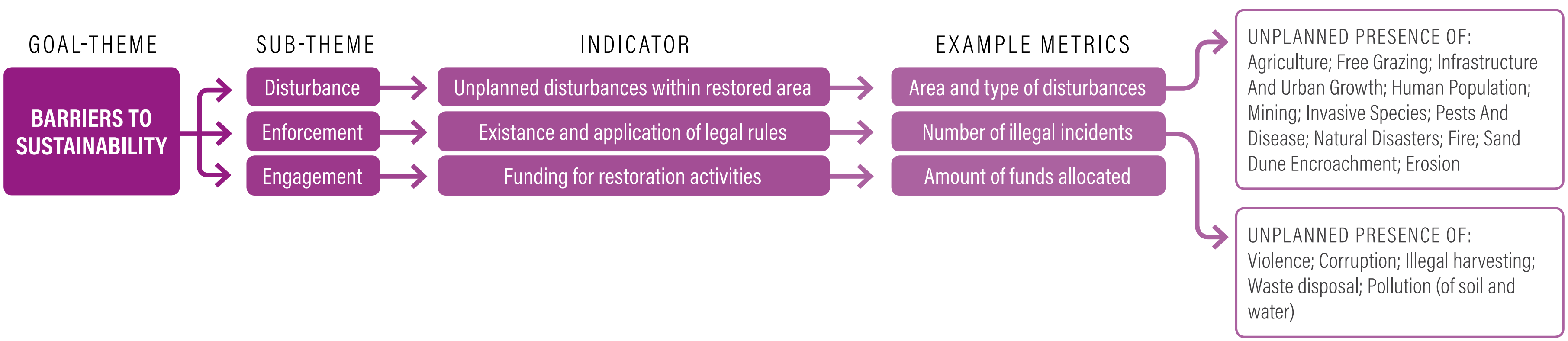
QUESTION 3. WHICH BARRIERS TO SUSTAINABILITY?

Understand which barriers to sustainability affect your restoration effort. Restoration is a long-term process. If restoration efforts are to be sustainable, they must account for drivers of degradation or deforestation. Addressing the causes of degradation, either before or during the restoration program, will significantly reduce the likelihood of failure. Another crucial element of long-term success is ensuring broad support for the restoration effort (Box 2).

More specifically, an indicator framework for monitoring restoration should include indicators that measure the drivers of continued or new degradation and aspects that could prevent progress on restoration such as lack of community engagement, lack of legal enforcement, or unplanned disturbances (Figure 8). Because barriers can affect future as well as current drivers of degradation, we categorize them as "barriers to sustainability." For a more in-depth look at barriers to sustainability, you may conduct the Restoration Diagnostic, a tool which helps to rapidly identify whether key success factors for motivating, enabling, and implementing exist, partially exist, or do not exist for restoration within a landscape (Hanson et al. 2015).

> If you have already determined the barriers to sustainability, focus on measuring the principal or priority concerns. Return to the list provided above at regular intervals to see whether additional barriers are impeding the success of the restoration effort.

Figure 8 | Which Barriers to Sustainability?



Source: Authors.

Box 2 | Encouraging a Participatory Monitoring Process

Participatory approaches that include local stakeholders in the creation of an indicator framework help provide accountability, generate local buy-in, and catalyze learning. The goals of restoration should be simple and agreed on by stakeholders. The goals must be translated into feasible objectives and measurable targets. Successful participatory indicator frameworks emphasize data availability and constraints, rather than focusing primarily on scientifically rigorous data. A minimum set of indicators should be decided early on; however, discussions about indicators and metrics should center around answering some key questions that will make the process practical and sustainable:

- **How** are the monitoring data going to be used?
- **Who** will conduct the monitoring, and manage and interpret the data?
- **Who** is responsible for monitoring, and paying for it?

For example, the stakeholders analyzing the data could be different from those that are commissioning the collection and paying for it. If these questions are neglected, technical and financial constraints may impede stakeholders' ability to monitor indicators (Evans et al. 2018).

In Kenya, for example, the Kenya Water Towers Agency convened a national technical working group of more than 17 stakeholders from government agencies, NGOs, and community-based associations. This cross-sectoral group included people whose work is relevant to the water towers, including government officials with expertise in forests, water, agriculture, conservation and wildlife, energy, climate change, cultural heritage, and governance.

In addition to the national technical working group, sub-national consultative forums were held with local stakeholders across the water towers to better understand their views. These local forums help ensure that the monitoring framework addresses the needs of the people living in the water towers, and build ownership among different groups of stakeholders on the ground. Lastly, peer-review forums (consultative forums) were held with scientists from various sectors in local and international institutions in the country to collect their views.

COUNTRY CASE STUDY

Malawi: Identifying Goals and Land Use

It is important to start with a country's priorities and focus on realistic landscape targets that may already exist. Malawi's *National Forest Landscape Restoration Strategy* of 2017 sets out five intervention targets and seven restoration goals. The monitoring framework was structured around measuring progress toward these targets and goals (Figure 9). The first two steps in our process—"Why Restoration?" and "Which Land Use?"—to map out restoration goals and land-use types were thus easily streamlined.

Five intervention targets in Malawi's national strategy:

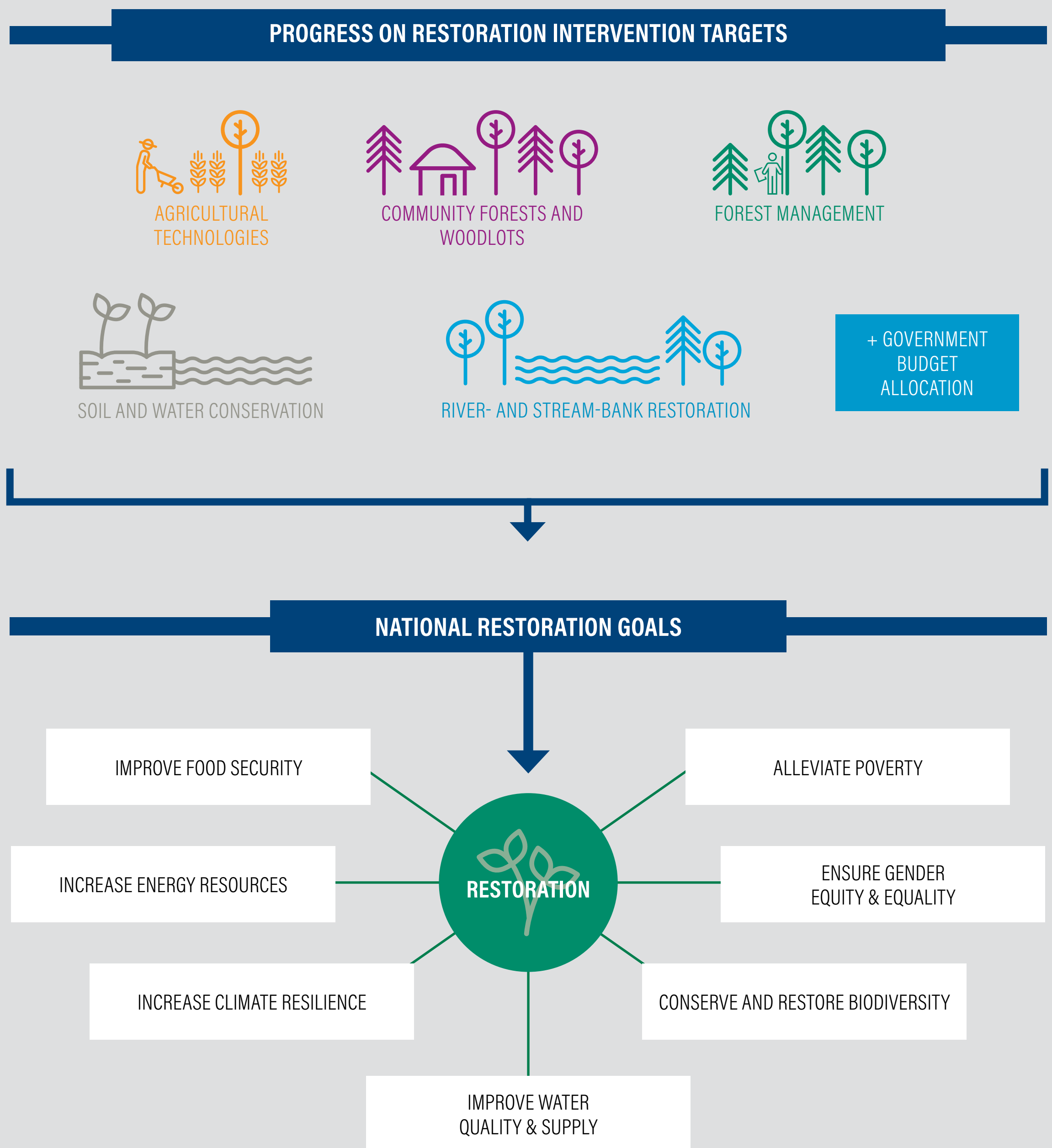
1. Achieve at least 10 percent tree cover on 50 percent of cropland in Malawi by 2020 and on 80 percent of cropland by 2030, by using agricultural technologies (e.g., agroforestry, conservation agriculture).
2. Increase area of community forests and woodlots to 200,000 ha by 2020 and 600,000 ha by 2030.
3. Improve protection and management of 2 Mha of natural forest, and establish 100,000 ha of commercial plantations by 2030.
4. Apply soil and water conservation measures on 250,000 ha by 2020 and 500,000 ha by 2030.
5. Regenerate or plant 20 million trees along river and stream banks by 2020 and 50 million trees by 2030.

The national strategy outlines seven national restoration goals that can be achieved if the intervention targets are met. Malawi's restoration goals are tightly interlinked with the country's national development agenda. The seven restoration goals identify elements from all the goal-theme areas identified in this guide:

1. Improve food security (Food & Products)
2. Increase energy resources (Energy)
3. Increase climate resilience (Climate)
4. Improve water quality and supply (Water)
5. Conserve and restore biodiversity (Biodiversity)
6. Ensure gender equity and equality (Culture/Community)
7. Alleviate poverty (Community/Food & Products)

Full details on methods and selected indicators are available in *A Framework for Monitoring Progress on Malawi's National Forest Landcape Restoration Strategy* (GoM 2018).

Figure 9 | Malawi's Framework for Monitoring Progress



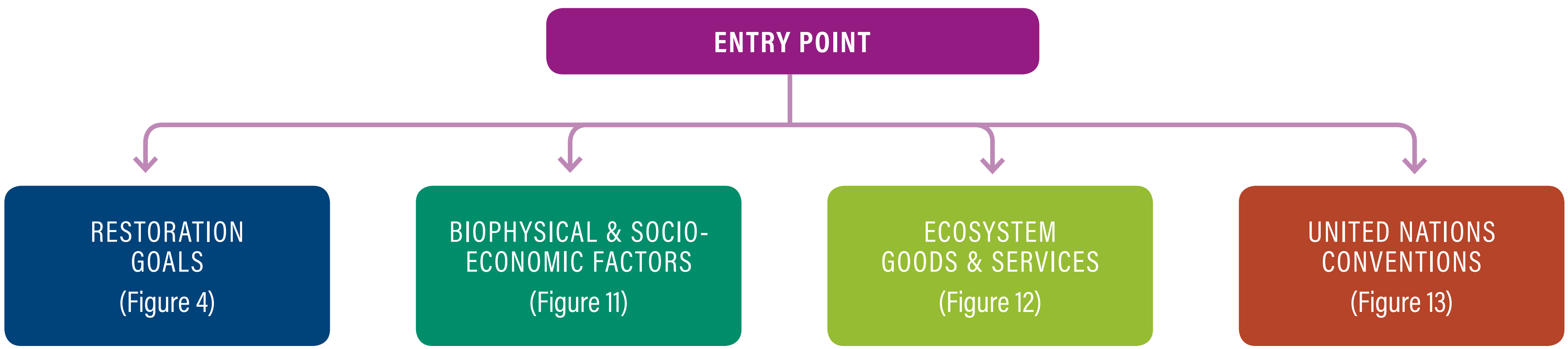
Source: GoM (2018).

DIFFERENT ENTRY POINTS FOR SELECTING INDICATORS

The **goal-based approach** to monitoring is generally understood by a wide range of stakeholders. However, some stakeholders, depending on their priorities, may want to start from a different perspective (Figure 10). Common alternative entry points focus on a checklist of biophysical and socio-economic factors. Other stakeholders may prefer to use ecosystem goods and services as an entry point. And stakeholders concerned with the UN Conventions may base their monitoring systems around the entry point highlighting indicators aligned with UN initiatives like the Sustainable Development Goals (SDGs), the Aichi Biodiversity Targets of the Convention on Biological Diversity (CBD), and the Land Degradation Neutrality indicators (LDN) of the Convention to Combat Desertification (UNCCD). Figures 11 through 13 provide examples of indicator frameworks that can be developed from these different entry points.

No matter which entry point stakeholders prefer, they will still need to determine key measurements for land use and barriers to sustainability, filter the measurements by their main constraints and priorities, and set up the framework based on the indicators chosen.

Figure 10 | Different Entry Points for Monitoring Frameworks



Source: Authors.

