The assessment report on

LAND DEGRADATION AND RESTORATION

CHAPTER **8**

DECISION SUPPORT TO ADDRESS LAND DEGRADATION AND SUPPORT RESTORATION OF DEGRADED LAND

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EXECUTIVE SUMMARY

Decision-making on land degradation avoidance and restoration strategies requires an analysis and accessible information. Such an analysis can allow comparison between relative long-term and short-term merits of plausible options for a particular socio-ecological system *(well established)*. Decisions on feasible options are more likely to reach their goal when guided by scientific scrutiny of the risks, costs and benefits, social and environmental fulfillment associated with each of the available options and climate change scenarios {8.2.1, 8.2.2}. Degradation mitigation and restoration responses are, however, constrained by availability of resources, technologies, knowledge of the system and institutional competencies {8.2.2, 8.3}.

Although conceptual frameworks for combatting land degradation and enabling restoration exist, current knowledge, information and tools cannot seamlessly support the complete process of evidence-based decision-making *(well established)*. The use of tools and the associated data require close cross-disciplinary collaboration and enabling conditions. Monitoring strategies, verification systems, adequate baseline information and data are needed to measure, understand, design, implement and adapt decisions on land degradation avoidance and restoration. Currently, most decision support tools are mainly focused on assessing the biophysical state of the land; more-integrated tools that combine socio-economic and biophysical variables are needed to capture social-ecological interactions and impacts and are being developed {8.2.1, 8.2.2, 8.2.3, 8.3.5}.

Institutional competencies and policies are key drivers of land degradation and restoration *(established but incomplete)*. Building an adequate set of institutional competencies is a crucial first step to design, implement and combine efficient policy instruments {8.3.1, 8.3.2, 8.3.3, 8.3.4, 8.3.5, 8.3.6}. Robust science to evaluate the impact and efficiency of different institutional competencies and strategies in mitigating land degradation and developing restoration is still in its infancy {8.3}.

Institutions able to apply and align diverse policy instruments are more likely to mitigate land degradation and promote land restoration *(established but incomplete)*. To design, implement, select and align policy instruments (including legal, regulatory, financial, cultural and technical measures), different institutional competences are required {8.3}. Economic instruments like payments for ecosystem services and biodiversity offsets are efficient in theory, but require a set of institutional capacities to deliver expected outcomes {8.3.1, 8.3.3, 8.3.6, 8.4.3}.

Evidence shows that customary practices and indigenous and local knowledge are used within local, tribal or indigenous communities for sustainable land management *(well established)*. Formalizing customary practices requires the adaptation of policies based on multi-stakeholder participatory approaches towards restoration of degraded lands. The use and development of community protocols can play an important role in advancing the respect of customary norms in formal decision-making {8.3.2.3}. Participatory and stakeholder engagement approaches can lead to co-development of restoration responses and jointly agreed prioritizations, making it easier to identify opportunities for collaborative responses that harness synergy {8.2.2, 8.3.4}.

To address multiple environmental and social challenges as well as harnessing synergies, restoration decisions and strategies to combat land degradation must be well aligned to ensure impact within other decision-making areas *(well established)*. For example, national-level decisions seeking to ensure availability of adequate food - through the reduction of land degradation - need also to consider the impacts of the selected strategies on the achievement of policy goals targeting (e.g., water, energy and shelter for the growing population at other scales). Tools and approaches are available to assess coherence between policy areas. Reducing trade-offs, enhancing alignment and harnessing synergies among decision-making areas requires institutional coordination, multi-stakeholder engagement and the development of governance structures that bridge different ministries, types of knowledge, sectors and stakeholder groups {8.4.2, 8.4.3}.

Effective responses to land degradation can simultaneously contribute towards multilateral environmental agreements and goals including the Aichi Biodiversity Targets, the Sustainable Development Goals, the Ramsar Convention and climate change-related agreements such as the Paris Agreement and REDD+ *(well established)*. Taking a multi-level approach towards preventing and reducing land degradation, and restoring degraded areas offers the potential to deliver benefits at various spatial and/or institutional levels, as well as working across a number of policy areas and stakeholder groups {8.4.1}. While these policies seek to ensure good quality of life and that national growth is supported, they sometimes fuel land degradation, which over time reduces productivity – leading to higher demand for more land and can increase deforestation with negative impacts on climate {8.4.1, 8.4.2}.

8.1 INTRODUCTION

In this chapter we consider how decisions are made to halt land degradation and restore the degraded lands, including actions to prevent, reduce and/or mitigate the processes of land degradation and to rehabilitate or restore degraded land. Decision makers operate across spatial levels ranging from local to international level, and can be part of different entities like international agencies, regional consortiums, national or local governments or even a farm. The decisions they make require knowledge and information about the resource and the tools available to address land degradation, institutional competencies to implement the decision, and an enabling environment. In light of the above, it should be noted that decisions to halt land degradation and restore degraded lands do not operate in isolation. They interact with other policy areas at regional, national and international level.

Decision making is a process not a single act in time and it does not follow strict sequential steps (Mintzberg *et al.,* 1976). In a decision making process, problems and objectives are normatively described and agreed upon, appropriate actions are explored, and actions are put in place and evaluated (Cowling *et al.,* 2008; Reed & Dougill, 2010a; Simon, 1986). At all stages, information, knowledge and/or tools are used by the decision maker.

Decision support tools and methods particularly support the normative understanding and evaluation of trade-offs throughout the decision-making process, be it for an individual or groups of decision makers. Decision support tools are approaches and techniques based on science and other knowledge systems that can inform, assist and enhance decision-making and policymaking (IPBES, 2016a). A decision support tool aims to capture the trade-offs (Ackoff, 1981) between often nested, chained and poorly structured decision problems that can be wicked in nature (Rittel & Webber, 1973). In this chapter, we do not synthesize various theories of planning, decision and policy processes. We provide guidance in choosing and using decision support tools.

Decision makers can opt to use one or more policy instruments to achieve the decided upon goals for land degradation and restoration strategies. These include legal, financial, and cultural instruments (see Chapter 6). To design, select, and implement a policy instrument, institutional competencies are needed. Institutional competencies are the set of abilities which a given institution can use to achieve policy goals. Institutions encompass formal and informal social interactions and structures that determine how decisions are taken and implemented, and how responsibilities are distributed (IPBES, 2015a).

Land degradation and restoration is a cross-cutting issue. It influences the delivery of various ecosystem services that are essential for human well-being and a good quality of life (see Chapter 5). Various policy areas influence land degradation or enhance possibilities to address land degradation and develop restoration actions. These include climate change adaptation, biodiversity and ecosystem conservation and use, pollution, invasive alien species and disease management, infrastructure development, and flood risk and water resource management. Efforts to avoid and reverse land degradation will require the identification of synergy or trade-offs of multiple policy areas, and evaluating the possible outcome of a decided action.

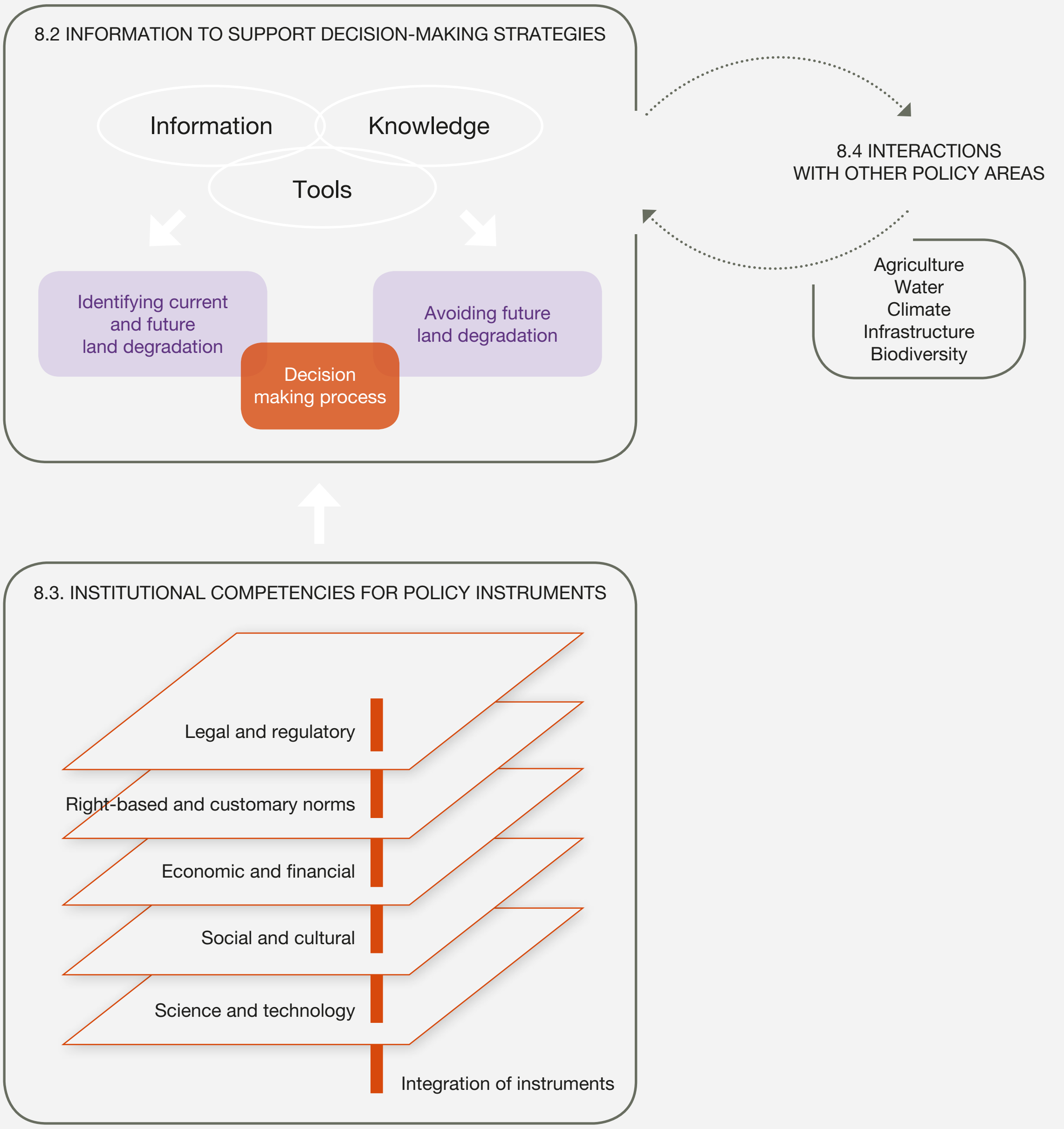
As such, decision making strategies and policies to avoid land degradation and restore degraded land will depend on: (i) available information; (ii) institutional competencies to design and implement policy instruments; and (iii) influences of other policy areas.

Therefore, in this chapter, we consolidate information and tools necessary to support evidence-based decision-making for policy makers and practitioners responsible for selecting and implementing strategies to halt and reverse land degradation. We also assess institutional competencies necessary in the detection and analysis of land degradation problems, and the design, implementation, management and monitoring of response strategies. In the final section of this chapter, we place land degradation problems and potential restoration solutions within the wider policy context and describe other indirect drivers which can also be root drivers of both land degradation and land restoration. We consider interactions between land degradation, restoration and other major policy areas addressing agriculture, water, climate, infrastructure, and biodiversity. Where possible, we endeavor to separate information related to decision making levels and entities.

This chapter is structured in three main sections (Figure 8.1), which include an assessment of evidence on:

i. **Information, knowledge and tools** decision makers need to develop strategies on land degradation and restoration (8.2)
ii. **Institutional competencies** to design and implement strategies on land degradation and restoration, with a specific focus on national level actions and abilities (8.3)
iii. **Interactions between policies to halt land degradation and restore degraded lands, and other major policy areas** (8.4)

Figure 8 1 **Restoration decision-making addressed in the three sections of Chapter 8.**



8.2 INFORMATION TO SUPPORT DECISION-MAKING STRATEGIES ON LAND DEGRADATION AND RESTORATION

In this section, we focus on decision-making needs regarding information, knowledge and tools to identify land degradation problems (see Section 8.2.1), restorations solutions (see Section 8.2.2) and requirements for seamless-use of information, knowledge and tools throughout the different phases of the decision-making process (see Section 8.2.3). We address decision-making as a process over time as opposed to a single, discreet moment in time. Throughout the process, different questions need to be addressed which require insight into both biophysical and social systems.