Figure 11 | Restoration Indicator Menu Developed from Biophysical and Social Factors Entry Point

FOCUS	SUB-THEME	INDICATOR	EXAMPLE METRICS
BIOPHYSICAL	Yield	Products harvested	Volume of products harvested per year
	Quantity	Water balance	Streamflow & baseflow (hydrograph)
		Quantity of woodfuel produced	Quantity of woodfuel produced per year
	Quality	Community composition	Abundance of indicator species
		Sediment in water	Sediment level in reservoir
		Soil health	Faunal density and richness
	Stability	Soil compaction and permeability	Infiltration and percolation rate
	Connectivity	Connection between habitats	Mean nearest distance between habitat patches
	Mitigation	Biomass and carbon sequestration	Aboveground biomass stock per hectare
SOCIAL	Equity	Restoration benefits for women & minorities	Yield of non-timber forest products
	Values	Perception of restoration	% engaging in restoration activities
	Resilience	Capacity to deal with shocks & stresses	Existence of local risk reduction strategies
	Scarcity	Extent of energy needs being met	Energy burden (expenditure)
	Practices	Sacred land or cultural site protection	Area of cultural/sacred land protected
	Health	Improvements in nutrition	% of people experiencing food shortage
ECONOMIC	Income	Economic benefits from restoration	% income from restoration related activities
	Market	Access to markets	Producer's share of final price
	Finance	Access to financial services	% accessing financial services
GOVERNANCE	Rights	Land and natural resource tenure	% with perceived land tenure security
	Management	Sustainable sourcing of energy	% of households with access to sustainable energy
		Use of soil conservation practices	% of farmers using practices
		Use of water conservation practices	% of farmers using practices
	Protection	Protected area coverage	Area of key biodiversity areas protected

Source: Authors.

Figure 12 | Restoration Indicator Menu Developed from Ecosystem Goods and Services Entry Point

	FOCUS	SUB-THEME	INDICATOR	EXAMPLE METRICS
ECOSYSTEM SERVICES	PROVISIONING	Yield	Products harvested	Volume of products harvested per year
		Quantity	Water balance	Streamflow & baseflow (hydrograph)
			Quantity of woodfuel produced	Quantity of woodfuel produced per year
		Scarcity	Extent of energy needs being met	Energy burden (expenditure)
	REGULATING	Mitigation	Biomass & carbon sequestration	Aboveground biomass stock per hectare
		Stability	Soil compaction & permeability	Infiltration and percolation rate
		Quality	Soil health	Faunal density and richness
			Sediment in water	Sediment level in reservoir
		Management	Use of soil conservation practices	% of farmers using practices
			Use of water conservation practices	% of farmers using practices
	SUPPORTING	Quality	Community composition	Abundance of indicator species
		Connectivity	Connection between habitats	Mean nearest distance between habitat patches
		Protection	Protected area coverage	Area of key biodiversity areas protected
	CULTURAL	Practices	Sacred land or cultural site protection	Area of cultural/sacred land protected
		Values	Perception of restoration	% engaged in restoration activities
DRIVERS OF CHANGE		Management	Sustainable sourcing of energy	% of households with access to sustainable energy
CONSTITUENTS OF WELL-BEING		Adaptation	Impact of shocks and stresses	% of people experiencing food shortage
		Resilience	Capacity to deal with shocks & stresses	Existence of local risk reduction strategies
		Rights	Land and natural resource tenure	% with perceived land tenure security
		Income	Economic benefits from restoration	% income from restoration related activities
		Equity	Restoration benefits for women & minorities	Yield of non-timber forest products
		Health	Improvements in nutrition	% of people experiencing food shortage
		Market	Access to markets	Producer's share of final price
		Finance	Access to financial services	% accessing financial services

Note: Ecosystem goods and services entry points derived from Millennium Ecosystem Assessment (2005).

Source: Authors.

Figure 13 | Restoration Indicator Menu Developed from United Nations Conventions Entry Point

GOAL-THEME	SUB-THEME	INDICATOR	EXAMPLE METRICS	SDGs	Aichi	LDN
CULTURE	Practices	Use of knowledge, innovations, & practices	Number of speakers of indigenous languages		18	
	Values	Perception of restoration	% engaging in restoration actvities			
	Rights	Secure tenure rights to land	Proportion with perceived land tenure security	1		
COMMUNITY	Income	Income of small-scale food producers	Average income, by sex and status	1		
	Equity	Fair and equitable sharing of benefits	# of legislative, admin & policy frameworks	15		
	Health	Improvements in nutrition	Prevalence of undernourishment	2		
FOOD & PRODUCTS	Yield	Land productivity	Net primary productivity	8	7	UNCCD
	Market	Access to markets	Producer's share of final price	8		
	Finance	Access to financial services	% accessing financial services	8		
CLIMATE	Mitigation	Biomass and carbon sequestration	Aboveground biomass stock per hectare	2		
	Adaptation	Impact of shocks and stresses	% of people experiencing food shortage	2		
	Resilience	Capacity to deal with shocks & stresses	Existence of local risk reduction strategies	2		
SOIL	Quality	Carbon stocks	Soil organic carbon			UNCCD
	Stability	Soil compaction and permeability	Infiltration and percolation rate			UNCCD
	Management	Use of soil conservation practices	% of farmers using practices		8	UNCCD
WATER	Quality	Sediment in water	Sediment level in reservoir	6	14	
	Quantity	Level of water stress	Proportion of freshwater withdrawal	6	14	
	Management	Integrated water resources management	Degree of water management	6	14	
ENERGY	Quantity	Access to electricity	Proportion with access to electricity	7		
	Scarcity	Extent of energy needs being met	Energy burden (expenditure)	7		
	Management	Sustainable sourcing of energy	% of households with access to sustainable energy	7		
BIODIVERSITY	Quality	Red List Index	Change in Red List Index	15	12	
	Connectivity	Connection between habitats	Mean nearest distance between habitat patches	15	5	11
	Protection	Significant sites for biodiversity	Proportion covered by protected areas	15	5	11

Source: Authors.

COUNTRY CASE STUDY

Ethiopia: Monitoring Using Ecosystem Goods and Services Goals

Ethiopia's tree-based landscape restoration monitoring framework is adapted from the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment 2005), and reflects the **ecosystem goods and services** supplied by trees and forests.

National, regional, and district experts were convened by Ethiopia's Environment, Forest, and Climate Change Commission to identify the various ecosystem goods and services that trees and forests can provide in support of Ethiopia's economic, social, and environmental goals. Once the desirable goods and services were determined, participants identified areas in which to establish trees, taking into account the landscape and the spatial arrangement of trees. Trees deliver different bundles of ecosystem goods and services, depending on their location in the landscape. For example:

- **trees in settlements** can provide food, shade, carbon sequestration, and beautification; and
- **trees in cropland** can contribute food, high-value non-timber tree products, wood fuel, erosion control, soil fertility, and carbon sequestration.

Trees within the same land use-land category (e.g., cropland) can be associated with different ecosystem goods and services based on their spatial pattern (e.g., whether they are scattered, clustered, in a linear pattern, or in a regular pattern). For example, for a farmer

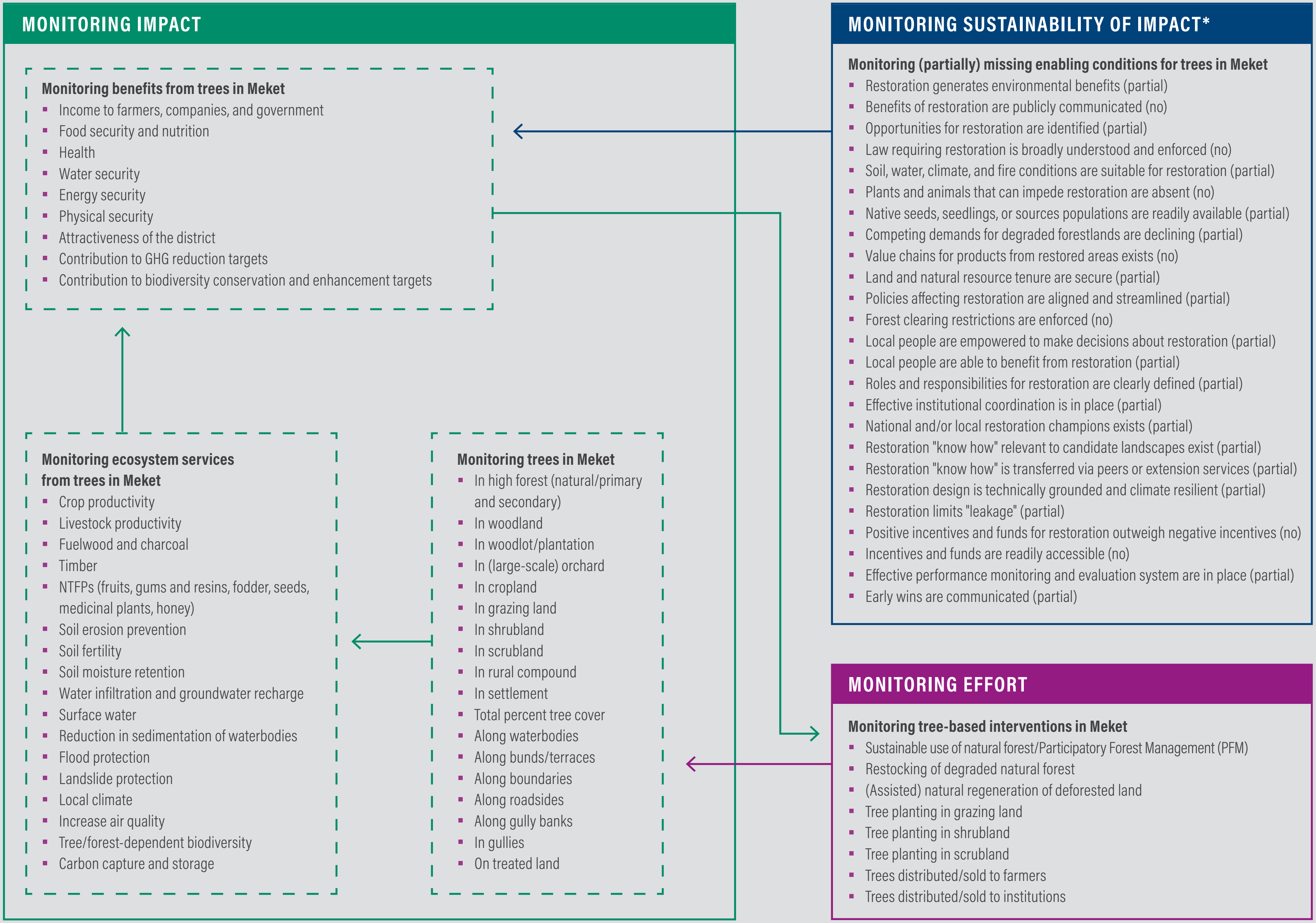
- **trees along farmland boundaries** can increase timber or wood fuel; and
- **trees scattered within the field** can increase crop and livestock productivity.

Restoration experts in Ethiopia agreed that monitoring tree-based landscape restoration had to go beyond monitoring trees. It must include specific restoration objectives and track whether enabling conditions—selected from the Restoration Diagnostic (Hanson et al. 2015)—are in place to support the long-term contribution of trees to human well-being and ecosystem health. The framework must also reflect the fact that it might take a decade before the impacts of a tree-based intervention on human well-being and ecosystem health materialize.

Ethiopia's framework to monitor tree-based landscape restoration thus includes indicators tracking interventions, impacts, and sustainability over time (Figure 14). Relevant entry points are indicated in parentheses:

1. Tree-based interventions to increase tree cover (Land Use).
2. Tree cover and distribution in the landscape (Land Use).
3. Ecosystem goods and services supplied by these land-scapes (Ecosystem Goods and Services Goals).
4. Benefits people derive from these ecosystem goods and services (Ecosystem Goods and Services Goals).
5. Enabling conditions for tree-based interventions. Missing enabling conditions need to be put in place to motivate individuals, communities, and companies to take action (Barriers to Sustainability).

Figure 14 | Indicator Framework Developed in Ethiopia to Monitor Tree-Based Landscape Restoration, Focusing on Effort, Impact, and Sustainability for Meket district



Note: *Enabling conditions taken from *The Restoration Diagnostic* (Hanson et al. 2015). Conducted by IUCN.