8.2.1 Information, knowledge, and decision support tools available to identify land degradation problems

Empowering decision- and policy-makers with the spatial and temporal knowledge on the extent and severity of land degradation (see also Chapter 4) is essential to choose and implement adequate response actions. Effective decision support tools are of paramount importance to address land degradation problems. Decision support tools are approaches and techniques based on science and other knowledge systems that can inform, assist and enhance decision-making and policymaking (IPBES, 2016a). Decision support tools can provide insight into the extent and severity of land degradation and possible future alarming scenarios influencing decision makers to initiate conservation or restoration initiatives. A response process to halt or reverse land degradation is more effective when the problem assessment is carried out in a participatory way (Borrini-Feyerabend *et al.,* 2000; Bousquet *et al.,* 2007; de Vente *et al.,* 2016). Specifically, stakeholder participation can increase the likelihood that environmental decisions are perceived to be holistic and fair, accounting for a diversity of values and needs and recognizing the complexity of human-environmental interactions (Richards *et al.,* 2004). It may also promote social learning (Blackstock *et al.,* 2007; Reed *et al.,* 2008). Multi-scale approaches – making use of common indicators and a variety of information sources including scientific data and local knowledge through participatory methods – allow cross-scale analyses and there is established and documented evidence based on local experiments for decision-makers at various levels (Schwilch *et al.,* 2011). A study from southern Africa shows that local land managers participate in the collection and reporting of data, especially when tangible benefits come out of this process (Reed *et al.,* 2011). In this section, we describe decision support tools and their related information and knowledge sources which can support decisions makers in identifying and mapping current and future land degradation problems.

8.2.1.1 Identifying and mapping current land degradation

A range of decision support tools are available for assessing land degradation elements, such as: accelerated soil erosion; landslides; deforestation; problems of water logging, salinity and alkalinity; sea water encroachment; wind erosion; forest fire; declining soil fertility and crop yield; water scarcity; soil compaction and crusting; increases in wasteland; overgrazing; invasion of alien weeds; chronically drought- and flood-prone areas. Common technologies used in decision support are databases and look-up tables, geographical information systems (GIS), remote sensing, computer-based simulation models, knowledge-based or expert systems and hybrid systems. The methods behind these decision support tools employ qualitative or quantitative measures to assess the severity of land degradation and enumerate degradation footprints. Here we describe the functionality of the most commonly used qualitative and quantitative land degradation assessment tools per spatial level (and see **Table 8.1**). This Section does not cover all available decision support tools, as they are compiled on the online IPBES Policy Support Tools and Methodologies catalogue (https://www.ipbes.net/policy-support).

At the global level, and to some extent at regional levels, tools like GLASOD (Bridges & Oldeman, 1999; Jones *et al.,* 2003; Oldeman *et al.,* 1990), GLADA (Bai *et al.,* 2008; Bai & Dent, 2006), LADA (Koohafkan *et al.,* 2003), are available to describe the distribution and intensity of degradation and to identify where degradation has been halted or reversed (see **Table 8.1**, all full names of the tools are listed there). GLASOD provides expert judgement on land degradation and can be used to raise the awareness of policymakers and governments for the continuing need for soil conservation (Bridges & Oldeman, 1999). ASSOD (Van Lynden *et al.,* 1997) is a more detailed tool, but has a strong regional affiliation to South and Southeast Asia. The NFPA (Borucke *et al.,* 2013; Weinzettel *et al.,* 2014) is a tool based on the concept of "bio-capacity". The tool calculates the amount of biologically-productive land and sea area available to provide the resources for a given population and absorb its wastes - with its current state of technology and management practices. Countries differ in the productivity of their ecosystems and this is reflected in the accounts. IMAGE (Hootsmans *et al.,* 2001; Stehfest *et al.,* 2014) is an integrated ecological-environmental model framework that simulates the environmental consequences of human activities at spatial levels (global or national level). IMAGE represents interactions between society, the biosphere and the climate system to assess sustainability issues such as climate change, biodiversity and human well-being. The objective of the IMAGE model is to explore the long-term dynamics and impacts of global changes that result from interacting socio-economic and environmental factors, and are therefore data intensive. One of its components assesses the loss in soil productivity as a result of human-induced land degradation, its effect on the carbon cycle, nutrient balance and crop productivity. The global IUCN Red List (IUCN, 2017) presents the extinction risk of thousands of species and subspecies. The Red List aims to: (i) provide scientifically-based information on the status of species and subspecies at a global level; (ii) draw attention to the magnitude and importance of threatened biodiversity; (iii) influence national and international policy- and decision-making; and (iv) provide information to guide actions to conserve biological diversity.

For regional or national levels, a range of tools is available to assess land degradation through soil related measures (see **Table 8.1**). These include PESERA (Kirkby *et al.,* 2004), SWAT (Arnold *et al.,* 1993), Geo-WEPP (Arnold *et al.,* 1993; Flanagan & Nearing, 1995; Renschler & Harbor, 2002), CORINE (Dengiz and Akgul, 2004) and the USLE/ RUSLE/ MUSLE models (Nearing *et al.,* 1989; Wischmeier & Smith, 1978). Soil organic matter is influenced by land management. The soil organic matter turnover can indirectly indicate the state of degradation and can be assessed using various models such as Roth C (Coleman & Jenkinson, 1996), CENTURY (Parton *et al.,* 1992), DNDC (Li *et al.,* 1992) to a considerable degree of confidence. These models are point-scale models and can be extrapolated to large spatial extents (for global or regional level applicability) using remote sensing and GIS approaches. Though these models are widely used, the erosion and hydrological flux associated soil organic matter movement requires coupling to multiple hydrological and erosion models. These process-based models are very accurate owing to their capabilities to simulate and describe the spatial distribution of degradation, but are heavily dependent on local and spatial input databases on land-use, soil and weather information. Lack of field validation and uncertainty in model parameters are major barriers in their applicability to areas where local databases are very scarce. Remote sensing-based information sources to assess land degradation – including high resolution Digital Elevation Models (DEM) by Shuttle Radar Topography Mission (SRTM) or Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) – provide morphometric and hypsometric characteristics of the land mass and are used as an indicator of degradation activities (Farhan *et al.* 2015; Prasannakumar *et al.,* 2011).

Other tools mostly applied at regional or national levels focus on land degradation from a biological perspective (see **Table 8.1**). SPLASH (Davis *et al.,* 2017) uses bioclimatic indices to assess ecosystem function, species distribution and vegetation dynamics under changing climate scenarios, for which direct observations on surface fluxes are sparse. The MODIS-NPP/GPP product (Zhao *et al.,* 2005) provides a remote sensing-based solution to quantify the primary production of vegetation as an indicator of land degradation, and is used in tools like LNS (Prince, 2004; Prince *et al.,* 2009). Biota (http://viceroy.eeb.uconn.edu/biota) offers a robust database with spatially-referenced, taxonomically-classified biodiversity inventories ranging from one-hectare vegetation plots, to regional or protected-area biotic inventories, to continental-level specimen databases. The database updates help to provide degradation status of biodiversity. Complimenting IMAGE derived outputs, GLOBIO (Janse *et al.,* 2015) assesses impacts of human-induced environmental drivers on land biodiversity in terrestrial ecosystems and freshwater systems in the past, present and future. Impacts on biodiversity are captured in terms of the biodiversity indicators Mean Species Abundance (MSA) and ecosystem extent. They can be considered applications of the Convention on Biological Diversity (CBD) indicators (i.e., "trends in abundance and distribution of selected species" and "trends in extent of selected biomes, ecosystems and habitats", respectively).

Land degradation assessments at global or regional levels can provide a coarse resolution assessment to identify large areas and patterns or types of areas likely to have degradation problems. But due to the coarse resolution of these assessments, the management units related to the exact degradation becomes difficult to locate. As halting and reversing land degradation requires location-specific solutions and multi-sectoral collaboration, global and/or regional decision support tools do not provide any prescriptive solutions to combat the degradation problem.

At farm and landscape levels, the FALLOW (Forest, Agro-forest, Low-value Lands Or Waste) model provides prospective information on the impact of a particular strategies (Suyamto *et al.,* 2009; van Noordwijk, 2002). The model simulates land-use and/or land-cover change dynamics with various feedback loops and assesses the consequences of the resulting land-use mosaics on economical utilities and ecosystem services. Model results identify trade-offs between ecological and economical values. Process-based models such as

SWAT, Geo-WEPP/WEPP are also capable of accurately map land degradation in quantitative terms at a fine spatial resolution.

Land degradation can be described using different methods. What constitutes an appropriate method depends on applicability and adaptability to a condition or form of land degradation. **Table 8.1** provides an overview of the popular and mostly freely available land degradation assessment tools. In **Box 8.1** we present examples of applications of decision support tools to assess land degradation at different spatial levels.

To ensure effective dissemination of land degradation-related information to those stakeholders who are at the level where they can influence decision-making, the assessment levels should be scalable from global to local level commensurable to the implementation level. The information exchange between the stakeholders and the science-driven knowledge should live up to five principles comprising: (i) the knowledge exchange goals; (ii) adjustability to changing user needs and priorities; (iii) long-term trusting exchangeability; (iv) having deliverables tangible in nature; and (v) sustaining a knowledge legacy (Reed *et al.,* 2014).

Table 8 1 **Popular land degradation assessment tools.**

Tools	Description	Spatial application level	Application outcome
Global Assessment of Human-induced Soil Degradation (GLASOD) method http://www.isric.org/projects/global-assessment-human-induced-soil-degradation-glasod	• Provides basic data on the world distribution and intensity of erosion, chemical and physical types of degradation	• Global	• Maps distribution and intensity of degradation
Global Assessment of Land Degradation and Improvement (GLADA) http://www.isric.org/projects/global-assessment-land-degradation-and-improvement-glada	• Involves a sequence of analyses to identify land degradation hotspots using remotely-sensed data and global ISRIC datasets	• Global • National • Local	• Identifies degradation hotspots and restoration bright spots
Assessment of the Status of Human-Induced Soil Degradation (ASSOD) https://esdac.jrc.ec.europa.eu/content/assod-status-human-induced-soil-degradation-south-and-southeast-asia-dominant-degradation	• Follow-up study of GLASOD in South and South-East Asia • Provides data for 17 countries and includes data on water and wind erosion, chemical deterioration	• Regional	• Identifies areas with severe erosion risk • Provides more spatially explicit and detailed information on land degradation
Land Degradation Assessment in Dry lands (LADA) http://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1036360/	• A Global Land Degradation Information System (GLADIS) database	• Global • National • Local	• Maps pressure and threat indicators at global level • Allows access to information at national, land use and pixel levels
Coordination of Information on the Environment (CORINE) https://www.eea.europa.eu/publications/COR0-landcover	• Erosion and land quality database • Preparation of erosion maps and classification accordingly	• Regional • National	• Provides spatial and temporal soil erosion status maps (severity, impact)
Pan-European Soil Erosion Risk Assessment (PESERA) http://www.isric.org/projects/pan-european-soil-erosion-risk-assessment-pesera	• Spatially-distributed model • Quantitative analysis of soil erosion by water	• National • Regional	• Provides spatial and temporal soil erosion status maps (severity, impact)
Universal Soil Loss Equation model (USLE)/ Revised Universal Loss Equation (RUSLE) http://milford.nserl.purdue.edu/weppdocs/overview/usle.html http://www.iwr.msu.edu/rusle/	• Empirical model • Quantitative data on spatial distribution of soil erosion • Requires data on annual average rainfall, soil, land use, management practices and terrain	• Local • Watershed • Regional • National	• Provides maps of soil erosion severity • Provides long-term annual soil loss due to the rill- and inter-rill erosion by water from the agricultural lands

Tools	Description	Spatial application level	Application outcome
Water Erosion Prediction Project model (WEPP/ Geo-WEPP) http://geowepp.geog.buffalo.edu/ http://milford.nserl.purdue.edu/weppdocs/overview/wepp.html	• Process-based erosion model • Quantitative estimate of soil erosion • Requires data on soil, DEM, daily climate, land use	• Hill slope • Landscape • Watershed	• Provides quantified estimates of severity of erosion on a hill slope
Soil and Water Assessment Tool (SWAT) http://swat.tamu.edu/	• Process based hydro-ecological model • Quantitative estimate of water yield, sediments, pollutants • Requires database on soil, daily weather data, land use, DEM	• Watershed • Sub-basin • River basin	• Provides spatial and temporal distribution and magnitude of soil erosion, water yield, pollutant load • Applied to quantify the impact of land management practices in large and complex watersheds
Integrated Model to Assess the Global Environment (IMAGE) http://themasites.pbl.nl/models/image/index.php/Welcome_to_IMAGE_3.0_Documentation	• Process-based ecological-environmental model framework • Quantitatively simulates the environmental consequences of human activities • Requires global database on precipitation, temperature, aridity index, biomass, land cover, Net Primary Production	• Global	• Identifies socio-economic pathways and projects the implications for energy, land, water and other natural resources
GLOBIO http://www.globio.info/	• Empirical/statistical model • Quantitative assessment of past, present and future human impact on biodiversity	• Global • Regional • National	• Provides a single measure of the intactness of ecological communities and the average abundance of all species
DNDC/ RothC/ CENTURY https://soil-modeling.org/resources-links/model-portal	• Process based modeling using data on long- and short-term climate, land management history, organic carbon status	• Local • Regional • National • Global	• Provides carbon turn over in soil from land management practice with plant input • Provides information on organic carbon status as an indicator of soil degradation
FALLOW (Forest, Agro-forest, Low-value Lands Or Waste) https://www.worldagroforestry.org/publication/forest-agroforest-low-value-landscape-or-wasteland-fallow-model	• GIS-based spatially explicit model • Quantitative analysis of land use change • Operates at spatial resolution of 1 ha, temporal resolution of 1 year and socio-economical resolution of 1 community	• Local • Regional	• Applied for rural agro-forested landscapes • Provides simulated land- use and/or land-cover dynamics due to local responses on external drivers biodiversity
Simple process-led algorithms for simulating habitats (SPLASH)	• Process-based species distribution model • Requires bio-climatic variables derived from climate database • Uses global climate data	• Global • National • Regional	• Provides species distribution as an indicator of habitat loss or gain • Applied as a surrogate indicator of degradation
National Foot Print Accounts (NFPA) http://www.footprintnetwork.org/resources/data	• Quantitative database • Based on approximately 15,000 data points per country per year • The accounts calculate the Footprints of more than 200 countries, territories, and regions from 1961 to the present	• Global • National	• Provide time series of both Ecological Footprint and bio-capacity • A surrogate for indirect estimation of bio-capacity degradation
Local Net Primary Production scaling (LNS) method https://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MOD17A2_M_PSN	• Spatial manipulation model with vegetation index values derived from satellite imagery (MODIS)	• National • Regional	• Estimates potential production inhomogeneous land capability classes and models the actual productivity using remotely-sensed observations. • The difference between the potential and actual productivities provides a map of the location and severity of degradation

Box 8 1 **Examples of Application of decision support tools at various assessment levels.**

Global/National: China (Bai *et al.* 2005).