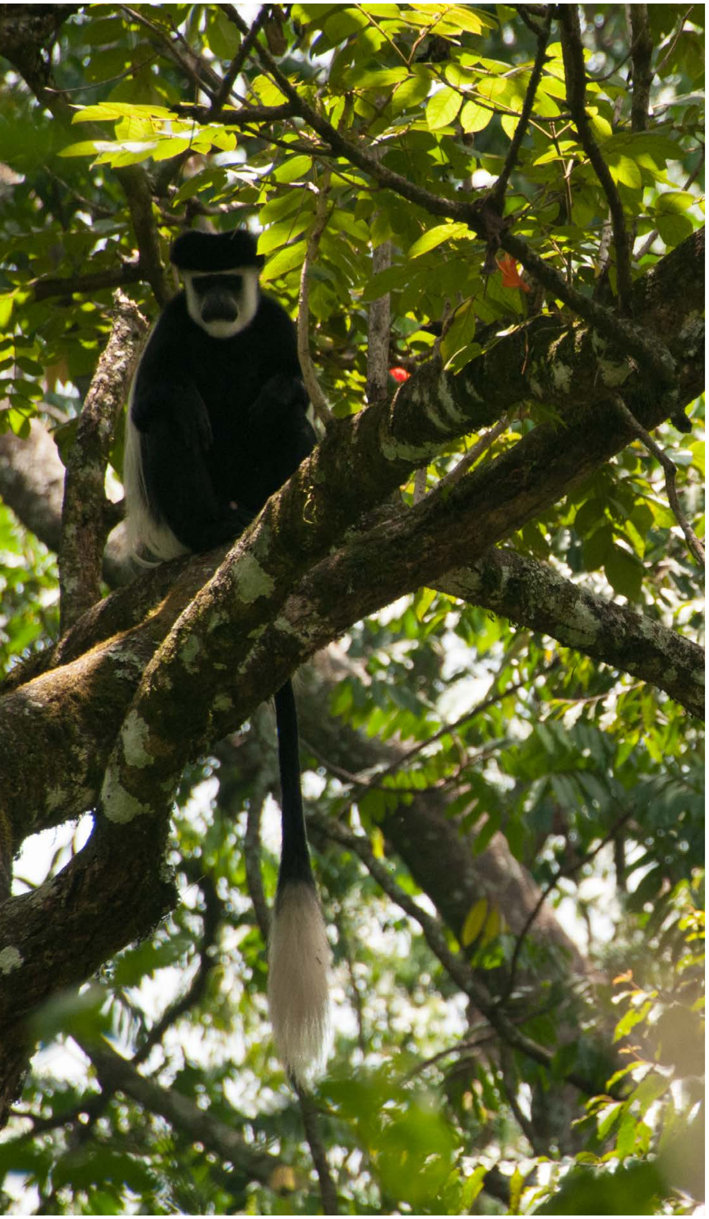
Source: Ethiopia's Environment, Forest and Climate Change Commission and WRI.

CHAPTER 3:

FILTER INDICATORS ACCORDING TO LOCAL CONSTRAINTS, PRIORITIES, AND DATA AVAILABILITY

In an ideal world, the most scientifically accurate methods available would be chosen to monitor restoration. However, every project is faced with real-world constraints. Not everything can be adequately monitored—priorities need to be identified and constraints acknowledged. A more practical, feasible, and sustainable system can be created and available resources carefully assessed. Stakeholders can then make informed choices about available data and suitable technologies.

QUESTION 4. WHICH CONSTRAINTS AND PRIORITIES?



IDENTIFY THE RESOURCES AND OTHER ESSENTIAL CONSIDERATIONS THAT CONSTRAIN YOUR MONITORING PROGRAM

Indicators cannot be developed and used without an adequate assessment of resource constraints regarding data availability and technical capacity. Practitioners have different resource constraints that affect what type of data can and should be collected. For example, many practitioners lack adequate funds and must prioritize affordable and cost-effective monitoring systems. Other constraints on data include availability, ease of collection (access), and quality. Other considerations include the monitoring period (time necessary to show effects), the comprehensiveness of the indicators, their sensitivity to change and ease of classification, and the ethics of the data-collection process. The specifics of these factors make use of a generic indicator and metric framework challenging.

Your particular constraints will inform how you choose your indicators and metrics for monitoring restoration. In Table 3, we suggest some criteria and highlight the relevant questions and constraints.

As one example, a variety of different metrics can be used to measure soil health (Table 4 and Figure 15). Each metric is ranked on a scale of one to three, with three being the highest, to indicate how well it meets the assessment criteria outlined in Table 3. From this assessment, soil organic carbon and soil fauna density and richness receive the two highest scores. Although this approach is subjective, it offers a a pragmatic way to make decisions about indicator and metric selection for restoration monitoring.

Table 3 | Possible Assessment Criteria for Use by Restoration Practitioners

CRITERIA	KEY QUESTION	KEY CONSTRAINT
Resources		
Ease of data collection	How easy is it to collect data for this indicator? How much time, effort, expertise, and technology is required?	Technical and logistical constraints may limit the capacity of stakeholders to collect data. Assessing how technically challenging data collection is for various indicators will help ensure that restoration efforts are sustainable.
Affordability of data collection	How great are the financial resources needed for collecting data and analyzing trends for this indicator?	Restoration monitoring efforts may face financial constraints. Considering the cost of collecting data for indicators is therefore important.
Availability of data	How consistently can data be collected for this indicator? Is there an agency or program that can take responsibility for data collection?	Even though information for some indicators may be affordable and easy to collect, restoration practitioners can face constraints when setting up systems to collect data regularly. Assessing the reliability of collection will help ensure that indicators can be consistently monitored.
Quality of data	Are available data based on transparent and consistent collection and reporting methods?	Often, metrics based on data that are simpler, cheaper, or easier to collect come at the expense of quality.
Considerations		
Time taken to show effects	How much time will it take for the effects of the restoration intervention to be measurable?	Effects may become apparent over a period of months to years, which constrains aggregation of different metrics into a composite indicator.
Comprehensiveness	How comprehensive are the metrics in representing the desired restoration goals or land uses?	Some metrics provide a broader view of progress, while others may focus on narrow characteristics. For example, soil organic matter content gives an idea of general soil health, while nitrogen content focuses on a specific nutrient. Practitioners interested in creating a streamlined indicator framework may want comprehensive metrics that enable the use of fewer indicators. On the other hand, there may be some very specific indicators that practitioners are interested in monitoring.
Sensitivity to restoration interventions	How sensitive are indicators to restoration activities? Does the metric accurately reflect progress?	Indicators that are sensitive would show a proportionate response to progress made in restoration. This is only applicable to indicators that measure restoration outcomes, not to indicators that provide information on management, inputs, or the process of restoration.
Ease of disaggregation	How easy is it to disaggregate data informing the indicator regarding different attributes such as gender, age, and ethnic background?	Indicators that can be disaggregated (i.e., are based on separate metrics) may allow practitioners to monitor how restoration is benefiting different groups in a community. Disaggregation of data can help ensure that restoration is managed in an inclusive and equitable way.
Ethics of data collection	How risky or serious are the ethical hazards associated with collecting and reporting data for this indicator?	Ethical considerations may affect data collection in some contexts. For example, in areas where land tenure is not clearly delineated, attempting to determine who has tenure rights can cause conflict.

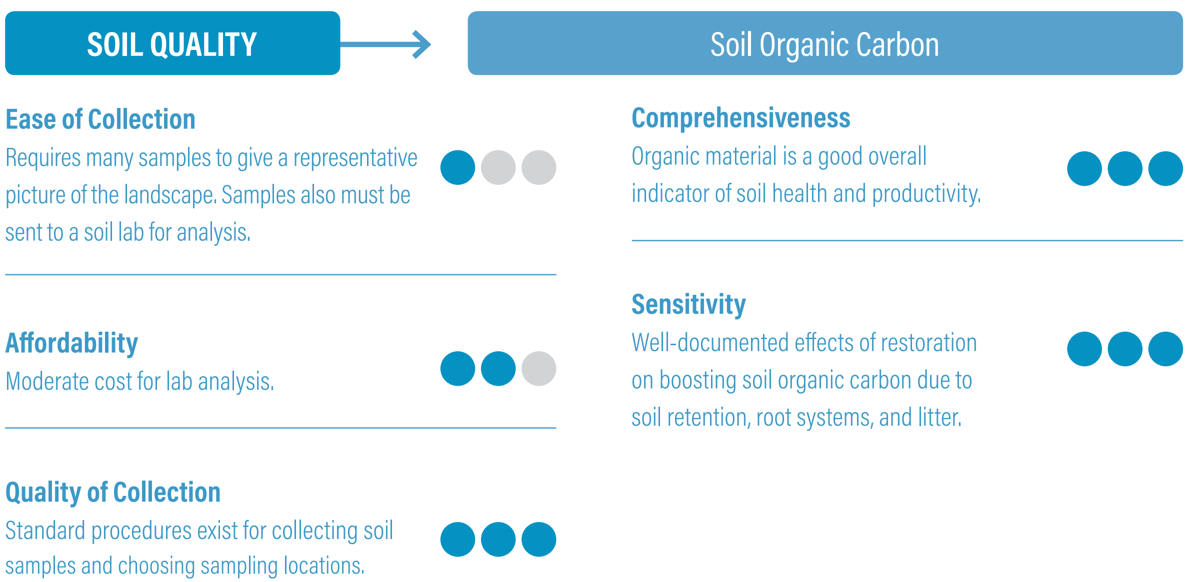
Source: Authors.

Table 4 | Assessment of Soil Health Metrics against Monitoring Criteria

INDICATOR	METRIC	EASE OF COLLECTION	AFFORDABILITY	QUALITY	COMPREHENSIVENESS	SENSITIVITY	AVERAGE SCORE
SOIL QUALITY	Soil organic carbon	1	2	3	3	3	**2.4**
	Nutrient concentrations	2	2	3	1	2	**2**
	Soil pH	2	2	3	1	1	**1.8**
	Amount of fertilizer applied	3	3	1	1	1	**1.8**
	Soil fauna density and richness	2	2	2	3	3	**2.4**
	Soil respiration	2	2	3	1	1	**1.8**
	Decomposition rate	1	2	3	1	2	**1.8**

Note: Metrics are ranked on a scale of 1 (low, does not meet criteria), 2 (partially meets criteria), and 3 (high, meets criteria).
Source: Authors.

Figure 15 | Assessment Process for Metrics: An Example of Soil Organic Carbon



Source: Authors.

In cases where metrics score equally, other factors should be considered, such as overlap with other monitoring and reporting conventions. In such a case, soil organic carbon levels may be the most relevant metric to select because it is also used to monitor Land Degradation Neutrality under the United Nations Convention to Combat Desertification (UNCCD). More information for each of the indicators highlighted in the indicator menu for restoration goals is provided in Appendix C.

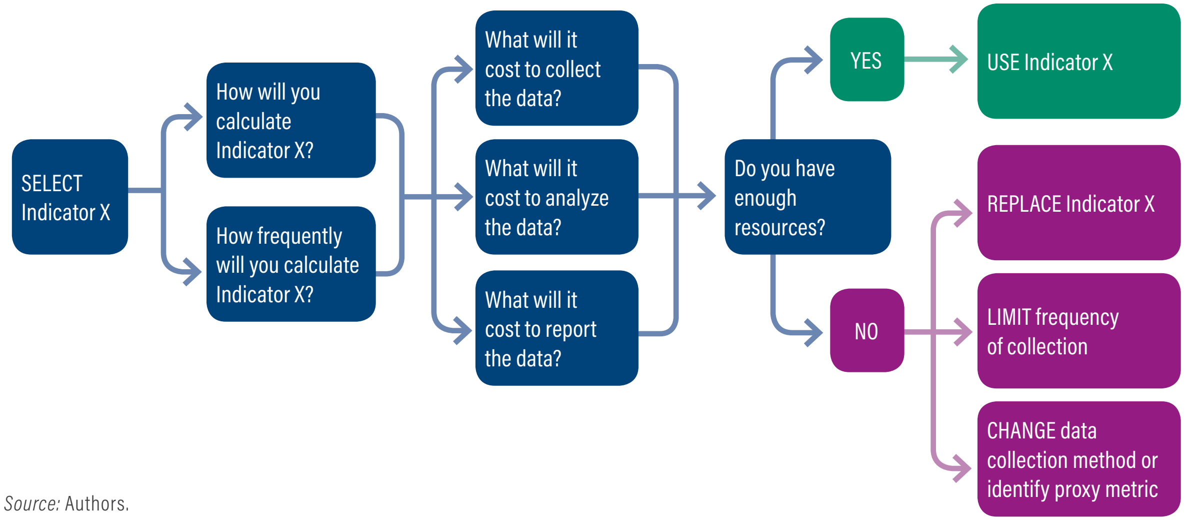
CONSIDER THE AFFORDABILITY OF YOUR INDICATORS

Choosing affordable indicators at the beginning of the project can lead to more sustainable restoration monitoring systems (Figure 16).

First, you need to understand how you will gather data to calculate the indicators (e.g., remote or local survey methods) and how frequently (higher frequency leads to better data but is often more expensive). You should estimate the costs for collecting, analyzing, and reporting the data. With that information, you can then determine whether you have enough resources to use the chosen indicator or whether you need to replace the indicator, limit its frequency, or change the data-collection methods. Another consideration is the level of rigor required for the specific monitoring need. Some indicators may require rigorous data (e.g., laboratory testing of soils). Other indicators may require less rigorous data (e.g., time-series photographs of a landscape under restoration identifying visible changes in erosion).

In Malawi, for example, the lack of secure, dedicated funding to support restoration monitoring presented a challenge for data collection, particularly in terms of the feasibility of introducing new, large-scale data-collection processes that could be costly. To overcome these challenges, the government decided to minimize costs by prioritizing indicators already being collected as part of existing, well-established monitoring or survey activities. Many of the final indicators came from the National Statistical Office's Integrated Household Survey, which is conducted every three to five years in Malawi and contains many data points relevant to restoration.

Figure 16 | How to Assess the Affordability of an Indicator



Source: Authors.