The study on the status and trends of land degradation and identification of hotspots (using the GLADA method) was carried out in North China using the 22-year NOAA-AVHRR GIMMS dataset of normalized difference vegetation index data and ancillary information. The results indicate that overall green biomass increased over the 22-year period with an insignificant correlation with rainfall. A delayed response of declined biomass production was observed with diminished rainfall. Rain-use efficiency was found to follow an inverse trend with improvement in land conditions. Normalized difference vegetation index attenuation took place quite long before the growing season climax. Declining green biomass production, a surrogate indicator of land degradation, is highly localized. Authors opined that various indicators developed - with direct and indirect reference to land degradation such as soil erosion, infiltration, water storage and soil organic matter - could be used as input for an early warning system for land degradation. These facts were corroborated through field validation.

Regional: Australia (Jackson & Prince 2016)

This study employed the local NPP scaling (LNS) approach to identify patterns of anthropogenic degradation of NPP in the Burdekin Dry Tropics region of Queensland, Australia, from 2000 to 2013. This region (7.45 X 10^6 km^2) was investigated at a spatial resolution of 250 m. The average annual reduction in NPP due to anthropogenic land degradation in the Burdekin Dry Tropics region was estimated at 2.14 $MgCm^{-2}$ yr^{-1}, or 17% of the non-degraded potential, and the total reduction was 214 $MgCyr^{-1}$. Extreme average annual losses of 524.8gCm^{-2} yr^{-1} were detected. Approximately 20% of the region was classified as "degraded". Varying severities and rates of degradation were found among the river basins. Inter-annual, negative trends in reductions of NPP occurred in 7% of the entire region, indicating ongoing degradation. There was evidence of areas that were permanently degraded.

Local: China (Zheng & Hong 2012)

The spatial pattern of soil erosion and deposition on a catchment scale were estimated with the Geo-WEPP model in a small catchment of the Sichuan Hilly Basin. The estimated sediment delivery per unit area and sediment delivery ratio was estimated to be 2760 Mg km^2 yr^{-1} and 0.485, respectively. Compared with the results derived by the second soil erosion survey based on remote sensing, the results by the Geo-WEPP model were validated through field observation. Post-validation of the scenario analysis was carried out to establish spatial pattern sediment delivery. It was found that the woodland has better soil and water conservation benefits than cultivated slopes. Geo-WEPP was found to be a useful tool to establish effective policy.

8.2.1.2 Identifying future land degradation

Decisions addressing land degradation problems are not only based on an assessment of the current land degradation, but also on the expected future state of the land. Scenarios can be used to assess the dimensions of future land degradation (IPBES, 2016b) (see also Chapter 7). Scenarios employ climate conditions, anthropogenic and natural drivers, and institutional and governance drivers in a future time frame. These could be linked to process-based land degradation models with GIS integration like SWAT or Geo-WEPP **(Table 8.1)**. Assessing land degradation drivers and future degradation is key for deciding the urgency, societal relevance and stakeholder's preparedness for land degradation responses.

Land seldom remains in a state of equilibrium and often exhibits multiple ecological and social states. Underlying socio-economic processes can move systems slowly towards thresholds, and once reached, the bio-physical integrity of the system can rapidly be interrupted. This process is also known as non-linear regime shifts and can be extremely difficult and costly to reverse. To understand land degradation and prioritize action, there is a need to identify and manage for the small set of "slow changing" variables (e.g., loss of soil nutrients) that drive the "fast changing" ecological variables (e.g., reduction in crop yield) which matter at any given scale, in the context of multiple system thresholds. These thresholds need to be evaluated and the cost of recovery quantified in order to seek ways of managing the thresholds to increase resilience (Reynolds *et al.,* 2007).

A new dryland development paradigm (Stringer *et al.,* 2017) which builds upon the work by Reynolds *et al.* (2007) identified three integrative principles: (i) to identify linkages and feedbacks among multiple actors involved in decision-making by "unpacking" relationships and interactions between socio-ecological systems, livelihood portfolios and value chains; (ii) research needs incorporating multiple knowledges "traversing" across spatial and temporal scales and comprising of "fast" and "slow" variables – the reason being that degradation is mediated by interactions between multiple drivers of change, socio-technical innovation and investment options across sectors and scales; and (iii) "sharing" knowledge across multiple decision-making stakeholders to co-produce contemplative output for communities – at broader spatial and social scales – through social learning, including empowering disadvantage groups to participate in research and development process.

The identification of a unifying concept or explanation for land degradation processes is still a challenge. Such complexity can be tackled referring to the concept of "syndromes" (Ceccarelli *et al.,* 2014). "Syndromes" of land degradation can be evaluated in the past constructing land-use and/or land-cover change trajectories using prediction rules and scenarios developed for the future, using external drivers such as climate change and anthropogenic interferences. This can serve as information baselines for sustainable land management strategies and interventions. Still, challenges exist to develop an effective scenario pathway to develop the future land degradation trajectories. There is a need, through proactive science and policy dialogue to: (i) embrace a long-term scenario strategy that has the potential to significantly improve the relevance of future assessments on biodiversity and ecosystem services; and (ii) adopt a participatory, multi-scale scenario approach that captures the diversity of local social-ecological dynamics and builds understanding of interactions between global and local processes intertwined in generating ecosystem services and human well-being (Kok *et al.,* 2017).

8.2.2 Information, knowledge and decision support tools to identify land degradation prevention and restoration options

8.2.2.1 Quantitative and comparative analysis of land degradation avoidance solutions and restoration options

Land degradation response actions include land degradation prevention and restoration. While prevention lies in proactive policy decisions on conservation and the sustainable use of resources, restoration is a forward-looking process that seeks to initiate or accelerate the recovery of an ecosystem from a degraded state. The decision on a restoration option needs to be goal oriented, specific to a certain ecosystem, at various scales taking into account the recovery potential of the system as well as the needs of the society (see Chapter 1 and 6). Hence, defining clear restoration goals requires not only the identification of plausible options that are available for the particular ecosystem, but also considerations of the diverse interests of stakeholders. Besides, restoration and degradation mitigation responses are constrained by variables such as available resources (e.g., budget, community support), technologies, knowledge of the system and choice of options. Given the heterogeneity of such variables across systems and scales, a context-specific restoration or degradation avoidance solution is more likely to be effective than generic prescriptions (Gärtner *et al.,* 2008; Hobbs & Harris, 2001).Therefore, a comprehensive assessment of the biophysical, socio-economic and governance/institutional variables is essential to make informed decisions on restoration.

Decision support for restoration or degradation avoidance solutions aim to assist in making informed decision on available option – one that is optimal and feasible in terms of technology, cost and stakeholder satisfaction. Decision support tools can help to maximize the cost-effectiveness of restoration by identifying areas with different capacities for natural regeneration (Príncipe *et al.,* 2014; Guzmán-Álvarez & Navarro-Cerrillo, 2008). These tools require data and information from scientific studies of risks, cost-benefit analysis and qualitative assessment of stakeholders' views. The tool can be either written guidelines or software-based guidance. Some of the commonly applied decision support tools include Multi-Criteria Analysis (MCA), Life Cycle Analysis (LCA), Cost-Benefit Analysis (CBA) and Cost-Effectiveness Analysis (CEA), as described in Onwubuya *et al.* (2009) (see **Box 8.2**).

In the UK, the Environment Agency and Defra have developed a written guidance document entitled "Model Procedures for the Management of Contaminated Land" or simply referred to as "Contaminated Land Report 11 (CLR11)". This document outlines procedural guidance for the whole life cycle of the management of contaminated sites. Another example is from Germany, which has detailed written guidance documentation used for decision-making in contaminated land management – providing procedural step-by-step guidance for each and every activity. Similarly, the Swedish Environmental Protection Agency (SEPA) provides a broad national (written) guidance on remediation of contaminated sites, extending from inventory estimation to implementation of remediation projects. The guidance is given in the form of guidelines and manuals that are used (as decision support tools) by local authorities and practitioners taking responsibility for the investigation, remediation and after-care of contaminated sites. In addition to the written guidelines, software-based tools are also developed for remediation of contaminated sites in Europe (Onwubuya *et al.,* 2009). Examples of such models are given in **Box 8.3**.

There is a large variety of ecosystem-based management tools that can be applied for selecting a solution for land degradation **(Table 8.2)**. The tools can be found in the "Ecosystem-Based Management Tools Database, 2012" (http://www.natureserve.org/conservation-tools/ecosystem-based-management-tools-network). Despite the wide range of tools provided in the database, few

Box 8 2 Description of common decision support tools to select land degradation response actions. Based on Onwubuya *et al.* (2009).

Multi-Criteria Analysis (MCA): identifies the preferred option, ranks and distinguishes acceptable from non-acceptable alternatives. MCA is largely driven by expert judgment and a degree of bias in the outcome is unavoidable. MCA can be applied in combination with monetary and non-monetary values in the decision-making process, which is also called Multi-Criteria Decision Analysis (MCDA). MCDA is applied to analyze complex problems that are characterized by any mixture of monetary and non-monetary objectives. The tool can be used to synthesize data and information on identified problems and organize a set of decision criteria for each category of problems, so as to enable decision makers to choose the appropriate solutions.

Life Cycle Analysis (LCA): compiles and evaluates the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. The technique is often used to analyze for example the "cradle to grave" of products. Though LCA is popularly applied in the manufacturing industry, it has also become an important environmental decision support tool in managing and selecting technological options for degraded land restoration and remediation of contaminated lands. LCA enables comparisons between impacts of effectiveness of actions on land restoration. It also allows the selection of technological options by taking into account of stakeholder interests and views.

Cost-Benefit Analysis (CBA): assesses all costs and benefits involved in the different available options. Costs can be considered not only as monetary context, but also anything that can reduce human well-being - while benefits are anything that can enhance human and environmental well-being. Application of CBA may require expert knowledge, and sometimes difficulties associated with the monetization of ecosystems and the evaluations of the social acceptability of a certain option can be barriers to implementation.

Cost Effectiveness Analysis (CEA): provides a framework for making decisions on the least costly option to deliver the required standard outcomes. It is a relatively simple balance of the costs of a measure against its effectiveness and whether it meets given restoration objectives.

Box 8 3 Examples of decision support tools for remediation of contaminated sites in Europe. Based on Onwubuya *et al.* (2009).

PhytoDSS: applies phytoremediation technology to restore contaminated or polluted sites with the use of targeted plant species. The technique restores degraded sites through uptake of selected contaminants by specifically-selected plants (a process called phytoextraction) and through immobilization of contaminants through re-vegetation of sites with target species of plants and through the addition of other chemical inputs to immobilize the pollutants (mainly metals and metalloids), which is a process of phytostabilization. *PhytoDSS* uses the REC model (described below) for its implementation (http://www.eugris.info/displayProject.asp?ProjectID).

REC (Risk reduction, Environmental merits and Cost): combines risk reduction, environmental merits and cost, which in earlier times had been studied individually and integrated into decision-making to manage contaminated land.

ABC (Assessment, Benefit, Cost): it is similar to REC, but improved in many respects. The tool assesses the feasibility of different options and utilizes LCA to assess the advantages and disadvantages of each option and evaluates the cost of each of the remediation technical options.

are directly relevant and applied for multiple ecosystem services analysis (Bagstad *et al.,* 2013). For instance, ESR is a simple spreadsheet-based process decision support tool developed by the World Resource Institute (WRI) to qualitatively assess the impact of corporate businesses on the ecosystem services, so as to identify mitigation options at multiple scales, both to benefit the business and society at large (Hanson *et al.,* 2012).

Amongst the spatially-explicit ecosystem-based tools, MIMES can incorporate inputs from stakeholders and biophysical data sets for ecosystem valuation and decision-making. MIMES simulates human and natural systems interactions and provides estimates of near-term and long-term effects at different spatial levels. At the landscape or watershed levels, InVEST helps decision-making based on quantitative assessment of trade-offs in alternative management options (Kareiva *et al.,* 2011; Tallis *et al.,* 2013). Similarly, the ARIES model is a watershed-scale model that quantitatively maps natural capital, natural processes, the human beneficiaries and ecosystem service flows in an understandable way to manage ecosystems (Villa *et al.,* 2011).

There are also the GIS-based spatial analysis tools such as the SolVES and LUCI tools, which are applied at landscape and watershed scales (Jackson *et al.,* 2013). SolVES incorporates quantified social values and perceived non-market values that the public ascribes – such as cultural services, aesthetic and recreational services – into the ecosystem services assessments for different stakeholder groups (Sherrouse & Semmens, 2014). LUCI uses Multi-Criteria Analysis to explore the impacts of decisions on land-use and management changes. Among the web-based tools, Co$ting Nature is a model that aims to facilitate decisions on conservation priorities and to assess impacts of development activities such as agricultural production, mining, industrial developments on ecosystem services, as a result of human pressure on biodiversity and ecosystem services. The WOCAT tools collect and share standardized local knowledge on sustainable land management. **Table 8.2**, below, provides descriptions on the applications of some of the common and freely-available ecosystem-based decision support tools.

Some of the above-mentioned tools have been applied in a variety of ecosystems **(Box 8.4)** and delivered encouraging results for restoration decision making. Spatial modelling and decision support tools can provide decision makers with information on optimal options in restoring degraded ecosystems (Goldstein *et al.,* 2012) by quantifying natures' contribution to people under different scenarios of management decisions.

Table 8 2 **Tools for finding restoration solutions.**

Tools	Description	Spatial application level	Application
Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) http://www.naturalcapitalproject.org	• Software-based spatially- explicit model (GIS-based). • Quantitative analysis of spatial changes on ecosystem services for different management options • Requires parameterization of qualitative variables	• Landscape • Watershed	• Quantitative spatial output (ecosystem services mapping and valuation) • Flexibility to assess alternative management options by measuring the trade-offs • Operation involves expert rules and outputs may involve some degree of bias
Multi-scale Integrated Models of Ecosystem Services (MIMES) http://www.afordablefutures.com	• Set of software-based integrated dynamic models developed through web-based participatory process • Qualitative and quantitative analyses of changes in ecosystem services • Serves as a training tool, allowing simulation of policy options before making decisions • Interactive and participatory analysis of ecosystem services based on different policy scenario	Multi-scale: • Global • National • Regional • Local	• Spatially explicit quantitative output on ecosystem services • Spatial and temporal changes on the values of ecosystem services • Through a simulation iterative process, it allows decision makers to understand ecosystem dynamics, the link to human well-being and how the values change under different management scenarios.
Ecosystem Services Review (ESR) http://www.wri.org/	• Simple spreadsheet-based model • Qualitative analyses of impacts on ecosystems and society	• Landscape • Watershed	• Qualitative output • Direct and indirect negative impacts of development and corporate business that are linked to ecosystem services • Output is used to make decisions on mitigation and management options. • Applied for environmental auditing • Improves reputability of corporate businesses
Artificial Intelligence for Ecosystem Services (ARIES) http://aries.integratedmodelling.org/	• Agent-based software modelling tool • Quantitative analysis of ecosystem services (e.g., carbon sequestration, using Bayesian networks and Monte Carlo simulation) • Monetary valuation of ecosystem services	• Landscape • Watershed	• Quantitative output • Spatially explicit ecosystem service flows (maps) and the trade-offs, including uncertainty maps • To make decision on efficient and cost-effective actions that improve biodiversity and ecosystem services

Tools	Description	Spatial application level	Application
Land Utilization & Capability Indicator (LUCI) http://www.lucitools.org/	• Process-based Spatial software • Quantitative analyses of spatial information on ecosystem services	Multi-scale: • National • Regional • Watershed • Landscape • Local • Land unit/ site	• Spatially explicit ecosystem service tradeoff maps • Potential trade-offs and synergies among multiple ecosystem services • Quantitative output on potential gain or loss of ecosystem services different management scenarios. • Map outputs with ecosystem services • Quantitative output (data on ecosystem services) • Explores the capability of a landscape to provide ecosystem services.
Co$ting Nature http://www.policysupport.org/costingnature	• Web-based spatial model • Quantitative analyses of ecosystem services under future climate change scenarios • Simulates human actions to identify intended and unintended consequences • Helps to understand effectiveness of policies before implementation • Freely available for non-commercial use (open access)	• Landscape	• Spatially-explicit quantitative output • Baseline indicators • Provides index for analyzing changes on ecosystem services (e.g., carbon stock, clean water availability, hazard mitigation) • Applied for Natural Capital Accounting and analyzing the ecosystem services supply • Used for conservation prioritization and analysis of co-benefits
Social Values for Ecosystem Services (SolVES) http://solves.cr.usgs.gov	• GIS software-based spatial model • Quantitative analysis of social values for ecosystem services • Freely available	• Landscape	• Transforms non-monetary social values of ecosystem services as perceived by different social groups • Provides scaled index of quantified non-market values of ecosystem services
World Overview of Conservation Approaches and Technologies (WOCAT) https://qcat.wocat.net	• Sustainable Land Management Database of good practices • Quantitative data on local knowledge, tested technology and practices	Multi-scale: • Local, • National • Regional • Global	• Identifies suitable SLM technologies and approaches • Helps to determine priority areas for interventions

Box 8 4 Application of SoLVES and InVEST in Taiwan for conservation priority decision-making.

Lin *et al.* (2017) applied SolVES and InVEST models to prioritize ecosystem services in systematic conservation planning in the Datuan Watershed of Northern Taiwan. The study was aimed at making a comparative spatial analysis of biophysical service areas with social value areas. High priority areas of biophysical ecosystem services were identified and mapped based on location-specific data, which were generated using the InVEST model. The social ecosystem services (high priority social value) areas were identified using SolVES based on data generated from questionnaire surveys. Land-use suitability maps, which ultimately dictate future land-use change, were calculated based on both land-use allocation maps and direct drivers of environmental variables. The systematic conservation planning zonation then generated spatial-prioritization scenarios based on different inputs. The zonation results were then compared in multiple objective programming via social-ecological matrix analysis. The findings showed that while the biophysical services were distributed with high spatial variability, the social values had high spatial overlap. About 6% of the watershed area showed both high biophysical and social services, while about 24.5% of the areas were identified either high in biophysical services or vise-versa. Urban development scenarios affected the conservation area selection drastically. The results indicate trade-offs and potential synergies between development, social values and biophysical services. The results can be used for finding solutions to social-ecological planning complexities that serve multiple stakeholders. The results of the comparison can also inform decision makers and prompt further discussion about conflicting priorities.

8.2.2.2 Spatial prioritization of land degradation avoidance solutions and restoration options

Different approaches to prioritize locations and spatially plan for land degradation avoidance and restoration actions exist.

Spatial conservation prioritization (SCP) addresses resource allocation and ecologically based land-use planning. It is a quantitative analytical step that is often utilized within a broader operational framework for the implementation of conservation, such as systematic conservation planning (Kukkala & Moilanen, 2013). SCP analyses are often carried out using special software, originally designed for solving reserve selection problems - such as Marxan, Marxan with Zones (Watts *et al.,* 2009), or Zonation (see Pouzols *et al.* (2014) for references). The strength of SCP analyses is that they can integrate a large number of spatial data layers relevant for ecologically-based land-use planning. Most common analyses are based on data about the distributions of species and habitat types, but additional information about costs, threats (including land degradation), connectivity or ecosystem services is sometimes used depending on analysis needs and data availability.

The original form of the conservation area selection problem is a target-based formulation: which set of sites satisfies targets given for biodiversity features (often species) with minimum cost (see Moilanen *et al.* 2009 for review)? This type of problem is frequently solved with the Marxan or Marxan with Zones software (Watts *et al.,* 2009). A second form of analysis is balanced spatial priority ranking, which allows versatile analysis – also from the perspective of impact avoidance and accounting for land degradation. Spatial priority ranking is often done using the Zonation approach and software (see application examples in **Box 8.5**). Linking land degradation to spatial conservation prioritization can help answer the following types of questions: (i) How much biodiversity has been lost due to land degradation compared to the reference state? (ii) Where are optimal expansion areas for reserve networks given that parts of the landscape have become reduced in quality? (iii) Where would it be most important to avoid further land degradation? (iv) Where are areas where further land degradation is least harmful for biodiversity?

The **Restoration Opportunities Assessment Methodology (ROAM)** offers a framework for countries to identify and assess potential for forest landscape restoration and to locate specific areas for restoration at the national or sub-national level (IUCN, 2014). ROAM is used to support planning of national restoration programmes, based on collaborative engagement with stakeholders. The methodology is meant to be quick and non-technical, allowing broad stakeholder engagement in the process.

Box 8.5 Examples of spatial prioritization applications. Based on Lehtomäki & Moilanen (2013); Pouzols *et al.* (2014).

Typical uses of spatial priority ranking include:

i. Traditional reserve selection, which is the identification of the highest-ranked part of the landscape (~reserve network) that produces high return on investment and balanced outcome across all biodiversity features.
ii. Reserve network expansion. Here, an optimal balanced expansion of an existing reserve network is identified, optionally accounting (e.g., connectivity or costs).
iii. Evaluation of an existing or proposed conservation area network. This is implemented as a comparison between how good it is and how good it could have been.
iv. Spatial ecological impact avoidance (e.g., Kareksela *et al.,* 2013). Here, the objective is to identify areas where economic development leads to limited ecological losses.
v. Balancing of alternative land uses. A balance between many biodiversity features and the needs of several alternative land uses is achieved by entering alternative uses (~opportunity costs) as negatively weighted features into the analysis - which helps to resolve conflicts between conservation and resource utilization (Kareksela *et al.,* 2013).
vi. Target-based planning. This addresses the requirement for identification ways to meet the targets with least cost or to maximize the number of targets met (achieve highest output) with a given resource (Moilanen, 2007).
vii. Biodiversity offsetting. Find areas that best compensate for ecological damage: how to expand the existing reserve network in a balanced manner to compensate for specific losses. This requires land degradation and offsetting gains to be developed into spatial layers for input.
viii. Planning under climate change. These analyses use both present and future distributions of biodiversity features, as well as connectivity between the present and future distributions to identify current and future areas of relevance.
ix. Targeting of habitat restoration or habitat management. This requires modelling of the feature-specific "difference made" by management or restoration, leading to a comparatively complicated and data demanding analysis.

In implementing restoration programmes, decision makers need to prioritise which landscapes they will be working in, taking into account the multiple uses of areas and considering diverse social and ecological needs (Vogler *et al.,* 2015). A **production possibility frontier (PPF)** framework can be used to graphically illustrate trade-offs between two inputs in pursuit of a particular output level. For example, to understand how distributions of forest stressors and ecosystem services shape restoration options across the landscape (Vogler *et al.,* 2015).

Another example is the **Ecosystem Management Decision Support (EMDS)** tool (Reynolds & Hessburg, 2005). This tool is based on an integrated approach to evaluate the system, which answers the question of "what is the state of the system?" and planning of response options which answer the question of "what are the optimum solutions to address the problem?". This tool can be applied in a single watershed or sub-watershed in a landscape.

Bayesian Network for catchment restoration (Stewart-Koster *et al.,* 2010) facilitates the development of conceptual models of likely cause and effect relationships between flow regime, land-use and river conditions and provides an interactive tool to explore the relative benefits of various restoration options. When combined with information on the costs and expected benefits of intervention, one can derive recommendations about the best restoration option to adopt - given the network structure and the associated cost and utility functions.

Another tool that can be used for prioritization of land degradation response options is the use of **a scorecard** (see ELD Initiative (2015); CATIE & The Global Mechanism (2011)). Scorecards can be developed to assess - based on stakeholder knowledge - how feasible different options are and can also include considerations of trade-offs and synergies in identifying preferred options to halt, prevent and reverse degradation. Scorecards have been used to prioritize incentive- and market-based mechanisms in countries such as Zambia, Panama and Cambodia. The use of these can facilitate a ranking of options through the use of numerical scoring. However, scorecards need to be used as part of a suite of tools that allow overall evaluation of the implications of decision-making.