FILTER YOUR CHOSEN INDICATORS BY THE CRITERIA YOU HAVE SELECTED

Based on the earlier questions "why restoration," "which land use," and "which barriers to sustainability," you should be able to put together a list of possible restoration-related indicators and metrics.

To create this list, you can also look at existing indicators used in related monitoring systems (e.g., a national or county monitoring system, if appropriate at the desired scale). Another option is to use a menu of restoration-related indicators as a starting point that can then be adapted. We have assembled some examples of indicator menus and explain how we chose those indicators in Appendix D.

After creating this initial list of indicators, you can now assign each indicator a score for how well it meets each of the criteria on a scale of one to three, as shown in Table 4.

We recommend creating a table with all possible indicators and each of the criteria chosen from the "which criteria" question. These scores assigned should be specific to your restoration context.

> If you have clear criteria determined ahead of time, dedicate more time to assigning the scores to each of the indicators you have chosen.

COUNTRY CASE STUDY

Kenya: Considering Constraints

The technical working group for the Kenya Water Towers Agency agreed to structure the monitoring framework around three national goals that form the pillars of the national monitoring framework:

1. **Conservation.** Improved conservation of the water towers: indicators that measure ecosystem health (biophysical factors)
2. **Productivity.** Improved productivity of the water towers: indicators that measure crop, energy, water, and product yields (biophysical factors)
3. **Governance.** Enabling the policy and institutional environment: indicators that monitor management and governance such as stakeholder involvement, regulations, public awareness, and management (socio-economic and governance factors)

Table 5 | Kenya Water Towers Agency's Criteria for Assessing Indicators

CRITERIA	WEIGHT	LIKERT SCALE SCORING
1. Affordability	0.6	(1–most expensive; 5–least expensive)
2. Current data availability	0.6	(1–not being measured; 5–being measured)
3. Technical capacity/requirements	0.3	(1–most technical; 5–least technical)
4. Time taken to monitor	0.1	(1–most time; 5–least time)
5. Accessibility of data	0.3	(1–least accessible; 5–open source)
6. Ethics of data collection	0.1	(1–most ethical issues; 5–fewest ethical issues)
7. Relevance/effectiveness	0.6	(1–least relevant; 5–most relevant)

Source: Kenya Water Towers Agency (2019).

The stakeholders divided the goals into biophysical and socio-economic factors (see alternative entry points), because this entry point of conservation, productivity, and governance aligned more closely with the local vision. Once these three areas had been selected, the working group considered constraints and priorities. The working group decided on a set of seven criteria to assess each indicator option on a Likert scale of 1 to 5 (a rating scale that offers options from one extreme position to another). The working group weighted these criteria by urgency and importance. Table 5 shows the different prioritization criteria, their weight, and the scoring standards.

Over the course of several sessions spanning seven months, the working group analyzed each indicator option and assigned each indicator a score for the seven criteria. Weighted score averages were then calculated for each indicator option. Indicator options scoring an average of 4 and above were selected for the monitoring framework. Data for many of these indicators were already being collected (thanks to the prioritization of criteria such as "current data availability" and "accessibility of data.") Indicators with an average score of 2 to 4 were classified as medium priority for integration in the medium term, while those scoring below 2 were classified as low priority for measurement and integration in the monitoring framework in the long term.

QUESTION 5. WHICH DATA?

CONSIDER WHICH DATA ALREADY EXIST AND WHICH DATA ARE MISSING BUT NECESSARY

Relevant existing data and the data that still need to be collected will support the indicator framework you have designed. Where data need to be collected, you should devise uniform, coordinated, and replicable methods of collecting the data at regular intervals. Creating a monitoring system is beyond the scope of this guide. However, we provide some information on different types of data and analysis and how they might be used in designing your monitoring system.

FAO has been supporting countries' efforts to establish National Forest Monitoring Systems (NFMS) for decades. Best practices and lessons learned from this support are summarized in FAO's *Voluntary Guidelines on National Forest Monitoring* (FAO 2017). It is important that systems for specific needs such as restoration monitoring build on existing systems (such as NFMS) and existing capacities in the countries (FAO 2018).

CHOOSING YOUR MONITORING DATA

When setting up your indicator framework, you should consider which technologies could be leveraged for your monitoring process. FAO's Open Foris tools (www.openforis.org) are one such technology being utilized in developing countries to facilitate monitoring of forests as well as other key societal issues. New technologies may be able to help overcome challenges and constraints of data quantity, but potential problems such as sampling bias and poor data quality should always be considered. Using new technologies can encourage evaluative learning, interactive sharing, and greater public engagement with the findings of an evaluation (Raftree et al. 2014).

Data can be categorized in terms of the types of datasets, the size of datasets, and the methods of data analysis.

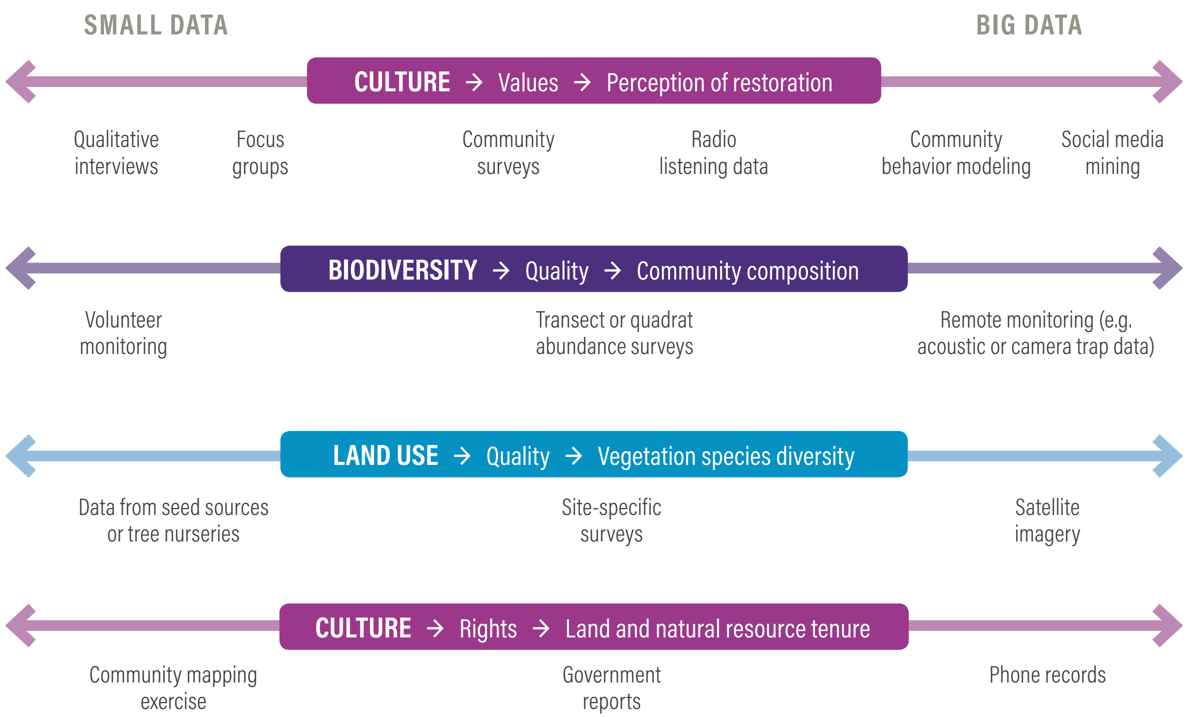
Types of data: Data may be quantitative or qualitative and may be collected in a variety of ways including low or high technology methods such as surveys, in-person questionnaires, automated measurement, remote sensing, or social media scanning. Examples of data types relevant to several themes of interest are shown in Figure 17.

Size of datasets: "Small data" refers to relatively small datasets, often collected at a local level. Examples include household consumption of energy or water within a specified area, or crop production on farms within a specified region. "Big data" refers to very large datasets, often collected at a national or global level, and sometimes aggregated from multiple sources and incorporating multiple types of data.

Data analysis: Data may be analyzed or mapped in real time or over periods of time. Datasets can be analyzed individually, or multiple datasets may be analyzed together using descriptive statistics and charts, traditional statistical models, new machine-learning algorithms, or through process models.

Each of these analytical methods may be used to analyze almost any of these types of data, and any size of data, and much thought must be given to choosing appropriate analytical methods to achieve the desired goals. Suitable data summaries and analytical methods should be carefully considered when creating the indicators for your indicator framework for monitoring restoration.

Figure 17 | Examples of Data Sources and Collection Methods Appropriate for Monitoring Restoration Indicators



Source: Authors.

You should also consider reducing the burden of data collection through crowd-sourcing and “citizen science”—active public involvement in scientific research, which is growing bigger, more ambitious, and more networked. In addition to monitoring pollution levels and taking millions of pictures of flora and fauna, people are building Geiger counters to assess radiation levels, photographing stagnant water to help document the spread of mosquito-borne disease, and taking videos of water flow to calibrate flood models. For example, the U.S. and Scottish environmental protection agencies have incorporated citizen science in their routine work. UN Environment is exploring ways of using citizen science to both monitor the environment and activate environmental concern. To gain legitimacy, many expect that the field will have to overcome lingering concerns about the reliability of its measurements and its usefulness in research (Irwin 2018).

The expansion of mobile networks and messaging capabilities into remote areas has encouraged development organizations to use mobile technology to engage the broader public (Raftree et al. 2014). Access to technology, however, is still a limiting factor to communications, particularly in low-income countries and in rural areas, where there is limited access to electricity. People who live in rural areas, including restoration practitioners, are also less likely to have access to the internet, mobile phones, and other communication technology. Women in Africa are 13 percent less likely to own a mobile phone than men (GSMA 2016). For those with access, information and communication technology, like mobile apps, encourage broader participation and enable a wider range of inputs at reduced cost. Apps allow for the collection of real-time data on participant experiences, behaviors, and attitudes. Analysis can be conducted early in the process and course corrections made to improve interventions and outcomes. In addition, with the promise of data science, natural language processing (NLP), machine learning (ML), and artificial intelligence (AI), new data streams for measuring progress on restoration are becoming available to researchers.

CHAPTER 4:

SET UP A MONITORING SYSTEM BASED ON INDICATORS, METRICS, AND OPTIONAL INDEX

Once stakeholders have determined their goals, land-uses, and barriers to sustainability, and have filtered their indicator choices according to constraints, priorities, and data availability, they are ready to set up an indicator framework based on suitable metrics. Some stakeholders may wish to go beyond indicators and calculate an index, which allows for an overall score of the landscape and provides a benchmark for comparing progress in different landscapes or areas within a landscape.

QUESTION 6. WHICH INDICATORS AND METRICS?

BY THIS POINT YOU SHOULD BE ABLE TO SET UP AN INDICATOR FRAMEWORK FOR MONITORING RESTORATION BASED ON THE MEASUREMENTS YOU HAVE SELECTED

At this stage, you will have selected your indicators, and you will have considered the goals, constraints, priorities and data availability. With this information, a less generic and more tailored indicator framework with metrics of measurement should be taking shape. You may need to streamline your indicator selection further and reduce the total number to the minimum necessary to cover your priority issues. Choices regarding indicator selection will depend on your priorities, resources, capacity for data collection, and the availability of data. A discussion regarding capacity should be undertaken with all relevant institutions that currently collect data relevant to your preferred indicators.

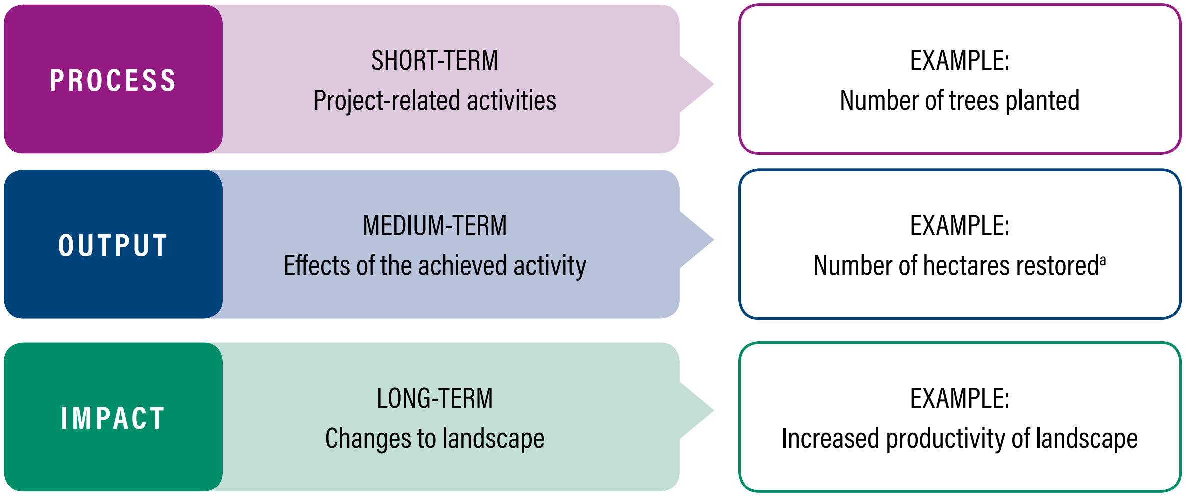
CHOOSING WHAT STAGE TO MEASURE

Indicators can be divided into three types—those that measure process, output, and impacts (Figure 18). Choosing the right indicators for your framework depends on what you are trying to measure and at what stage. Some indicator frameworks identify additional types of indicators, including input indicators (the measure of the contrbutions necessary to enable restoration) and outcome indicators (the benefits that a project or intervention is designed to deliver) (DFID 2013). For simplicity and because these categories overlap to some extent, we group process and input indicators together and output and outcome indicators together.

Indicators can be used to motivate further change, even before impacts have been identified. This guide is concerned primarily with measuring medium-term and long-term impacts so we focus on output and impact indicators. However, it is important to consider which indicators can best support your restoration project and lead to change. It may be important to identify a number of progress indicators that are easy to measure.

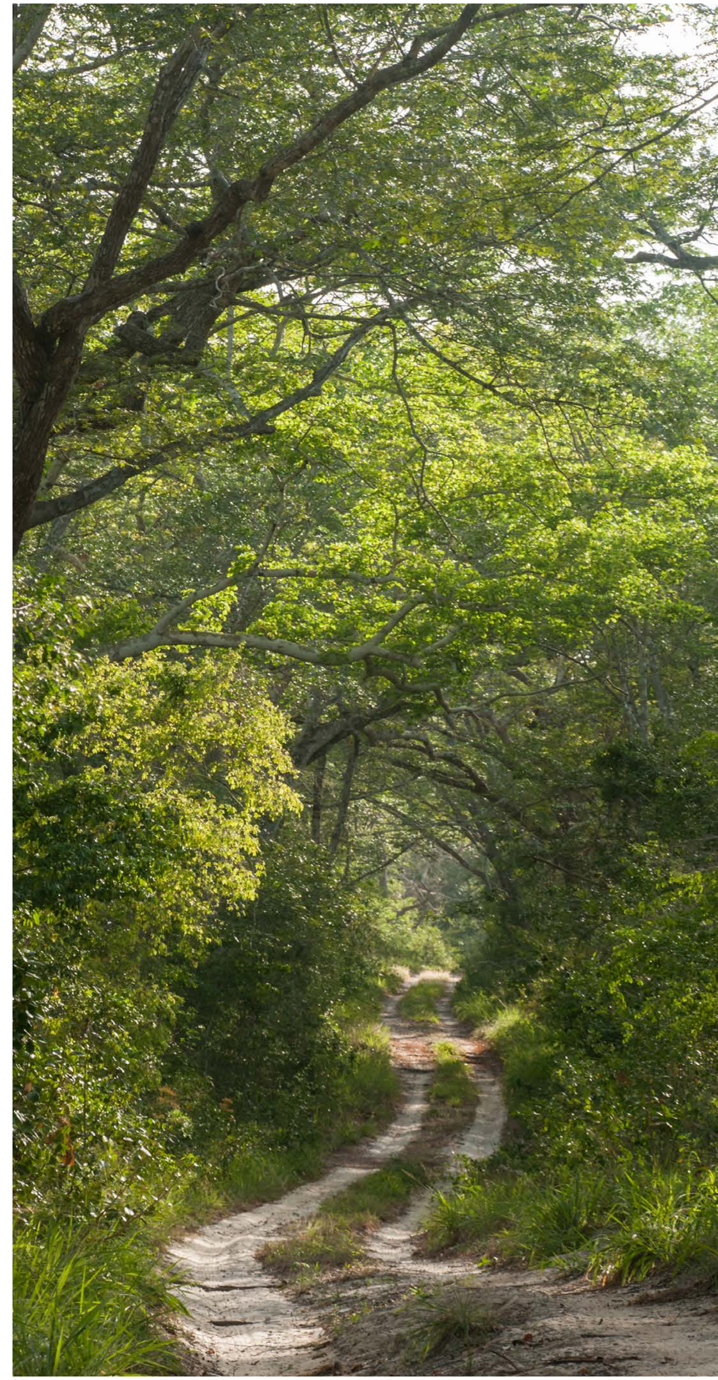
- **Process** indicators identify whether the project-related activities are on track or have been completed:
  - Number of native trees planted
  - Number of stakeholders involved in restoration activities
  - Total program funding invested in restoration activities
- **Output** indicators measure medium-term effects of the restoration activity:
  - Number of hectares restored along waterways
  - Survival rate of of trees planted
  - Number of restoration-related jobs
- **Impact** indicators focus on significant long-term changes at the landscape level resulting from the restoration activity:
  - Change in agricultural yield in restored areas
  - Change in sediment in waterways near restored areas
  - Change in community nutrition levels in restored areas

Figure 18 | Process, Output, and Impact Indicators



Note: a. We recognize that "number of hectares restored" might be a problematic indicator of progress because it may prioritize quantity over quality of restoration.
Source: Adapted from UNDP (2009).

> Having identified the most suitable indicators, you can refer to the constraints, priorities, and data availability to clarify the final metrics to use in your monitoring system.



QUESTION 7. WHAT INDEX?

CREATE A RESTORATION INDEX TO BETTER HIGHLIGHT YOUR PROGRESS

Monitoring restoration often requires working with several goals and multiple indicators that feed into complex reporting processes. This is not conducive to simple and effective communication with a wide audience. You might want to communicate progress more simply by creating a "restoration index," which is a composite measure that aggregates several different indicators. Indexes are often used in the fields of development and environmental sustainability, as they help to distill complex information from multiple sources into a single number that communicates the amount of progress made (Gan et al. 2017). One well-known example is the United Nations Human Development Index (HDI), which aggregates the indicators of life expectancy, educational attainment, and per capita income. An index provides information that can help people easily see overall progress toward several restoration goals. Creating an index involves repeating some of the earlier steps in this guide.

1. CONSIDER YOUR GOALS AND TARGETS WHEN CREATING AN INDEX

Identify the overarching goals and specific targets for your restoration effort. For example, a high priority goal might be to increase water availability and a target might be to achieve an increase in water availability of a certain amount over a certain period of time. One or more water-related indicators should then be included among the indicators chosen for the index.

2. SELECT WHICH MEASURES YOU WANT TO INCLUDE IN THE INDEX

You will not need to include all the indicators in your framework, but you should highlight those that track your most important priorities and are most meaningful for your stakeholders. You will want to specifically outline the goal-theme, sub-theme, indicator, metric, and baseline. By this point, you should be able to easily identify all these elements. You will also want to input information you have on the baseline for each indicator and determine which target to use (if you have more than one) (Table 6). Finally, you will need to weight the indicators to reflect their relative importance.

3. WEIGHT THE INDICATORS

If the goals have different levels of priority, you can weight the indicators to reflect their relative importance in the context of your restoration project. Assigning weights can be complicated as it involves value judgments that should be discussed with the relevant stakeholders. Some goals can be complementary while others can involve trade-offs (see Figure 5), which complicates weighting further.

4. STANDARDIZE THE MEASURES OF SUCCESS

Since metrics use a variety of units, you will need to create a common frame of reference for success, such as a scale from 0 to 10, where 10 means that the target was achieved and 0 means there was no progress. Clearly define what each of those scores means (Table 7).

5. CALCULATE THE INDEX

After standardizing and scoring the targets, and weighting the indicators, you can then calculate the index by aggregating the scores and the weights. Using this process, the index will be calculated as an arithmetic mean. This is commonly called a normalization process because all indicators are measured on the same scale.

Once calculated, the index will function as the overall score for your landscape and show whether restoration is succeeding in meeting targets and aligning with stakeholder priorities. The use of a single number can help decision-makers to assess and compare the status of different landscapes. An example of how indicators were integrated into a restoration index for El Salvador's monitoring framework is provided on page 46. More detailed guidance is provided in Appendix C.

Table 6 | Information Needed to Create a Restoration Index

MEASUREMENT	GOAL-THEME	SUB-THEME	INDICATOR	METRIC	BASELINE	TARGET	WEIGHT (0–1)
1	Land use	Growth	Forest cover	ha	150,000 ha	Increase forest cover by 300,000 ha	0.5
2	Biodiversity	Connectivity	Biological corridors	ha	20,000 ha	Incresase the area in corridors by 60,000 ha	0.25
3	Community	Income	Permanent jobs created	Jobs	250 jobs	Increase number of permanent jobs by 800	0.25

Source: Authors.

You may not need an index to show the restoration priorities in your landscape. However, this is a holistic way to present the status of the landscape as a system. Those at more advanced stages in the monitoring process have found indexes to be particularly useful. Those at the beginning of the process may decide that creating an index is too complex or not yet relevant to their needs. In that case, skip this step or modify it by identifying targets to match your indicators.

Table 7 | Standardize the Measures of Success (Scoring Progress against Targets)

SCORE	DEFINITION	TARGET
10	Target achieved	Increase forest cover by 300,000 ha
5	Target half completed	Increase forest cover by 150,000 ha
0	No progress on target	No increase

Source: Authors.

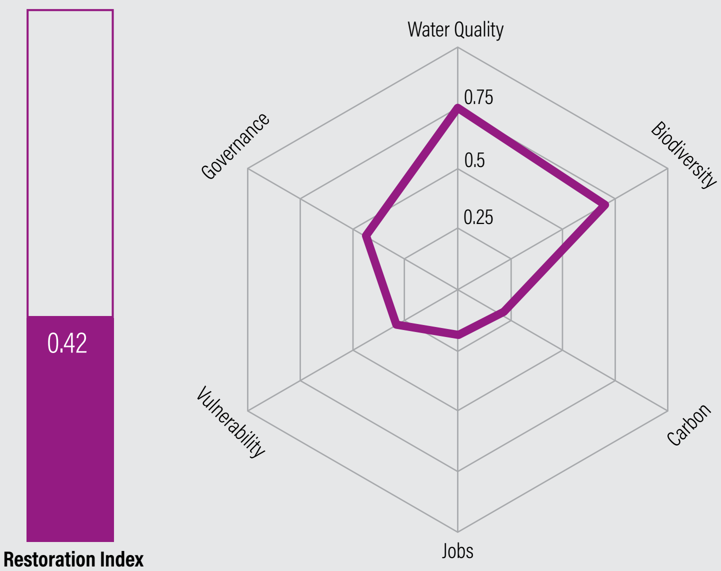
COUNTRY CASE STUDY

El Salvador: Considering Priorities Using an Index

In El Salvador, the Ministry of Environment and Natural Resources in partnership with WRI considered a choice of indicators, taking into account the availability of resources for monitoring and prioritizing the production of a cost-effective, minimum viable framework. The final indicators selected included:

1. **Water Quality:** Chemical analysis at main rivers (analysis performed by Ministry of Environment stations) (Water)
2. **Soil Quality:** Organic matter (Soil)
3. **Biodiversity Connectivity**: Index of Biodiversity (Biodiversity)
4. **Community Income:** Additional jobs created by restoration activities (Food & Products/Community)
5. **Community Engagement:** Governance Index (Community/Culture)
6. **Climate Carbon:** Carbon by land use (Climate)
7. **Adaptation:** Vulnerability Index (Barriers to Sustainability)

Figure 19 | Composition of El Salvador's Restoration Index



Source: Zamora-Cristales et al. (In Review).

After deciding on the indicators, the Salvadoran government expressed a desire to use them to create a sustainability index for restoration. WRI worked with the government to aggregate the indicators into a single composite index. El Salvador's objective was to prioritize and track progress toward its restoration policy targets in a straightforward and meaningful way. Policy targets that were identified in El Salvador included creating 80,000 new direct jobs, increasing carbon stocks by 2.9 million tons of CO_2 by 2030, and creating a continuous corridor to connect protected areas in the landscape. These objectives helped guide construction of the restoration index. The government also wanted an index that was easy for local people to access and that allowed more detailed exploration of specific indicators.

The six main indicators in El Salvador's minimum viable framework (the core priorities for the initial trial of the index) were used to construct the sustainability index. First, a panel of government representatives set targets for each indicator using a standard scoring process on a 0 to 1 scale. The scoring assesses progress on the scale. Then, they assigned equal weight to each indicator, given that all areas are priorities in the landscape. Since the government already had baseline data, the index measurements could be aggregated into a single score to create the 2018 index (Figure 19). Soil information was not available at the time of calculation, but the entry exists and will be displayed in the future.

El Salvador plans to score targets and calculate the index for several landscapes. The indexes can then be used to compare progress toward restoration targets within and between different landscapes.


Google Earth
CIAT

RECOMMENDATIONS AND NEXT STEPS

This guide presents an approach to identifying priorities and indicators for restoration monitoring. Fundamentally, restoration involves a multitude of different interventions, with different goals, in different landscapes. This guide was developed to reflect the diversity of restoration. It is designed to be a supportive starting point to help you focus on a specific landscape context, considering goals, constraints, priorities, targets, indicators, metrics, indexes, and data.

RECOMMENDED ACTIONS

Now that you have read through the guide, consider what's needed to begin your monitoring work:

1. **CONSIDER** your local context for restoration
2. **UNDERSTAND** your objective for developing an indicator framework for monitoring restoration
3. **CALCULATE** the available time, funding, and interest in monitoring restoration
4. **ORGANIZE** a stakeholder group to design the indicator framework
5. **GET STARTED** by using the guide

As practitioners move beyond this guide, the following steps will be important:

1. **ESTABLISH** baseline data
2. **DEVISE** methods of collecting data
3. **CREATE** a platform to host data
4. **MEASURE** progress
5. **ASSESS** need for adaptive management

These steps should be a part of setting up and implementing any monitoring framework as they are essential to collecting data and measuring progress.