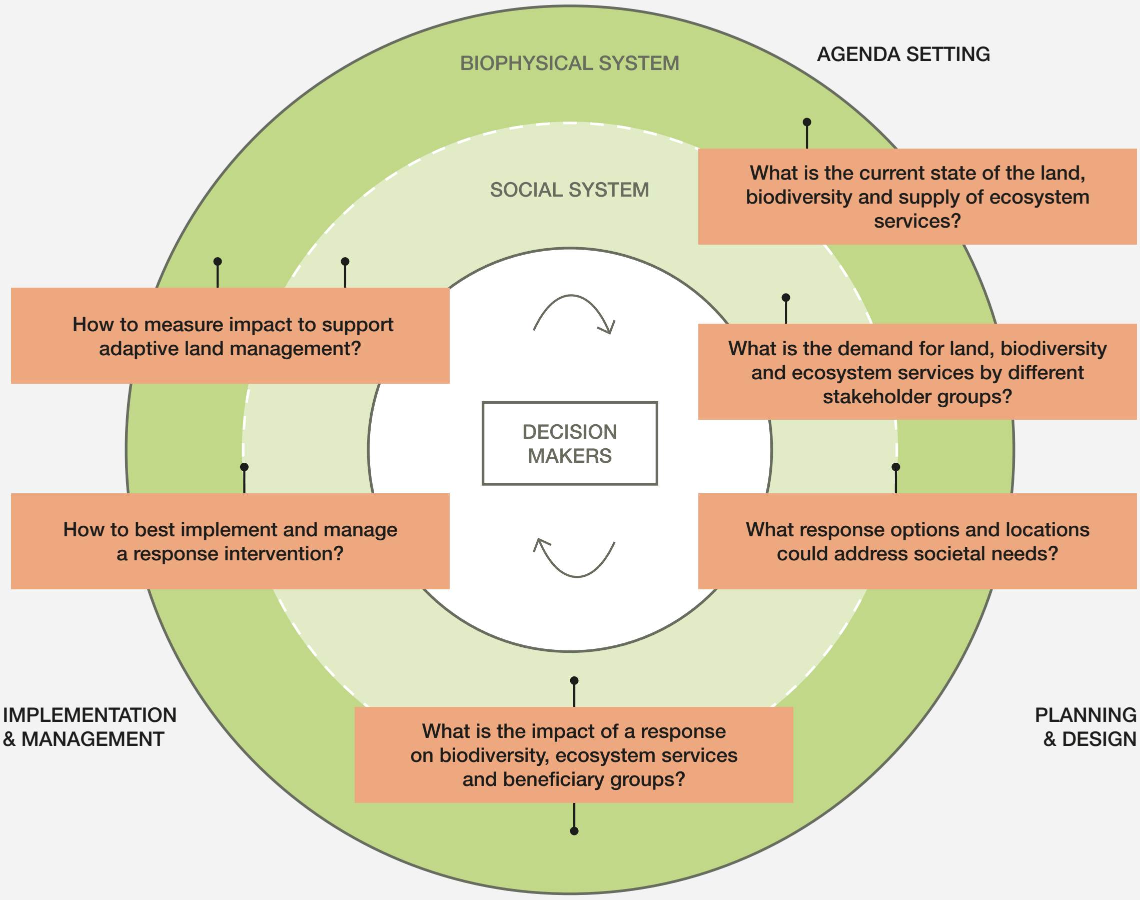
Dynamic systems modelling has been used to develop options for prioritization in environments as diverse as Botswana's Kalahari (Dougill *et al.,* 2010), Brazil's tropical forests (Vitel *et al.,* 2013) and in watershed planning in Quebec, Canada (Adamowski and Halbe, 2011). **Scenario modelling** is another useful approach as it can highlight possible plausible futures and therefore land degradation response priority locations (Costanza *et al.* 2015) (see also Chapter 7).

8.2.3 Linking decision support tools to the whole land restoration decision-making process

Different divisions and labels are proposed to describe such decision-making processes in land management (e.g., Cowling *et al.* 2008; Hessel *et al.* 2014; OECD 2016; Reed & Dougill 2010; Scherr *et al.* 2014). We describe the process with the Agenda setting, Planning and Design and Implementation and Management phases, followed by a review of progress towards meeting the objectives as set in the Agenda-setting phase (IPBES, 2016b). This iterative cycle of improving management policies and practices by learning from the outcomes of previously employed policies and practices can be referred to as adaptive management (Cowling *et al.,* 2008; Lal *et al.,* 2002; Sayer *et al.,* 2013). **Figure 8.2** depicts such an adaptive cycle. Throughout the different phases the focus of decision makers changes from understanding to exploring, to planning, to revisiting and revising. The strict sequential occurrence of these phases (as shown in **Figure 8.2**) is, in practice, not always observed (van Stigt *et al.,* 2015). However, these phases do provide a useful architecture for grouping and linking activities and information needs in a decision-making process.

Both land degradation and restoration emerge from the interplay of social (including economic) and biophysical processes (Benayas *et al.,* 2009) (see also Chapter 4, 5 and 6). To support decision-making regarding land degradation response strategies, information and knowledge on social as well as biophysical characteristics are needed. **Figure 8.2** shows examples of questions decision makers address when identifying and resolving land degradation problems. These questions relate to the social and biophysical sphere, or their specific interlinkage. As there is no single decision support tool that is able to deal with the full suite and complexity of decision-making questions on land degradation and restoration responses, multiple tools and approaches are required throughout the decision-making process (Turner *et al.,* 2016). Tools that are used to address initial questions in the Agenda-setting phase should generate information and knowledge to feed into Planning and Management phases. Therefore, decision-making support is shaped by the compatibility of different tools and actor collaborations. By discussing decision-making support as an interlinked pathway rather than in terms of single tools, we can assess what information is needed to support the subsequent step and indicate the different actors that need to be involved in each stage of the policy cycle. In this Section, we describe the use of information, knowledge and tools to move from Agenda Setting to Planning & Design, to Implementation & Management phases in the policy cycle.

Figure 8 2 **Lining up evidence-based tools to address questions throughout the decision-making cycle. Source: After Willemen *et al.* (2014).**



To describe the linkages, we selected six example questions which also relate to the different chapters of this IPBES assessment (See **Figure 8.2** and **Table 8.3**). Policy support tools depend on information and knowledge, but also generate crucial new information and knowledge as input to subsequent phases of the decision process. Here, we assess what types of tools, information and knowledge are required to smoothly move through the different decision-making phases, eventually leading to informed decision-making. For example, to guide the selection of policy support tools from online repositories such as NEAT (http://neat.ecosystemsknowledge.net/tools.html) or the IPBES online tool catalogue (https://www.ipbes.net/policy-support).

From Agenda Setting to Planning & Design

During the Agenda-setting phase tools are needed to specify land degradation problems in order to plan and design adequate responses. This phase motivates and sets the direction for policy design and implementation (IPBES, 2016b). To identify solutions for land degradation, information on land degradation – together with social demands and values – need to be linked to plan and design viable options to mitigate land degradation and restore land. A wide range of tools are available to identify and describe land degradation (see Section 8.2.1 and the IPBES online tool catalogue), with a varying applicability for different spatial extents. Key outputs of these tools for decision-making includes knowledge and information on location, type, severity, temporal aspects of land degradation. These are preferably described with measurable indicators, adequate for the location, livelihood system and land degradation processes (see **Table 8.1** and Chapter 4) (also see Convertino *et al.,* 2013; Geijzendorffer *et al.,* 2015; Kairis *et al.,* 2014). The selected and measured indicators, in this phase, must be measurable over time to play a role in monitoring land degradation trends and impact assessment of response actions (Heenan *et al.,* 2016; Reed *et al.,* 2010b). The scope of the land degradation problem is set by the demand, expectations, values and perceptions of stakeholders regarding land availability and ecological functioning (also see Chapter 2) (Couix & Gonzalo-Turpin, 2015) - and other stakeholder objectives. A plurality of values can lead to different demands for land and ecosystem services, and different perceptions of the severity of degradation and impact, among different stakeholders. An important step, here, is agreeing upon the land degradation problems and related mitigation objectives; facilitation and negotiation and consensus-building tools can play a role in this (Van Noordwijk *et al.,* 2013). A review by Turner *et al.* (2016) shows that limited decision support tools and methods are available to assess stakeholder values and the social context of land degradation and response strategies.

An additional function of the assessments in the Agenda-setting phase is creating an understanding of the social and biophysical system contributing to land degradation and restoration. This dual outcome (i.e., knowledge on land degradation problems and response objectives) feeds into the next phase **(Table 8.3)**.

From Planning & Design to Implementation & Management

To identify possible land degradation response strategies, tools that incorporate knowledge and information on social and ecological processes are needed. In the Planning and Design phase, response options are selected based on an assessment of financial and social capital. Financial capital includes total costs, return on investment (Goldstein *et al.,* 2008) and options for financing mechanisms (Jack *et al.,* 2008). Integrated land management is based on the idea that coordinated planning and action can be more effective than disparate, uncoordinated actions of individual land managers in delivering the full complement of benefits expected from strategies to halt or reverse land degradation. Integrated land management therefore requires strong stakeholder collaboration and engagement, which makes an assessment of social capital necessary (Brondizio *et al.,* 2009). Ex-ante impact assessment tools have a function in highlighting synergies and trade-offs between different locations, ecosystem services supply and stakeholder interests (Rosa & Sánchez, 2016). Impacts of land degradation response actions can affect different groups in society in different ways, and insights on these potential impacts contribute to reduced human conflicts and improved benefit-sharing (Daw *et al.,* 2011). Formalized ex-ante impact assessments to support decision-making include environmental impact assessments (EIA) and strategic environmental assessments (SEA). These two tools have overlapping conceptual foundations (Bina, 2007). In many countries these assessments are part of legislation, but are conducted within a wide range of quality levels (Pope *et al.*, 2013). In impact assessments of urban development the impact on land consumption is rarely taken into account, yet it is highlighted as a serious pressure on landscapes worldwide (Nuissl *et al.,* 2009). At the moment the suite of available generic decision support tools to support the selection of a land degradation response strategy mostly focus on biophysical impact, however participatory scenario planning is an increasingly popular tool in place-based environmental research for evaluating alternative futures of social-ecological systems (Oteros-Rozas *et al.,* 2015). An assessment of trade-offs and synergies among ecosystem services beneficiaries and stakeholders (to select socially-feasible solutions) is currently based on case-specific surveys (Karrasch *et al.,* 2014), economic valuations (ELD Initiative, 2015), or not included at all in impact assessments.

From Implementation & Management to Evaluation & Adaptation of the Agenda

To support good long-term governance and technical management of the implemented restoration and mitigation actions, information, knowledge and competencies are needed **(Table 8.3)**. Due to the multiple dimensions of land degradation and response actions, a multi-sector, urban-rural, multi-level, adaptive governance system is most effective (Brondizio *et al.,* 2009; Gómez-Baggethun *et al.,* 2013; Kenward *et al.,* 2011; OECD, 2016). Based on early defined indicators (in the Agenda-setting phase) a monitoring strategy is put in place to allow for evaluation and adaptation of the response strategies. Monitoring begins before the implementation of response actions. Systematic monitoring of the implemented response activities is vital for designing new (or adjusting) activities and policies. Monitoring information of land degradation response interventions is scarcely available, due to a lack of standardized monitoring strategies and adequate baseline information. Some long-term monitoring initiatives exist. These include: the Millennium Villages (Chapman *et al.,* 2016); the Long-Term Ecosystem Research (LTER) network (Stoll *et al.,* 2015); the GLORIA network (Mark *et al.* (2006)) (see also **Box 8.6**); and Group on Earth Observations Biodiversity Observation Network (GEOBON) (Proença *et al.,* 2017); and the UN Convention to Combat Desertification (UNCCD) which has – with the Land Degradation Neutrality Targets – defined and provided indicators to establish a baseline to allow for tracking land degradation over time. Local stakeholder-based monitoring approaches include ground-based photo monitoring (Lassoie *et al.,* 2014) and participatory monitoring programs (Kusters *et al.,* 2017; Singh *et al.,* 2014).

Besides monitoring, retrospective assessments of restoration interventions are carried out to evaluate restoration actions which were implemented without monitoring schemes. For example, a meta-analysis of 70 experimental studies (Meli *et al.,* 2014) showed that in wetlands restoration, effects on biodiversity recovery and ecosystem services recovery depended on the following factors, listed in order of decreasing importance: main cause of degradation; restoration action; experimental design; and ecosystem type. Restoration age did not significantly affect restoration outcomes in their meta-analysis.

Table 8 3 **Illustrative decision maker questions in relation to information and knowledge outputs the support the next decision phase.**

PHASE	DECISION MAKER QUESTIONS	ADDRESSED IN CHAPTER	AVAILABLE TOOLS	INFORMATION AND KNOWLEDGE OUTPUT NEEDS PER PHASE
Agenda setting	What is the current state of the land, biodiversity and ecosystem services?	1,3,4	• Degradation assessment tools, 8.2.1	• Quantified land, biodiversity, ecosystem services indicators • Knowledge built
	What is the demand for land, biodiversity and ecosystem by different stakeholder groups?	1,2	• Surveys, negotiation, facilitation tools	• Quantified and agreed demand indicators • Knowledge built
Outcomes	**Land degradation problems identified, located and understood** **Land degradation responses objectives set**			
Planning and Design	What interventions options and locations could address social needs?	1,6,7	• Option and location screening, 8.2.2	• Response options • Response design • Ex-ante assessment social needs
	What is the impact of the interventions on land, biodiversity and ecosystem services?	1,5,7	• Impact assessments, 8.2.2 • Policy inter actions, Section, 8.4	• Ex-ante assessment land, biodiversity, ecosystem services
Outcome	**Selected land degradation response strategy**			
Implementation and Management	How to best implement and manage intervention?	1,6	• Instruments and competencies, 8.3	• Technical planning • Roles and responsibility governance actors
	How to measure the impact to support adaptive management?	6	• Instruments and competencies, 8.3	• Monitoring land, biodiversity, ecosystem services indicators • Evaluating objectives • Communication
Outcome	**Adaptive management to halt and reverse land degradation**			

Decision support tools to guide the evaluation and adaptation of decisions on halting and reversing land degradation are lacking in the scientific literature. This relates to the often-unknown thresholds leading to sudden non-linear ecosystem regime shifts (see also Chapter 4). Preventive and rapid actions are often required before the undesired and irreversible regime shift occurs. Long-term monitoring and adaptive decision-making can be jeopardized by the much shorter political life cycles of elected representatives in democratic regimes (see also Chapter 2).