NEXT STEPS

Among many actions needed, two key steps in moving forward involve the integration of technologies into monitoring systems and the continued involvement of local stakeholders in restoration projects.

TECHNOLOGY INTEGRATION

As monitoring systems, technologies, and tools develop, creating user-friendly tools, alongside guidebooks, is a key consideration. The expansion of mobile networks and messaging capabilities to remote areas has led to development organizations using mobile devices to engage the broader public. Using new technologies helps enable wider circulation of evaluative learning, interactive sharing, and greater public engagement with evaluation findings (Raftree et al. 2014).

In restoration, everyone has a different entry point to address the myriad reasons and aims for restoration. We have presented the entry point of goal-themes—community, market, climate, soil, water, biodiversity, energy, food & products, and culture. Other users may prefer to adopt the entry point of ecosystem goods and services or to fulfill certain Sustainable Development Goals (SDGs) through restoration. These approaches are not at odds with each other, particularly given the flexibility offered by technology. By developing a webpage or app for restoration indicators, users can choose their preferred entry point. Moreover, learning can be generated through the use of the tool, which could enable data input that would, in turn, provide case studies and feedback for development.

CONTINUED IN-COUNTRY STAKEHOLDER ENGAGEMENT

This guide was created as an iterative process in the course of work in El Salvador, Ethiopia, Kenya, and Malawi. The upcoming webpage and app enable feedback, so that the indicator framework can grow to reflect different geographies, priorities, and constraints. All four case studies are at national level and highlight the role of governments. Although many non-governmental practitioners have been engaged throughout the process, more work needs to be done to focus on developing indicator frameworks at more decentralized levels. The challenges encountered at national, subnational, landscape, and project-level or site-level restoration are different. The more the restoration community can collect data from different scales, the more we can collectively align on the most suitable approaches at different scales.

APPENDIX A: METHODOLOGICAL APPROACH

WRI and FAO developed this guide together. The initial brief was to create an indicator framework that could be used at both national and landscape levels. When conducting a literature review of indicators regarding restoration, it was clear that "restoration" takes on many different guises. While we may consider forest and landscape restoration a specific field of study, it cuts across sustainable forest management, climate-smart agriculture, watershed development, international development, and biodiversity conservation, among others issues. It was important to recognize that restoration is a goal-based field. From that starting point, indicator frameworks were assessed across the spectrum of different natural resource management and international development fields. Recognizing that the indicator framework could be extensive, three key indicators were identified per goal theme as examples for this guide. An exhaustive list of indicators was considered to be less helpful in trials than a framework with key themes. The indicators were then reviewed by global experts as well as WRI and FAO subject matter experts. With the goals-based framework, we also focused on the importance of a relationship between the indicators and restoration interventions. While direct cause and effect is difficult to establish, some attribution needs to be demonstrable.

Although the goals-based framework resonated with many stakeholders, others preferred different entry points; for example, ecosystem benefits and services or environmental, social, or economic indicators. The frame of reference for different stakeholders varied depending on their background or goals. To some, the goals framework was not sufficient, therefore reorganizing the indicators into different entry points was an important factor.

The initial framework was then trialed in several countries, including those highlighted in the guide. Although the initial focus was to create indicators, it became clear that no one country had the same starting point. Whereas some wanted to start from the goals, others had already identified indicators and needed a method to prioritize; others were at a stage where they wanted an index. With these different cases in mind, the creation of the different indicator frameworks informed the development of the guide. It was clear that an indicator framework was just one element of a monitoring system.

The guide is now being developed concurrently with a web application.

During the review stage, this guide was further trialed by FAO partners so that the approach could be reviewed on the ground and feedback obtained to inform the final version.

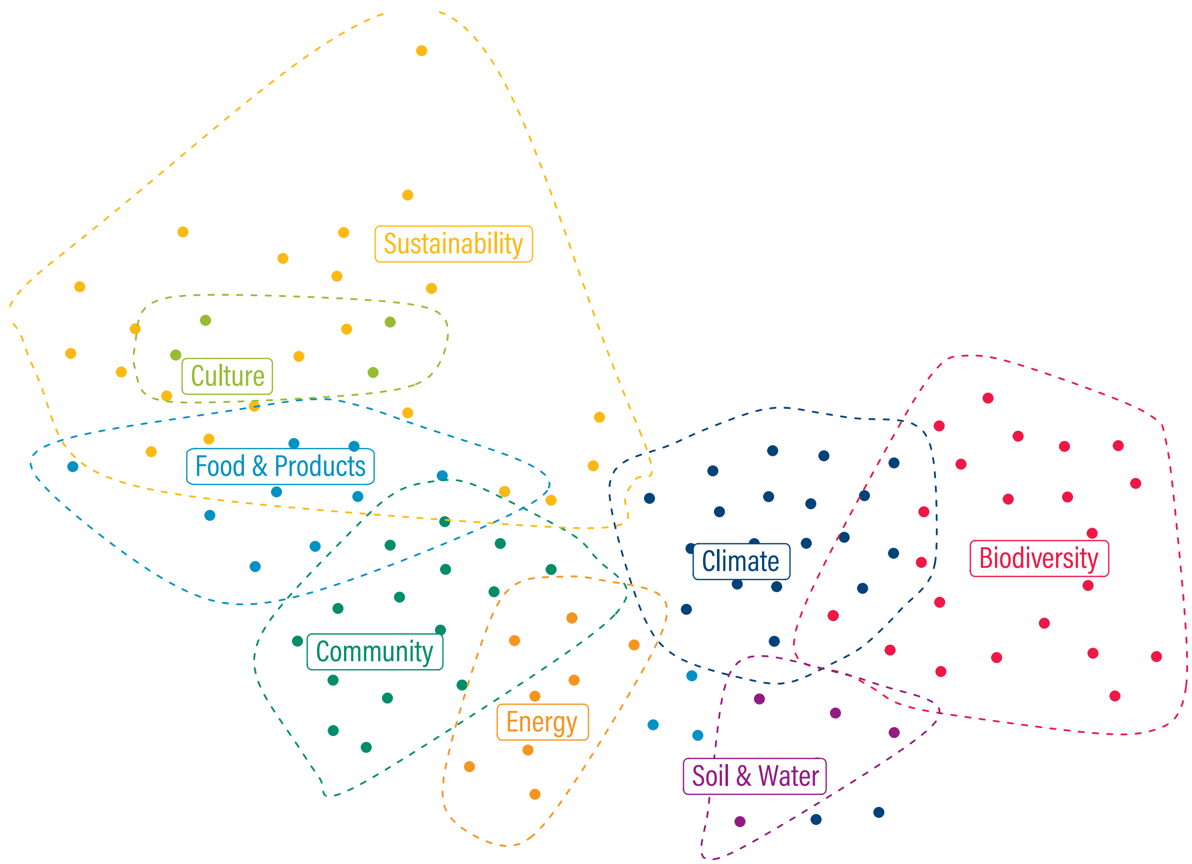
APPENDIX B: IDENTIFYING GOAL-THEMES AND SUB-THEMES FOR THE FRAMEWORK

To develop our sample framework of goal-themes and sub-themes, we evaluated them with machine learning and natural language processing to identify first whether any goals or sub-themes present in the surveyed literature are missing from the framework and second whether the placement of sub-themes and indicators within goals reflects how they are discussed in the literature. Neural word embeddings were used to quantify the semantic and ontological relationships between phrases and terms within all 119 restoration monitoring-related documents (Mikolov et al. 2013). The embedded hyperspace was projected to a flattened two-dimensional subspace with t-distributed stochastic neighbor embedding (t-SNE) and grouped with k-means clustering (van der Maaten and Hinton 2008; Donaldson 2016; R Core Team 2018). A label was assigned to each cluster by analyzing the underlying word distributions, which were matched to the terms and phrases used in the descriptions of each sub-theme and metric. This matching process resulted in the assignment of each cluster to a goal and sub-theme.

Figure B1 demonstrates that the eight goal-themes chosen for this framework are present in the literature and are generally distinct from each other. The neural embedding identified each of the present framework's goals. It did not identify additional groups of clusters that could be made into goals. This finding suggests that the identification and choice of the goals are consistent with the surveyed literature.

Neural word embeddings corroborate the placement of sub-themes and metrics within goals. For instance, Figure B2 shows that the clusters identified within the community goal are further disaggregated in space by their relevance to health, equity, and income. While each indicator has been placed into only one of these sub-themes, this representation demonstrates the fluidity of the sub-themes. For example, food and sanitation access bridge health and equity, while disease is specific to the health

Figure B1 | t-SNE Representation of the Clusters (Displayed as Dots) Assigned to Each of the Goals-Themes in the Framework

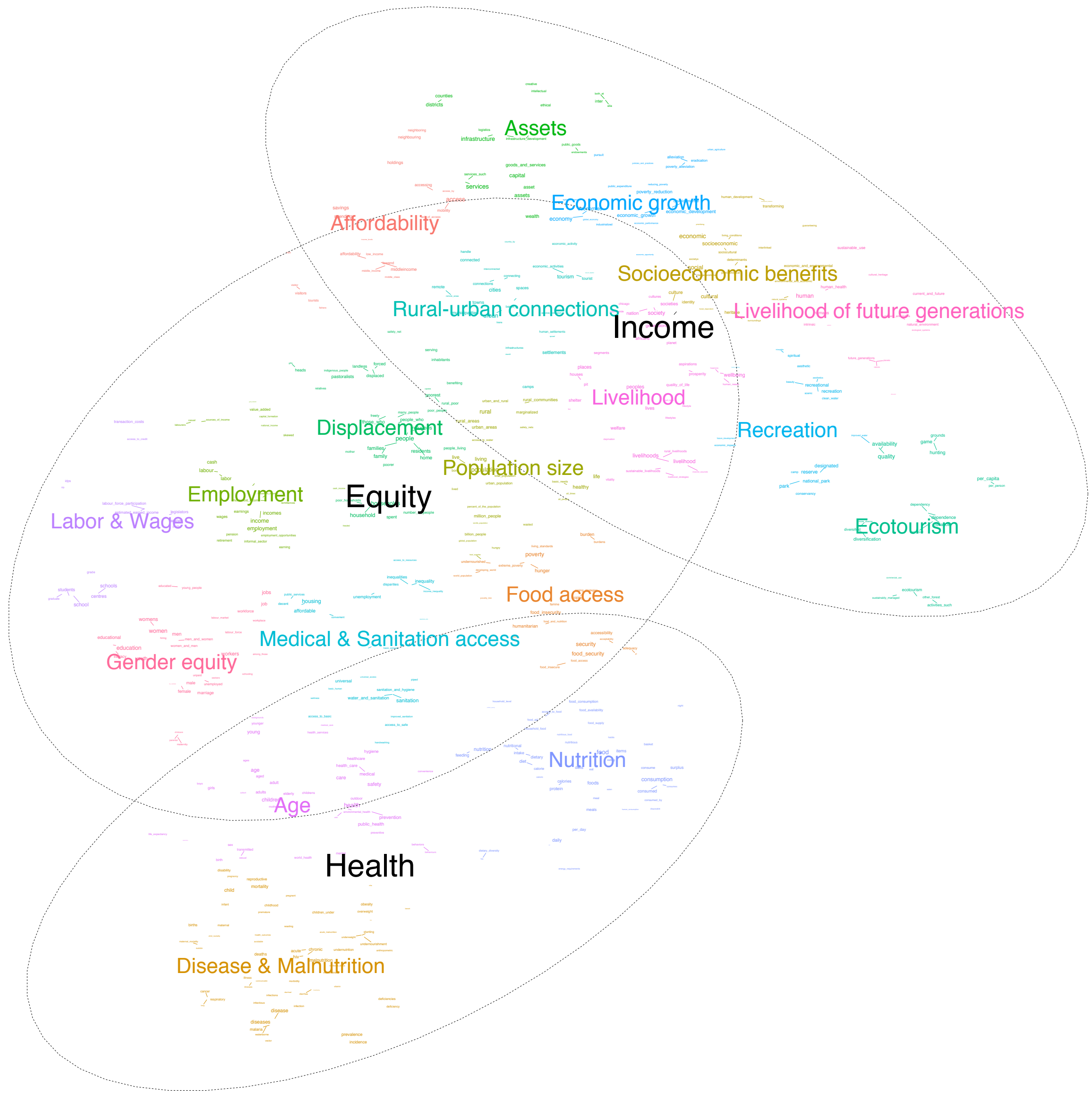


Source: Authors.

region. This granular look at the neural embeddings demonstrates that the framework's sub-themes are representative of each goal, and that no sub-themes present in the literature were not included in the framework.

While the goals and sub-themes were generally supported by the machine-learning approach, a number of different metrics were identified by the neural embeddings that are not included in the framework. For instance, genetic diversity is central to the cluster on food supply resilience within the climate goal. The guide's metric instead measures the number of crops cultivated, which is similar to genetic diversity but much more easily measured. Within the nutrition and food metric for the "Community" goal, the neural embeddings identify the importance of dietary diversity. We have instead placed this metric within Culture, as a measure of the number of households consuming traditionally cultivated foods on a regular basis. Finally, the neural word embeddings did not identify attitudes toward restoration as a metric present in the literature. It is likely that this literature gap is due to its intangibility and not its degree of importance, and we have included it because its quantification is integral to measuring restoration success.

Figure B2 | t-SNE Representation of the Underlying Word and Phrase Distributions for the "Community" Goal-theme, With Cluster Labels Grouped by Their Relevance to Each of the Three Identified Sub-Themes of Health, Equity, and Income



Source: Authors.

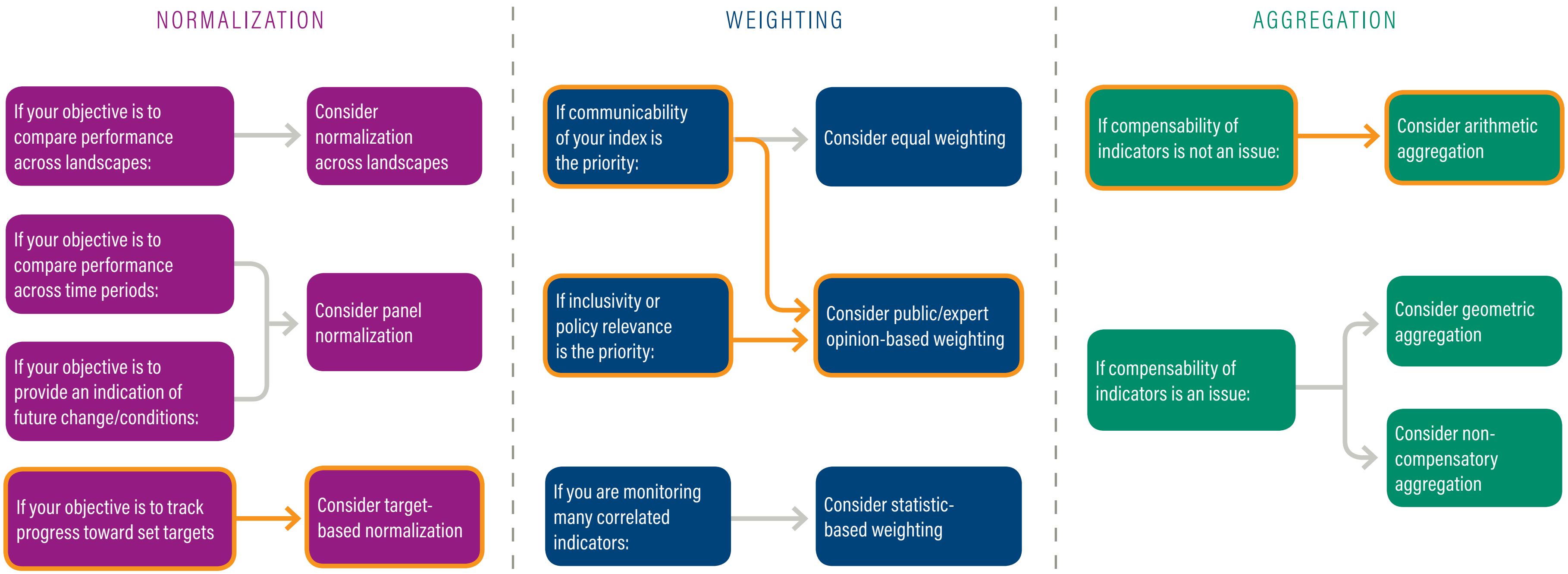
APPENDIX C: CONSTRUCTING A RESTORATION INDEX

More information is provided here on how to construct a restoration index. Practitioners may wish to integrate the information from multiple indicators into an index that provides a quick snapshot of the restoration program and landscape. This index allows practitioners to communicate the progress and impact of restoration to policymakers, donors, and the general public without having to delve into a discussion of multiple indicators and trends.

The methods practitioners choose to construct a sustainability index should be aligned with the objectives of the restoration index. Environmental and sustainability indexes are generally developed with the following objectives in mind (Saisana and Tarantola 2002; Singh et al. 2009):

- Compare performance across locations
- Compare performance across time periods
- Provide an indication of future change or conditions
- Provide an indication of progress toward set goals or targets

Figure C1 | Key Considerations for Normalizing, Weighting, and Aggregating Indicators



Note: El Salvador's objectives were to track restoration progress toward its policy targets in a straightforward and meaningful way. These objectives helped to guide its choices on normalization, weighting, and aggregation methods; El Salvador's choices are highlighted in bold outline.
Source: Authors.

Practitioners should consider the objective of their restoration index. With this objective in mind, practitioners can then think about other priorities and issues, and from there decide on the best combination of methods for normalizing, weighting, and aggregating. These are the three key steps that practitioners will need to take in order to integrate their selected indicators into an index for restoration:

Normalization: Indicators are expressed in a variety of units. Integration of different indicators requires normalization to a common frame of reference, such as a scale from 0 to 1.

Weighting: Indicators must be weighted to reflect their relative importance. Assigning weights can be a complicated process because it involves value judgments.

Aggregation: Normalized, weighted indicators must be combined to form the final index. How they are combined has implications for the compensability among indicators. Compensability refers to the fact that some highly ranked indicators can compensate for (i.e., offset) low values assigned to other indicators, affecting the value of the index. This can be overcome by using the geometric average that considers each indicator critical.

These steps have been simplified for a general audience. Figure C1 summarizes how key considerations may affect practitioners' choice of methods for normalization, weighting, and aggregation. Tables C1 to C3 provide more details and examples of indexes that use each method.

Table C1 | Methods for Normalizing Indicators

METHOD	DESCRIPTION	ADVANTAGES	DISADVANTAGES	EXAMPLES
Ranking indicator performance across landscapes	If multiple landscapes are being monitored with the same set of indicators, each indicator can be normalized by ranking all the measurements of all landscapes in order of performance. For each indicator, the highest performing measurement(s) can serve as the upper bound for normalization, and vice versa.	The approach is simple and easy to understand. It allows for meaningful comparisons between landscapes.	Performance over time may not be captured. For example, an indicator for one landscape could show improvement but be reflected in the index as worsening if other landscapes improve faster.	USAID Monitoring Country Progress, SDG Index
Panel normalization	If measurements from multiple time periods are available, each indicator can be normalized by ranking all the measurements of the time steps in order of performance. For each indicator, the highest performing measurement(s) can serve as the upper bound for normalization, and vice versa.	The approach is simple and easy to understand. It allows for meaningful comparisons over time for a given landscape.	As new measurements are added, the maximum or minimum measurement for an indicator may change, shifting the upper or lower bound for normalization. The old index scores must then be recalculated.	Living Planet Index, Red List Index
Target-based normalization	If target values have been set for each indicator, these can serve as the upper bounds for normalization while baseline measurements (or an arbitrary value) can serve as the lower bound.	This approach is simple and easy to understand. It allows the user to analyze progress toward targets.	Targets are set according to subnational, national, or international policy goals, or according to scientific thresholds. However, these targets may be arbitrary, unrealistic, or too easy to achieve.	Human Development Index, Environmental Performance Index

Source: Authors.

Table C2 | Methods for Weighting Indicators

METHOD	DESCRIPTION	ADVANTAGES	DISADVANTAGES	EXAMPLES
Equal weighting	All indicators are treated as equally important and are given the same weights.	Most straightforward approach, especially if there is no political consensus or empirical/ statistical evidence for choosing a different scheme.	This approach assumes that there are no interactions between indicators and runs the risk of double counting if two highly correlated indicators are both weighted equally.	USAID Monitoring Country Progress, SDG Index, Living Planet Index, Human Development Index
Statistic-based weighting	Various statistical methods, like principal components analysis, factor analysis, data envelopment analysis, regression analysis, or unobserved component models, can be used to assign weights to indicators based on statistical characteristics of the data.	Minimizes the risk of double counting. This approach is especially useful when many indicators are involved.	This type of weighting can be complex. It may be difficult to follow how an indicator is assigned a specific weight.	Environmental Sustainability Index
Public/expert opinion-based weighting	The participating public or experts make judgments on how to allocate weights to indicators based on importance. This can be done through opinion polls, budget allocation, analytic hierarchy processes, or conjoined analysis.	The approach is simple and easy to understand. It is also more transparent and inclusive.	Relies on subjective value judgments.	Environmental Performance Index, Index of Environmental Friendliness

Source: Authors.

Table C3 | Methods for Aggregating Indicators

METHOD	DESCRIPTION	ADVANTAGES	DISADVANTAGES	EXAMPLES
Additive aggregation	Normalized and weighted indicators are summed up, or aggregated using a weighted arithmetic mean.	This is the most straightforward approach.	This approach assumes that there are no interactions between indicators. In addition, high performance in one indicator can compensate for low performance in another (i.e., complete compensability).[a]	SDG Index, Environmental Performance Index
Geometric aggregation	Normalized and weighted indicators are multiplied together, or aggregated using a weighted geometric mean.	Fairly straightforward, and partially addresses the issue of compensability.	Geometric methods reduce – but do not remove – compensability among indicators.	Living Planet Index, Human Development Index
Non-compensatory aggregation	Techniques such as multi-criteria analysis can be used to aggregate indicators.	There is no compensability between indicators. Useful for situations where no compensation of performance between indicators is acceptable.[a]	Complex and computationally intensive to calculate.	Index for "Social Multi-Criteria Evaluation"

Note: [a] With additive aggregation, a landscape that performs very well in one indicator but very poorly in another would appear to be doing similarly to a landscape with moderate performance across the board. Non-compensatory aggregation can be used to eliminate this compensatory effect.
Source: WRI.

Methods for normalizing, weighting, and aggregating are not mutually exclusive. Practitioners can apply multiple methods in each of these steps, depending on the structure of their index. For example, the Environmental Performance Index (EPI) uses a hierarchical structure. It tracks 24 indicators, which are aggregated into 10 issue categories and then aggregated into two main policy objectives: Environmental Health and Ecosystem Vitality (Hsu et al. 2016). These two main objectives are ultimately aggregated to form the overall index score. In this structure, there are multiple levels of normalizing, weighting, and aggregating. For instance, weights are assigned to each indicator, each issue category, and each policy objective. Different weighting methods are used for each of these levels. Although the EPI uses the same target-based normalization method for all of its indicators and the same arithmetic aggregation method at all levels, multiple normalization and aggregation methods could have been used as well.

For further guidance on indicator construction, practitioners may refer to the following sources:

- Gan et al. (2017) provide more in-depth information on weighting and aggregation methods in "When to Use What: Methods for Weighting and Aggregating Sustainability Indicators."
- The EPI methodology clearly demonstrates how normalizing, weighting, and aggregating methods can be used in a hierarchical index structure (Hsu et al. 2016).
- The Competence Centre on Composite Indicators and Scoreboards provides a useful 10-step guide for constructing an index. It goes beyond normalizing, weighting, and aggregating methods to provide advice on how to perform sensitivity analyses and communicate index results through suitable visualization techniques (CCCIS 2019).

APPENDIX D: BACKGROUND INFORMATION FOR THE MENU OF INDICATORS

Each goal-theme highlights three sub-themes, and indicators for each of these sub-themes are numerous. The sub-themes underwent significant iterations and revisions over a period of three years. The Collaborative Roadmap for Restoration Monitoring working group provided feedback, and the framework was presented in numerous FAO meetings and workshops in Rome and Agadir. Expert review and natural language processing were used to identify the final categories. Under the categories, it was important to discuss with experts which indicators would be best to measure restoration's success and specifically the relative attribution that could be given to restoration activities. Although the indicators in this guide are based on peer review, practioners should use them only as a guide and create their own indicators and sub-themes as necessary.

Tables D1–D9 summarize our recommendations for climate, soil, water, biodiversity, culture, community, food & products, energy, and sustainability indicators.

Climate Indicators

Restoration is an important strategy for climate change mitigation and adaptation. It generally increases the productivity of landscapes, which helps to sequester carbon in biomass and soils. It can also improve ecosystem health and create livelihood opportunities for forest-dependent communities, enhancing the capacity of landscapes to respond to climate-related shocks and stressors.

Indicators for climate are split among three sub-themes: mitigation, adaptation, and resilience. Mitigation indicators focus on the amount of carbon sequestered through biomass accumulation and increasing soil organic carbon. Adaptation and resilience indicators both focus on the vulnerability of communities in the landscape to climatic stresses, but from different approaches. As adaptation traditionally has been focused on the ability of actors to cope with specific environmental stresses, adaptation indicators deal with specific areas of vulnerability, like food, water, and energy insecurity, and the effects of natural disasters (Nelson et al. 2007). In contrast, resilience is more concerned with systems and the capacity to absorb perturbations (Nelson et al. 2007). Resilience indicators therefore focus on how information is shared and acted upon within communities and on the options available to community members when faced with environmental change.

Adaptation is also often approached from a biophysical perspective that identifies how ecosystems and landscape functions can be improved to reduce vulnerability. Such approaches tend to focus on restoring and monitoring the hydrology, nutrient cycling, soil function, and biodiversity of a landscape (Stanturf et al. 2017). However, other parts of the framework address this aspect of adaptation and will not be covered here.