Seamless use of information, knowledge and tools

Conceptual frameworks on integrated environmental decision-making, including land degradation responses, exist (Cowling *et al.,* 2008; Hessel *et al.,* 2014; Reed *et al.,* 2010b; Scherr *et al.,* 2014) and the FAO is one of the institutions to have set up general guidelines to guide their implementation (FAO, 2015a). However, to apply these to the geographic, cultural, political, economic and historical contexts in different countries and regions, location-specific tools are needed. The current knowledge, information and tools base cannot seamlessly provide evidence-based decision support throughout the decision-making process. With seamless use, we mean a technical, conceptual and operation linkage between outputs and inputs of decision support tools for each decision-making step. This does not mean that successful decision-making on land degradation responses do not exist (see examples in Chapter 1, and Boxes in this Chapter).

To improve information, knowledge and tool use throughout the policy cycle, knowledge and information outputs **(Table 8.3)** need to be adequately generated. This could be done by cross-disciplinary and multi-actor collaboration, in order to tune research efforts and cross-sector harmonization. Also this could be achieved by encouraging scientists and leaders in government, businesses and civil society to work more closely together to develop the knowledge, tools and practices necessary to integrate social-ecological interactions into decision-making (Guerry *et al.,* 2015). However, there is limited evidence on when scientific tools are used in decision-making, as many factors influence actual uptake, including, but not limited to, relevance for policy objectives, time and cost cost-effectiveness, usefulness in case of missing data (Gibson *et al.,* 2017; McIntosh *et al.,* 2011; Zasada *et al.,* 2017). Decision-making is about more than having access to and using information, knowledge and tools. A range of institutional competencies are needed to support land degradation and restoration decision-making. These are addressed in detail in Section 8.3.

Box 8 6 **An example of governance halting malpractice and land degradation but with no immediate solutions for restoration. A case study from the rangelands of New Zealand.**

Lying relatively isolated in the temperate region of the Southwest Pacific, New Zealand was first settled by Polynesian Maori. Their main influence was through fire, which increased dramatically from the rare natural fires, and was a major factor in increasing the extent of grassland. By the time Europeans settled in the 1840s, forest cover had decreased from ~75% to ~50%, largely at the expense of tussock (bunch) grassland cover that increased to ~31% (82,436 km^2; Mark and McLennan 2005). Of this, some 54% still remains, mostly in the uplands. All of the remaining indigenous grasslands have been modified to varying extents through the effects of pastoral farming (burning and domestic grazing) on the more accessible rangelands and feral herbivores on the remainder, mainly deer introduced for hunting. Erosion was probably a feature of upland landscapes ahead of pastoral farming (Whitehouse, 1984), but degradation increased as a result and ranged from a drastic reduction in above-ground biomass through replacement of the tall tussock cover by a mixed short turf or herb field of grazing-tolerant grasses and forbs, and greatly increased bare soil and consequent erosion. In the more remote, non-rangeland regions, displacement of tussock cover was less serious. The extent of degradation was also related to the basement rock, as well as to variation in the topographic factors of elevation, aspect and slope.

Official responses to rangeland degradation.

The government took legislative action to address the situation in 1948 with an amendment to much earlier legislation, to provide much greater security for the pastoral use of the government-leasehold high-country tussock lands. Previously, the leases were reviewed at 11-year intervals with no right of renewal; such insecurity clearly encouraged unrestrained resource exploitation. The amendment carried some discretionary management constraints, but significantly provided a formal right of lease renewal at 33-year intervals, with "the same conditions and provisions as the original lease"– clearly offering absolute security of tenure. Despite the amendment, with continued deterioration in the rangelands condition and carrying capacity, the government established regional catchment authorities in the early 1950s. There was also provision of central government subsidies for improving both land management and access. Seasonal or intermittent spelling from grazing, although generally considered desirable, was only rarely practiced - even as a component of post-fire management. Retirement of land deemed to be unsuitable for sustained pastoralism, was usually a condition for subsidized assistance though relinquishment of the lease on this land, also a condition, but was rarely enforced.

Many of the discretionary constraints exercised by the local authorities on management and development activities were equivocal - there was a predominance of farmers among the elected members of the catchment authorities – and the continued degradation has been recorded in a long series of scientific papers from the 1860s onward and throughout the 20th century (see Allen *et al.* 1994; Buchanan 1865; Mark 1994; O'Connor 1982, 1984). During this time, a special committee on senior government ecologists was established to report to central government on the ecological basis for degradation of the upland snow tussock grasslands of the South Island pastoral lands. This committee recommended that research be carried out on both the systematics and ecology of the dominant tussock species and their communities, including the roles of introduced plants and animals. Several such studies were initiated, including those leading to separation of the effects of rangeland burning from those of grazing. Spelling for one (and preferably two) seasons following a management fire has therefore been recommended and now generally adopted, at least for the first post-fire season. Combined with these studies were the first measurements of upland water yield. Maximum yields among a wide range of cover types, including bare soil, came from the tall tussock grassland: 63-80% of measured precipitation (1300-1400 mm p.a.), varying mainly with frequency and intensity of fog. Yields from all other cover types were significantly less, but those from burned and clipped tussocks increased as they recovered (Holdsworth and Mark, 1990; Mark and Dickinson, 2008). Subsequent controversy over the contribution of fog interception by the tall fine tussock foliage was largely resolved with a stable isotope study (Ingraham *et al.*, 2008; Ingraham and Mark, 2000).

Concerns with the degraded state of the South Island rangelands continued and resulted in the establishment of a Ministerial appointed High Country Review Committee in 1994, to which the New Zealand Ecological Society and New Zealand Society of Soil Science made a comprehensive joint submission (Allen *et al.*, 1994). The Committee concluded (Party, 1994) that "a decline in soil condition is very likely on the unimproved lands. These lands comprise approximately 80% of the land area of the pastoral high country and receive no inputs. In the long term, the pastoral use of extensive areas of the South Island high country is unlikely to be sustainable." Largely in response to this report, the government initiated a review of the tenure of these high country rangeland leases in the mid-1990s, under special legislation (Republic of New Zealand, 1998). This provided for lessees to negotiate freehold title for the more productive, generally lower elevation lands in exchange for relinquishing their tenure on the more vulnerable, degraded and generally higher elevation lands with significant ecosystem services (Mark *et al.* 2013) and heritage values – as well as indigenous ecosystems and biodiversity, soil conservation, landscape, recreation, eco-tourism and water production values – for management in the public interest by the Department of Conservation. This is an ongoing process, described up to April 2012 by Mark (2012) and now (January, 2017) there remain the same ten conservation parks totaling 581,032 ha and five whole-property purchases (128,792 ha), with 119 of the original 303 leases now reviewed, totaling 623,413 ha: 53% allocated to freehold and 47% to conservation and with 48 leases at various stages of the process.

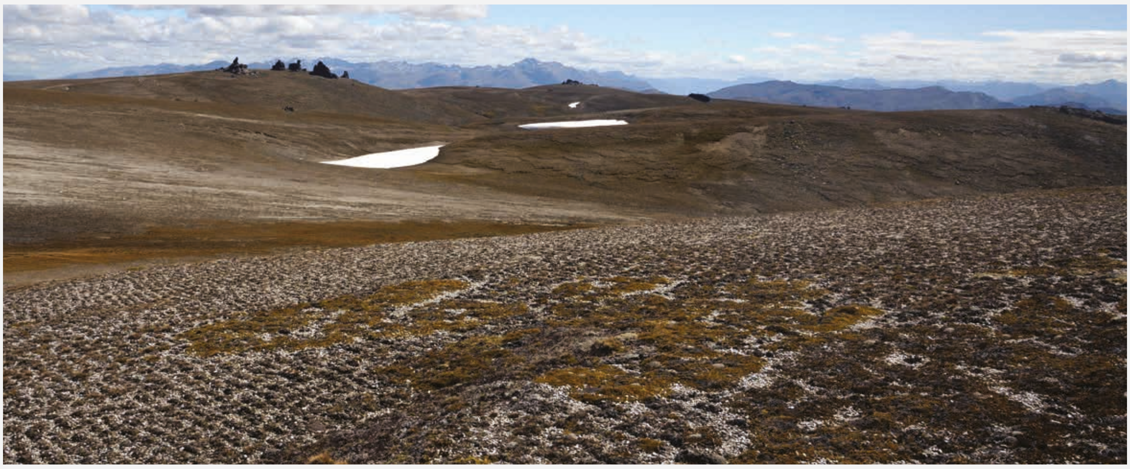
The long-term monitoring within the GLORIA network (http://www.gloria.ac.at/network_gloria_longterm.html, and Mark *et al.* (2006) revealed very slow recovery rates of degraded upland ecosystems. For example, the crest of the Pisa Range was used for extensive merino sheep summer grazing, in combination with intermittent burning, until 2012 when this detrimental land-use practice was brought to a halt through tenure review. Allen *et al.* (1994) quote an average soil organic matter recovery rate at 35 years, but for heavily-degraded areas such as the Pisa Range, the rate is even slower than that with the recovery rate of cushion plants (and subsequent soil formation) being no more than 5% over a decade. The photos below show hardly any vegetation recovery, between 2003 and 2014.

There is, therefore, no "easy fix" as to restoration methods of the upland grasslands, besides just conserving areas and facilitating their return to the original conditions at their own pace. Recovery of these degraded ecosystems was a very slow process because of the prevailing environmental conditions.

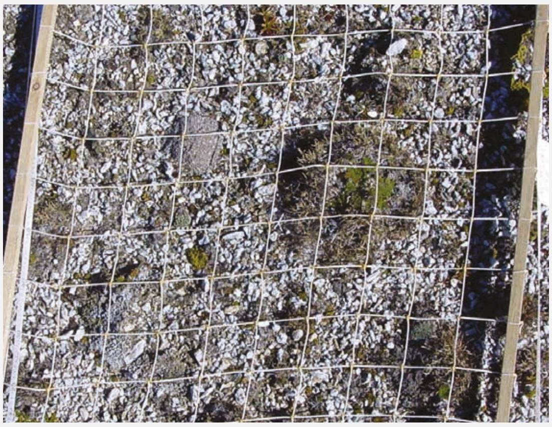
Figure 8 3 **Severely degraded alpine vegetation on the crest of the Pisa Range, south-central South Island, New Zealand.**

A Overview of the Pisa Range crest, B and C Close-ups of a permanently marked 1 m^2 plot on the Pisa crest GLORIA site, in late summers (February) of 2003 B and 2014 C, respectively, visualizing the very slow rate of vegetation recovery. Grey cushions are *Anisotome imbricata* (Apiaceae), dark green ones are *Dracophyllum muscoides* (Ericaceae), and more bright green ones being *Colobanthus buchananii* (Caryophyllaceae). Photos by Ulf Molau (A & C) and Katharine Dickinson (B).

A



B



C

8.3 BUILDING INSTITUTIONAL COMPETENCIES

Institutional competencies are a cornerstone for developing and implementing policy strategies, yet are often overlooked as drivers for ecosystem restoration or degradation. Well thought through decision-making processes regarding environmental issues – which forms part of environmental governance – and resulting environmental policies are paramount to halt and reverse land degradation. Institutional environmental policies define how and when to mitigate ecosystem degradation or regulate the use of natural resources (Ostrom, 2009). Institutional competencies are the set of abilities which a given institution can use to achieve those policy goals. Examples include the ability to collaborate with local communities, support the design of scientifically-sound restoration interventions, or foresee possible undesired secondary effects of policies. Besides organizational mandate and informal organizational practice, institutional competencies are an inherent part of the design and implementation of policy instruments and may even act as important drivers of land degradation or restoration (Ferraro & Hanauer, 2014; Guariguata & Brancalion, 2014; Primmer, 2017).

Institutional competencies support the successful design and implementation of policy instruments. Land degradation and restoration issues are typically driven by a complex interaction of drivers operating at different spatial and temporal scales. While rapid variables such as contamination events can cause sudden ecosystem degradation, slow variables are underlying structural processes - such as law implementation - that sets the scene for land degradation and restoration strategies (Reynolds *et al.,* 2007). Institutional competencies are a slow variable that indirectly triggers environmental degradation and/or the implementation of sound restoration strategies. Building the right institutional competencies is therefore as important as for instance providing financial incentives to promote land restoration. Robust science to evaluate the impact and efficiency of different institutional competencies in relation to land degradation and restoration decision making is still in its infancy stages (Guerry *et al.,* 2015; Polasky *et al.,* 2011) and is often hampered by significant time lags between policy implementation and measurable outcomes. For now, decision makers can learn from examples of how instruments are used in diverse contexts, such as the impact of institutional polices on biodiversity conservation or the provision of crucial ecosystem services such as carbon sequestration. For example, Prager *et al.* (2012) provide a framework describing key considerations for effective institutional and governance response that include the type of policy measure, specific institutions and governance structure. In this section, we aim to assess institutional competencies to design and implement: (i) legal and regulatory; (ii) rights-based and customary; (iii) economic and financial; (iv) social and cultural; (v) science-based instruments; and (vi) their selection and combination of instruments to support decision-making to avoid and reverse land degradation. We use examples from diverse decision-making contexts, specifically examples that relate to Sustainable Development Goals' targets, to illustrate these competencies.

8.3.1 Competencies for legal and regulatory instruments

8.3.1.1 Strengthen the implementation of legal and regulatory instruments

Institutional competencies create favourable conditions for the implementation of the law and regulations. Goal 16 (Peace, Justice and Strong institutions) of the Sustainable Development Goals specifies the need to develop conditions for access to justice and the law, as well as to encourage representative and participatory decision-making.

The development of conditions for access to justice and law

SDG Target 16.3 states: "promote the rule of law at the national and international levels and ensure equal access to justice for all." Access to justice can contribute to combating land degradation and developing restoration solutions. Sustainable land use could be safeguarded by access to justice to secure land-use rights, especially those of indigenous peoples. It has been recognized that the major part of the natural resources coveted for commercial purposes such as minerals, forests and oil are in territories used or occupied by indigenous peoples (UN General Assembly, 2013). At the same time, it is recognized (CIPTA & WCS, 2013; Jonas, 2017; Nelson & Chomitz, 2011; Porter-Bolland *et al.,* 2012; Schabus, 2017) that, under certain conditions (e.g., Ostrom 1990, 2000), "areas and resources under the governance and/or management of indigenous peoples and local communities are more effective than strictly protected areas at preventing deforestation, maintaining forest health and ecosystem connectivity, and conserving biodiversity and natural resources" (Jonas, 2017). Actions leading to the legal protection of the traditional land management methods can be favourable to address land degradation problems and develop restoration solutions. However, in this case, the question of how to secure land-use rights arises (see Sub-section 8.3.2.1) and more specifically the recognition of the rights of indigenous peoples and local communities (Schabus, 2017) (see also Chapter 5).

Also, as Oliver de Schutter noted: "there is no reason not to extend the recognition of communal rights beyond indigenous or traditional communities particularly where the management of common pool resources at the local level proves effective" (De Schutter, 2010).

However, access to justice is inseparable from access to law, as pointed out by SDG Target 16.10: "ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements". In other words, actors must first know their rights in order to initiate legal proceedings. This requires improving the transparency of institutions at different levels of decision-making, as targeted for in SDG 16.

The other side of this access to justice and law is to know legal obligations and prohibitions. These obligations and prohibitions must be accompanied by dissuasive sanctions in the event of non-performance, but also by strong institutions capable of enforcing them. This involves police and judicial institutions (SDG Targets 16.4 and 16.5). In addition to the fact that this corruption impedes the implementation of legal instruments designed to protect the environment, it also has a cost: "corruption, bribery, theft and tax evasion cost some $1.26 trillion for developing countries per year" (Kar & Freitas, 2011: i). Law enforcement problems are generally related to a lack of political willingness or high levels of corruption. Corruption, in particular, reduces the financial resources for land degradation response actions. It also hampers adequate project evaluation as reported results could inflate successes and omit failures (Langseth, 1999). Independent and sufficiently paid project coordinators and evaluators could reduce this risk.

Law enforcement and regulation are key in successfully halting and reversing land degradation. Irreversible ecosystem regime shifts towards non-desired states can be avoided by regulating or prohibiting activities such as the over-extraction of natural resources, uncontrolled pollution and/or land-use changes. While top-down law enforcement may be efficient in countries with strong and well-equipped institutions, regions with reduced social, physical and financial capital may suffer high levels of impunity. In the latter case, local surveillance brigades, regulation mechanisms and justice systems can contribute to monitoring systems and reduce the prioritizing of individual benefits over the conservation or restoration of the ecosystem (Karp, 2011). Local fire brigades (Beringer, 2000) and poaching surveillance teams are good examples of local (and often informal) initiatives to reduce ecosystem damage.

However, while it is important to provide legal access to justice, other dispute-resolution processes that also contribute to social peace should not be excluded (Frison-Roche, 2012). In other words, local social dispute-settlement mechanisms should not be overlooked. More generally, the role of local actors in the decision-making process should not be overlooked at all decision-making scales. This is discussed in the following Sections.

Representative and participatory decision-making

SDG Target 16.7 states: "ensure responsive, inclusive, participatory and representative decision-making at all levels". Consequently, different types of actors need to be involved in international and national decision-making, including companies, NGOs, indigenous peoples and local communities.

At the international level, the need for inclusive decision-making can be illustrated with intergovernmental decision-making to combat climate change. This top-down approach is sometimes considered a failure, because of the weak administrative capacity to monitor and enforce global greenhouse gas emission standards, and the strong debates between nations about the responsibility of those who benefited from climate-destructive practices (Orts, 2011). Also, the relocation of high-emission activities to less regulated places is a challenge for global regulation. The solution to intractable problems like climate change and land degradation can be found in new modes of global environmental governance (Orts, 2011). This has resulted in the opening up to other governance bodies such as cities, businesses, NGOs and universities, a phenomenon also known as "global assemblages" (Sassen, 2006). International law and international environmental governance gradually opens up to transnational law and not only intergovernmental law (Maljean-Dubois, 2003). These new modes of global environmental governance involve ensuring and strengthening the representation and participation of key players in international decision-making bodies. For this purpose, UNEP ensures that the voices of indigenous peoples are heard and taken into consideration in the development of programs at the local, regional, national and international levels. This consideration is formalized within the framework of the UN Declaration on the Rights of Indigenous Peoples of 13th September 2007. Indigenous groups operate at an international level through the UN Permanent Forum on Indigenous Issues (UNPFII), the Convention on Biological Diversity International Indigenous Forum on Biodiversity (IIFB) and the United Nations International Indigenous Forum on Climate Change (UNIFCC),

Nation-level participatory decision-making is also promoted. Concretely, this implies opening up spaces for participation at the local level **(Box 8.7)**, but also ensuring the effective participation of local actors in the decision-making process.

Box 8 7 **Competencies for including local participation in legal conservation actions.**

Sacred groves are relict forests conserved through reverence. They are found in many parts of the world across Asia, Africa, Europe and North America. In India the sacred groves are predominant in the Eastern-Ghats, Western-Ghats and Northeast region. In order to protect and conserve relict and keystone species of ecological importance many countries in the Asia Pacific region have been conserving sacred groves through traditional practices. Many keystone species are conserved by rural and tribal communities, who believe that these trees are abodes of their deity or spirits of their forefathers. The sacred groves have helped in many places to maintain the water table. The sacred groves have been conserved through traditional mechanisms and responsibility of protection and maintenance of the area of sacred grove is passed from one generation to the next through traditional means. Due to the dilution of traditional beliefs and increasing disinterestedness within the tribal youth, these sacred groves are gradually losing their importance and are shrinking in area. The Indian Biodiversity Act of 2002 aims to address this issue. A mechanism under this Act facilitates the recognition and formalization of a sacred grove as a Biodiversity Heritage Site (BHS) which are maintained by a legal body, namely the Biodiversity Management Committee (BMC); responsible for conserving bio-resources in a Panchayat. There is a need for further policy initiatives in the Asia Pacific region to recognize and conserve these sacred groves. The Indian mechanism could be replicated in the countries of Asia Pacific region that are signatories to the CBD, for example (Chandrashekara & Sankar, 1998; Ramakrishnan *et al.,* 1998).

Ensuring the effective participation of local actors in the decision-making process (Tamang, 2004) could offer some win-win solutions (De vente *et al.,* 2016), such as increases in local support for biodiversity conservation laws and policies and enhancements in the capacity to adapt to shifting environmental conditions (Thériault, 2011). Inclusive decision-making can also lead to legal reforms. For example, in Canada, the "free-entry mining" principle (on which most mining regimes are based) finds its direct origins in the practices and customs established by miners in the context of the 19th century's gold rushes (Barton, 1993). This principle entails a prioritization of mining activities over other uses of the land and may be fathomable in its historical context. However, there is a growing consensus that it has become at odds with competing priorities and values regarding environmental protection, social acceptability and respect for Aboriginal rights (Bankes, 2004; Campbell, 2004). Yet, Aboriginal peoples' constitutional rights have influenced recent mining governance reforms in Quebec and Ontario, in particular with the duty to consult and accommodate Aboriginal people (Thériault, 2013). On a global level, the International Council on Mining has developed a good practice guide for working with indigenous people (ICMM, 2015).

However, strengthening institutional competencies to ensure the implementation of legal policy instruments requires not only that the instruments exist, but also that the design of these instruments is relevant.

8.3.1.2 Design or improve legal and regulatory instruments

The improvement or design of legal tools applicable to land degradation and restoration decision-making relates to the gradual evolution of environmental law. In order to develop strong environmental law, institutional competencies are needed to help to strengthen existing legal tools. This is particularly the case for environmental impact assessment, a critical tool for making informed decisions. As for the design of legal instruments, it is important that it be guided by legal principles that favour a better consideration of the environment.

Improving existing tools: the key role of environmental impact assessment

In many countries, environmental impact assessments (EIA) are carried out before a project, plan or programme is implemented and constitutes an essential legal decision-making tool that typically leads to the authorization of the plan, the project or the programme in question (Wood, 2003). The "avoid-reduce-compensate" sequence helps to reinforce the consideration of the environment by specifying the nature and sequence of the data to be included in an impact study. This focuses chiefly on assessing the environment and, as such, omits the impacts of proposed developments on the culture, societies and ways of living of indigenous peoples and local communities. That explains the role of the Akwé: Kon Guidelines (adopted by the Convention on Biological Diversity) to conduct cultural, environmental and social impact assessments regarding developments on lands and waters traditionally occupied or used by indigenous and local communities (Schabus, 2017).

The "avoid-reduce-compensate" sequence can be improved in several ways to address land degradation challenges. The first possible improvement is to give a better visibility to the combat against land degradation and the development of solutions for its restoration by avoiding, reducing and offsetting land (UNCCD, 2013) (see also Chapter 2 for examples).

Secondly, another possible improvement is to clarify the "avoid-reduce-compensate" sequence as one of the elements of the environmental assessment, in particular regarding offsets. Indeed, the use of compensation in the land degradation decision-making must be properly understood. Offsetting can give the illusion of effective prevention of land degradation. More broadly, there is a risk of giving the illusion that economic development can nearly always be reconciled with environmental protection. Indeed, compensation can be an ecological solution since the degradation of one land will be compensated by the restoration of another, despite the fact that, in any event, land will ultimately be degraded. This is what conditions compensation. Moreover, it is based on a short-term logic since it assumes that there will always be a quantity of land available to compensate for past degradation. However, efforts can be made to prioritize the different steps of the avoid-reduce-compensate sequence. This sequence has been clarified, for example in the 2016 French Biodiversity Law by clearly hierarchizing the different stages, so that the compensation appears at the end of the sequence after the measures of avoidance and reduction of environmental damage (Article L. 110-1 French environmental code). The hierarchy of the different stages of the avoid-reduce-compensate sequence is an important evolution, but could be considered insufficient. In French legislation, maintaining and integrating the avoid-reduce-compensate sequence as a whole, into the principle of prevention, offers a paradoxical message: it suggests that compensation is a matter of prevention while the damage has in most cases already occurred (Martin, 2016).

Environmental impact assessment is an application of the principle of prevention defined in Principle 17 of the UN 1992 Declaration on Environment and Development. However, different environmental principles can be instruments of environmental law to guide states in the development of new policy instruments relevant to land degradation and restoration decision-making.

The design of new environmental tools: the role of environmental principles in order to take better account of the environment

Environmental principles are specific legal instruments insofar as they govern environmental action at the international, but also national level. These environmental principles can be integrated into the national law of states through the application of international law, but also through a reciprocal influence of the national laws. Environmental principles guide the writing of environmental law by contributing to coherence between environmental interests and other interests, but also by participating in the structuring of environmental law.

Many principles have already been developed and recognized internationally in the context of various international conventions and declarations (for example, Declaration of the UN Conference on the Human Environment, 1972 or the Rio Declaration on Environment and Development, 1992). Examples include the polluter-pays principle and prevention principle. More recently, the precautionary principle or the principle of public information and participation in decision-making has also been applied. In general, these environmental principles are now recognized as common references for the international community. Indeed, by virtue of being enshrined in international texts (even non-binding ones) these principles have acquired legal value. These same principles can also be incorporated into binding international conventions. In this case, the principles become binding to the country Parties of these conventions. For example, the Convention on Biological Diversity (CBD) includes the precautionary principle. Several principles also guide the parties to the UN Convention to Combat Desertification (UNCCD) "to achieve the objectives" of the convention and "to implement its provisions" (Article 3). These principles include, for example, the participation of local populations in the design and implementation of programmes to combat desertification and/or mitigate the effects of drought (Article 3a). It includes establishing "cooperation among all levels of government, communities, non-governmental organizations and landholders to establish a better understanding of the nature and value of land and scarce water resources in affected areas and to work towards their sustainable use" (Article 3c) (Chasek *et al.,* 2011; Stringer *et al.,* 2007).

So, to improve their state legislation, state institutions must have the necessary institutional competencies to participate in the elaboration of these international texts and above all to be able to respect these international conventions **(Box 8.8)**. UNEP is helping countries to meet commitments under multilateral environmental agreements and to integrate environmental concerns into national plans and strategies.