Table D1 | Recommendations for Climate Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC	BENEFITS	LIMITATIONS	ALTERNATIVE METRIC
Mitigation	Biomass and carbon sequestration	Aboveground biomass stock and soil organic carbon	High quality and proximity	Moderate to high cost and expertise required	Estimated sequestered GHG emissions
Adaptation	Impact of shocks and stresses	% of people experiencing food shortage	Higher proximity, low cost	Not directly related to natural disaster events/weather	Proportion of population affected by natural disasters
Resilience	Capacity to deal with shocks and stresses	Existence of local risk reduction strategies	High quality, low cost	Lower proximity to restoration interventions	Share of production of top three crops

Source: Authors.

Soil Indicators

The restoration of forests and trees improves soil. Root systems, understory growth, and leaf litter help to stabilize the soil, promoting infiltration and water storage while also preventing surface sealing and soil loss through erosion. They also improve chemical and biological soil health by promoting the accumulation of organic matter and nutrients. These improvements in soil quality and stability are some of the most important outcomes of restoration because they can enhance agricultural production and increase food security.

Indicators for soil are divided among three sub-themes: quality, stability, and management. Indicators for quality help to monitor the effect of restoration interventions on the chemical and biological health of soil, while indicators for stability help to monitor effects on physical structure. Management indicators help to monitor how soil conservation practices are implemented. This guidebook summarizes the process used to identify and assess indicators and makes recommendations for the best indicators to measure progress toward these three sub-themes.

Table D2 | Recommendations for Soil Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC	BENEFITS	LIMITATIONS	ALTERNATIVE METRIC
Quality	Soil health	Soil organic carbon	Very high quality and proximity	High cost and expertise required	Faunal density and richness
Stability	Soil compaction and permeability	Infiltration and percolation rate	High quality and proximity, low cost	Some expertise required	Sediment level in reservoir
Management	Use of soil conservation practices	% of farmers using practices	High quality, low cost and effort	Dependent on survey frequency	Capacity to implement soil conservation practices

Source: Authors.

Water Indicators

Improving the quality and quantity of water is one of the foremost reasons why countries pursue restoration. Restoration interventions help reduce surface runoff and erosion, which controls the amount of sediment and pollutants that flow through the watershed (Hamilton 2008). The effect of restoration interventions on water quantity is less clear, however. Forests are intensive users and interceptors of water, and restoration interventions that increase tree cover will reduce surface water availability. However, by promoting infiltration, interventions may help to renew groundwater supplies that would benefit communities in times of low rainfall and surface water availability, thus redistributing water supply across seasons (Hamilton 2008; Filoso et al. 2017).

Water indicators are broken down into three sub-themes: quality, quantity, and management. While indicators for quality and quantity measure the impact of restoration interventions, indicators for management monitor the process of implementing restoration interventions specific to water. This guide summarizes the process used to identify and assess indicators, and makes recommendations for the best indicators to measure progress under these three sub-themes.

Table D3 | Recommendations for Water Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC	BENEFITS	LIMITATIONS	ALTERNATIVE METRIC
Quality	Sediment in water	Sediment level in reservoir	Watershed scale, low cost and effort	Requires presence of reservoir	Turbidity
Quantity	Water balance	Streamflow and baseflow (hydrograph)	Watershed scale, high quality	Moderate to high cost and expertise required	Infiltration and percolation rates
Management	Use of water conservation practices	% of farmers using practices	High quality, low cost and effort	Dependent on survey frequency	Proportion of buffer zones with vegetation

Source: Authors.

Biodiversity Indicators

Biodiversity enhances the capacity of landscapes to adapt and it supports the provision of ecosystem services (Larsen et al. 2012; Thompson et al. 2014). Restoration is increasingly seen as a way to capitalize on these benefits, and to meet global biodiversity commitments such as the Aichi Targets (IUCN 2017; Benayas et al. 2009).

In the past, the field of conservation largely operated on the species level, targeting threatened species and species-rich hotspots for protection. However, there is increasing recognition that these efforts are too limited in scope. More recent approaches have sought to broaden this scope, incorporating genes, ecosystems, and landscapes into conservation efforts (Poiani et al. 2000; Jones 2011). With that in mind, indicators for biodiversity are split among three sub-themes: quality, connectivity, and protection. Indicators for species and protection focus on more traditional methods to monitor progress in biodiversity, while indicators for connectivity focus on how well restoration interventions are providing the linkages and landscape complexity needed for effective biodiversity conservation.

Table D4 | Recommendations for Biodiversity Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC	BENEFITS	LIMITATIONS	ALTERNATIVE METRIC
Species	Community composition	Abundance of indicator species	Low cost and difficulty	Success depends on choice of indicator species	Living Planet Index, Red List Index
Protection	Protected area coverage	Area of key biodiversity areas protected	High quality, proximity	KBAs may not be defined in landscape	Protected area coverage
Connectivity	Connection between habitats	Mean nearest distance between blocks of a particular habitat type	Low cost and difficulty	Does not account for intrapatch connectivity	Connectivity indices for habitat patches

Source: Authors.

Culture Indicators

The knowledge, value, and tenure systems of many local communities are linked to the physical landscape (Freudenberger 2013). Restoration changes the landscape, and thus has the potential to affect these arrangements. By promoting and conserving healthy landscapes, restoration can help preserve cultural systems and practices if the land-culture relationships of local communities are taken into account (Woodley et al. 2009). However, If implemented in a top-down fashion without stakeholder input, restoration interventions can lead to the erosion of these relationships. Culture is thus an important goal in monitoring that can help align restoration interventions with existing cultural practices.

Cultural indicators are divided among three sub-themes: practices, values, and rights. Indicators for practices assess how traditional, indigenous, or local knowledge, innovations, and practices are being used in the landscape. Indicators for rights focus on the ability of community members to access land and natural resources. This is especially important, as the plurality of formal and informal tenure systems in many regions has often created uncertainty and conflict that undermine development and governance efforts (Unruh 2008). Lastly, indicators for values assess how people perceive restoration efforts.

Table D5 | Recommendations for Culture Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC	BENEFITS	LIMITATIONS	ALTERNATIVE METRIC
Practices	Use of knowledge, innovations, and practices	Proportion of people fluent in local language	Easy and affordable proxy for other practices, aligned with Aichi target indicator	Not a direct measure of practices used in landscape	Area of sacred/cultural land protected
Values	Perception of restoration	Proportion of population that perceives restoration as beneficial	Low cost and difficulty	Dependent on survey quality	% engaging in restoration activities
Rights	Land and natural resource tenure	Proportion with perceived land tenure security	Low cost and difficulty, high proximity	Does not measure official use rights or tenure	% of land with officially designated use rights

Source: Authors.

Community Indicators

Forest landscape restoration is not only about regaining ecological functionality, but also about improving the well-being of people who depend on the landscape. This means that restoration must happen in a way that creates sustainable economic benefits and livelihood options.

Indicators for community center on the tangible economic and health benefits that restoration creates for people. They are split into three sub-themes: income, equity, and health. While income and equity both focus on the economic benefits brought about by restoration, indicators for income measure absolute gains while indicators for equity assess how these gains are shared within the community. Indicators for health examine the public health impacts of restoration.

Table D6 | Recommendations for Community Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC	BENEFITS	LIMITATIONS	ALTERNATIVE METRIC
Income	Economic benefits from restoration	Income from restoration-related activities	Low cost, high proximity	May be difficult to measure	Number of people employed in restoration-related activities
Equity	Restoration benefits for women and marginalized communities	Yield of non-timber forest products	Low cost and difficulty, high proximity	May not apply in all communities	Reduction in energy and water burden
Health	Improvements in nutrition	% of people experiencing food shortage	Low cost and difficulty, high proximity	Narrowly focused on nutrition	Child mortality rate

Source: Authors.

Food & Products Indicators

Restoration improves the health of the landscape, whether by improving soil fertility, reducing erosion, or promoting species diversity. Healthier landscapes are more productive, yielding greater quantities of forestry products, non-timber forest products, and crops that benefit local communities. But communities must also have adequate access to markets, credit, and insurance to fully reap these benefits. As such, indicators for products measure not only yield increases, but also access to markets and finance.

Table D7 | Recommendations for Food & Products Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC	BENEFITS	LIMITATIONS	ALTERNATIVE METRIC
Yield	Products harvested	Volume of products harvested, by type	High proximity	May be difficult to measure or estimate accurately	Net primary productivity / NDVI of productive land
Market	Access to markets	Producer's share of final price	Low cost, directly measures benefits	May be difficult to measure	Time to market
Finance	Access to financial services (credit, insurance, etc.)	Proportion of households accessing financial services	Low cost and difficulty	May be difficult to measure	Number of financial institutions

Note: NDVI: normalized difference vegetation index.
Source: Authors.

Energy Indicators

In many regions of the world, communities depend primarily on woodfuel as an energy source for cooking and heating (Rehfuess et al. 2006). Demand for woodfuel can lead to the degradation of forest reserves (Palmer and Macgregor 2009). Restoration interventions can ameliorate this degradation and improve energy security by providing woodfuel sources in the form of sustainably managed woodlots and on-farm trees (Ndayambaje and Mohren 2011).

Indicators for energy are broken down into three sub-themes: quantity, scarcity, and management. Indicators for quantity aim to quantify the amount of woodfuel being produced, while indicators for scarcity assess whether this woodfuel is sufficient in meeting local energy needs. Indicators for management examine the sustainability of the sources of these woodfuels.

Table D8 | Recommendations for Energy Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC	BENEFITS	LIMITATIONS	ALTERNATIVE METRIC
Quantity	Woodfuel produced	Quantity of woodfuel produced	Low cost, high proximity	May be difficult to get accurate estimates	Number of people harvesting wood for fuel
Scarcity	Extent of energy needs being met	Energy burden	Most sensitive to scarcity, low cost and difficulty	May reach a threshold time	Proportion of households using non-wood biomass (crop residues, animal dung) for fuel
Management	Sustainable sourcing of energy	% of households with access to sustainable energy	Low cost, high proximity	May be difficult to get accurate estimates	Number of woodlots and on-farm trees

Source: Authors.

Sustainability Indicators

Restoration is a long-term process. To become sustainable, restoration efforts must account for drivers of landscape degradation and governance factors. Indicators for sustainability are split into three sub-themes: disturbance, enforcement, and engagement. Indicators for disturbance examine the incidents and activities that may drive degradation and impair restoration efforts within the landscape. Indicators for enforcement address whether the legal system is adequately restricting harmful activities. Indicators for engagement gauge the level of commitment to restoration.

Table D9 | Recommendations for Sustainability Indicators

SUB-THEME	EXAMPLE INDICATOR	EXAMPLE METRIC
Disturbance	Unplanned disturbances within the restoration area	Area and type of disturbance
Enforcement	Existence and application of legal rules	Number of illegal incidents
Engagement	Funding for restoration activities	Amount of funds allocated

Source: Authors.

ENDNOTES

1. With all commitments each country has a different starting point. The expectation is that countries will have identified areas to be under restoration by the year deadlines, not that land will have been restored by this date.

2. Convention on Biological Diversity. "TARGET 15 - Technical Rationale extended (provided in document COP/10/INF/12/Rev.1)." https://www.cbd.int/sp/targets/rationale/target-15/. Accessed September 23, 2019.

3. More information on each initiative can be found on their respective websites.
   For Bonn Challenge: http://www.bonnchallenge.org/.
   For New York Declaration on Forests: http://forestdeclaration.org/.
   For Initiative 20x20: http://initiative20x20.org/.
   For AFR100: http://afr100.org/.
   For the Agadir Commitment: https://www.unccd.int/sites/default/files/inline-files/9-Agadir-commitment-en.pdf.
   For APEC: http://www.fao.org/in-action/forest-landscape-restoration-mechanism/resources/detail/en/c/412443/.

4. FAO, CILSS, GPFLR, GM UNCCD, UNCCD, ICRAF, IUCN, UNEP, World Bank, and WRI organized a Monitoring Week at FAO headquarters in Rome, Italy, in 2016.

5. An earlier version of this guide was used at the national level in Malawi, but used a landscape approach with other country examples.

6. Also known as an indirect indicator. It is an indirect sign or measure that can approximate or be representative of a phenomenon without the presence of a direct sign or measure. https://thelawdictionary.org/proxy-indicator/.

7. The Kenya Water Towers Agency (KWTA) is a State Corporation under the Kenyan Ministry of Environment and Forestry, established in 2012. The Agency coordinates and oversees the protection, rehabilitation, conservation, and sustainable management of critical water towers in the country. Water towers are upland forested areas that provide much of the country's freshwater.

8. Other sub-themes could be chosen. The guide aims to simplify the process of choosing indicators by identifying three key sub-themes for every goal-theme. These three sub-themes are not the only available options.

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ABOUT FAO

The Food and Agriculture Organization (FAO) is a specialized agency of the United Nations that leads international efforts to defeat hunger.

Our goal is to achieve food security for all and make sure that people have regular access to enough high-quality food to lead active, healthy lives. With over 194 member states, FAO works in over 130 countries worldwide.

ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity and human well-being.

Our Challenge

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

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