There are principles that do not fall within the scope of an international reference system, that is to say an internationally-shared vision by all states. In that case, a principle can be defended at the national level by a state. An example of this is the principle of ecological solidarity; an unprecedented principle adopted by French legislation since 2016 (see Chapter 2, Section 2.2.1.2). Looking at other national laws can be an important source of inspiration for other state legislations, but also for regional or even international conventions.

There are several ways of developing and integrating environmental principles that consider human relationship with land into environmental law. The adoption of these principles can guide decision-makers in the choice of relevant policy instruments to be developed. In particular, they contribute to the establishment of a coherence between environmental interests and other interests, Box 8 8 **Local environmental regulation in Pará, Brazil.**

In order to ensure the effectiveness of environmental regulation, the establishment of international standards is considered an important step. However, it is also established that the ultimate responsibility for the implementation of the regulations rests with the actors on site. These actors include state institutions which, in the name of national sovereignty (Hashmi, 1997; Willmore, 2017), may or may not adhere to international conventions for the protection of the environment and/or draw-up national environmental legislation. Other actors include citizens, NGOs and local public officials (Arnaud, 2014; Giddens, 2009).

Here the example is the case of halting deforestation in the Brazilian Amazon. In 2008, the offices and cars of the Brazilian Institute for Environment and Renewable Natural Resources (IBAMA) were burned down, because the institute's work had led to the closure of ten sawmills in Paragominas, State of Pará. The extraction of timber was the source of income for half of the inhabitants of this town. A pact between public administration, citizens, rural producers and businesses helped to relax these tensions. In 2011, the city of Paragominas adopted a municipal environmental code and created a council composed of representatives of the public administration and civil society to develop the project of living in a green municipality, where forest products would benefit from environmental certification. This project also appealed to companies. In a second stage, the municipality, with the help of NGOs, also instituted monitoring mechanisms to ensure compliance with the municipal environment code, in particular the ban on transforming indigenous trees into coal.

but also among environmental interests (e.g., as called for in SDG 17). In addition, these principles structure environmental law and contribute to its progression while leaving room for decision makers to manoeuvre.

Firstly, environmental principles contribute to the development of environmental law by bringing environmental interests in line with the objectives of halting or reversing land degradation, together with sustainable development. This is particularly the purpose of the principle of integration. According to Principle 4 of the Rio Declaration on Environment and Development (1992), "in order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it". Land-use planning and management is a practical way to achieve it (see also Chapter 6). The principle of integration can also be reflected in the promotion of integrated management, such as the "ecosystem approach" (Chapter 1). The ecosystem approach also concerns the principle of participation, as it underscores the need to understand and factor in societal choices, the rights and interests of indigenous peoples and local communities, and have inclusive decision-making (Morgera, 2017). In addition, the ecosystem approach concerns the precautionary principle, because of the lack of our knowledge and uncertainties in ecosystem functioning, further highlighting the need for adaptive management (Armitage *et al.,* 2009; Morgera, 2017). In this case, adaptive management is understood as a "new legal paradigm" (Tarlock, 2007).

Coherence is necessary within environmental objectives, themselves, and not just between the objectives of the various pillars of sustainable development. Further emphasis is placed on land in SDG Target 15.3: "by 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world". Goal 15 and its targets must therefore consider many different environmental goals. While legal solutions can be sought to identify synergies, they often also involve combating the fragmentation of the law regularly accompanied by institutional fragmentation (Maljean-Dubois, 2003). This requires water laws to interact with land and climate laws (Reed & Stringer, 2016). Dialogue must also take place between each corresponding institution (Stringer *et al.,* 2009). Indeed, institutional compartmentalisation can lead to inconsistencies or conflicts in policy proposals, between the authorities and in the missions of the institutions.

Secondly, environmental principles are tools to structure environmental law and the development of policy instruments without imposing a given instrument. In other words, they help to establish a strategy for environmental law in which land degradation and restoration decision-making must be implemented without pre-defining or pre-establishing any particular legal instrument. Depending on the place-specific needs, it can be a set of legal instruments adapted to the situation at a given moment.

8.3.2 Competencies for rights-based instruments and customary norms

This sub-section provides examples of institutional competencies that contribute to the effectiveness of a human rights-based approach to strategies to address land degradation problems and develop restoration solutions. In this context, it focuses particularly on competencies that have proven to be useful in processes and procedures aiming at securing land rights (see Section 8.3.2.1), in those aiming at advancing the enjoyment of a clean and healthy environment (see Section 8.3.2.2) and in those aiming at fostering the respect of customary norms (see Section 8.3.2.3).

8.3.2.1 Securing land rights

Secure rights to land of rural communities (indigenous and non-indigenous) and of their members are considered as an essential contribution to the realization of human rights such as the rights to adequate food, water, health and housing; even though a human right to land has not yet been recognized in international human rights law (UN High Commissioner for Human Rights, 2014; UN Human Rights Office of the High Commissioner, 2015). Secure land rights are also inextricably linked to land degradation and restoration issues (UNCCD CSO Panel, 2017). At the same time, the human rights principle of participation in decision-making plays an essential role for securing land rights and in the responsible governance of land and natural resources (FAO, 2012; UN Human Rights Office of the High Commissioner, 2015). Institutional competencies for the development of effective participatory processes are hence a core element of land tenure security and policy responses regarding land degradation, as shown in the following examples in **Box 8.9**.

8.3.2.2 Advancing the enjoyment of a clean and healthy environment

After recognizing that no global agreement explicitly establishes a right to a healthy (and other related adjectives) environment, the Independent Expert of the United Nations on human rights related to the enjoyment of a safe, clean, healthy and sustainable environment, identified two aspects of the relationship between human rights and the environment as "firmly established" in a first report to the United Nations Human Rights Council (United Nations Human Rights Council, 2012). First, that "environmental degradation can and does adversely affect the enjoyment of a broad range of human rights, including rights to life, health, food and water" (see also UNEP, 2015). Second, that "the exercise of certain rights can and does benefit environmental policymaking, resulting in better environmental protection and, as a consequence, greater protection of human rights that may be threatened by environmental degradation". He was referring specifically to the following procedural rights: rights of expression and association, the rights of information and participation, and the rights to remedy. In 1992, Charles Alexandre Kiss (a French environmental law pioneer) stressed the need to ensure that everyone and all human groups have adequate procedures to protect "their" environment, which is often shared with others. Kiss described this right to the environment as a procedural right of an individual, or an individual right to protect the environment. Concretely, Kiss explains that the constitutional provisions that impose on the State to protect the environment are generally formulated, whereas procedural law obliges the public authorities to intervene in concrete situations, on individual complaints (Kiss, 1992, 1993, 2004).

In a second report to the Human Rights Council (United Nations Human Rights Council, 2013), the Independent Expert identified three procedural obligations that human rights law imposes on States in relation to environmental

Box 8 9 **Securing land rights in Colombia and Costa Rica.**

In Colombia, Article 58 of the Constitution recognizes that property, as a social function that implies obligations, has an inherent ecological function. In this context, a participatory approach has been adopted in the procedure for expanding the territory of indigenous reserves ("*resguardos indígenas*"). As part of this procedure, compliance with the ecological function of property in an indigenous reserve is verified and certified by national authorities, as a legal requirement for delivering the authorization for the reserve's expansion. Acknowledging its intrinsic relation with the physical and cultural survival of those peoples, the ecological function of property in indigenous reserves has been seen as an opportunity for crossing different views over a territory and so, as a tool for facilitating dialogue between different disciplines and worldviews. As a means for enhancing institutional competencies for this facilitation purpose, it has been proposed that agencies in charge of the procedure put together multidisciplinary, multiethnic and interinstitutional teams (Londoño Toro *et al.,* 2004).

In Costa Rica, a participatory process initiated in 2005 has enabled taking important steps both for securing land rights of members of the non-indigenous communities that live inside the Ostional Wilderness Refuge and for perpetuating the management and conservation of sea turtles programme developed by the Ostional community. This process was formalized in 2008 with the creation of the Interinstitutional Advisory Council of the Ostional Wilderness Refuge (CIMACO). The enactment, in 2016, of the Ostional Wilderness Refuge Act, which authorized granting 25 years renewable concessions to members of the communities inside the Refuge, has been to a great extent possible thanks to this participatory process that succeeded in ending conflicts between different stakeholders in the Refuge through dialogue. Institutional competencies have been very important for driving this process: first by gathering all the interested parties in the Refuge around the discussion table; second by breaking the deadlock at a moment where no consensus could be reached, hiring the support of specialists in alternative dispute resolution, facilitation and social mediation; and third by building up a solid scientific base for decision-making support (Brenes Chaves & Cedeño, 2017).

protection: duties to assess environmental impacts and make information public, duties to facilitate public participation in environmental decision-making and the duty to provide access to legal remedies. The Independent Expert also identified the following three substantive obligations: (i) the obligation to adopt and implement legal and institutional frameworks; (ii) obligations to protect against environmental harm from private actors; and (iii) obligations relating to transboundary environmental harm. According to a 2012 survey, there are at least 92 countries that have granted constitutional status to this right and 177 countries recognize the right through their constitutions, environmental legislation, court decisions or ratifications of international agreements (Boyd, 2012). In 2017, the Brazilian High Court's Justice Antonio Herman Benjamin made similar conditions to guarantee the right to a healthy environment. He was invited to answer the following question within the framework of UNEP: "more than 100 constitutions recognize the human right to a healthy environment. So why do environmental degradation and natural resource exploitation continue to plague the planet?". His reply stressed the need for effective access to legal proceedings: "just because a right is laid out in a treaty doesn't mean that it's implementable. That's why we need courts". He added that "the best system for implementing environmental law is a system where all stakeholders participate in a transparent manner. This means that we need a transparent executive, an effective legislature, an efficient administration and a strong civil society to help hold the system to account" (UNEP, 2017).

Finally, in a third report to the Human Rights Council (United Nations Human Rights Council, 2015), the Independent Expert presented a compilation of good practices of governments, international organizations, civil society organizations, corporations and others in the use of human rights obligations relating to the environment. The following are examples of those good practices related to the enhancement of institutional competencies for designing and implementing policy instruments that are useful for fulfilling the above-mentioned obligations:

- Since 2010, the Asian Development Bank hosted a series of judicial symposiums on environmental decision-making, the rule of law and environmental justice, with the aim of building relevant expertise of judges.
- Certain states have committed to support the implementation of the Guiding Principles on Business and Human Rights, endorsed by the Human Rights Council in Resolution 17/4. The United Kingdom and Northern Ireland have done so by "ensuring that agreements facilitating overseas investment do not undermine the host country's ability to impose the same environmental and social regulations on foreign investors as does on domestic firms".
- Some states have promoted informed participation by those most affected by environmental harms. In Finland, the Action Programme on eServices and eDemocracy, implemented in 2009, was designed to develop new tools on citizen participation in land-use planning. In Finland too, the city of Tampere created public advisory groups. Since 2007, and for the time of the Independent Expert's Report, they had participated in more than 350 planning-related decisions.

Box 8.10 provides a recent example of a case in which human rights are linked to the right of a healthy environment.

Box 8.10 Appeal to the Philippine Commission on Human Rights for violation of the right to a healthy environment as human right.

On 22 September 2015, Greenpeace Southeast Asia and the Philippine Rural Reconstruction Movement – alongside persons surviving typhoons or cyclones – appealed to the Philippine Commission on Human Rights to identify the responsibility of 47 companies for climate change and their violation of fundamental human rights, such as the right to a healthy environment. In particular, this appeal asks the Philippine Government to take appropriate measures to reduce these effects, that is to adopt legislation which imposes environmental obligations on these companies and which would enable victims to seek redress in the courts. On 8 December 2016, the Philippine Commission on Human Rights decided to grant the request from civil society and to initiate investigations against companies accused of participating in climate change. On 27 July 2016, the Commission on Human Rights sent the complaints lodged by the applicants to the CEOs of these companies. On 11 December 2017, the Commission held a preliminary conference to which all parties had been invited with the aim of considering the following: simplification of issues, stipulation or admission of facts and of documents, witnesses to be presented, marking of documents and such other matters as may aid in the prompt resolution of the petition. The first formal inquiry hearing is expected to be conducted at the end of the first quarter of 2018.

This is a legally-unprecedented situation, since it is the first time that a complaint of this nature has been relayed (pointing to the risk of climate change for society and highlighting the involvement of private actors in the violation of human rights) by a Commission on Human Rights. This confers a clear legitimacy on the complaint.

8.3.2.3 Fostering the respect for customary norms

Adequate institutional competencies of indigenous and local communities to develop and use biocultural community protocols -- simply referred to as "community protocols" in the Nagoya Protocol to the Convention on Biological Diversity -- can play an important role in advancing the respect of customary norms and in this way contributing to strategies to reduce land degradation and restore degraded land **(Box 8.11)**. One of the main characteristics of these protocols is that they are developed through a community-led and endogenous participatory process (Jonas *et al.,* 2010). However, for reasons as simple as the fact that this concept is completely new for communities, they will usually need external assistance to enhance competencies both to initiate and to execute the process (LPP & LIFE Network, 2010). In this regard, NGO Natural Justice's toolkit for facilitating the development and use of biocultural community protocols suggests the facilitation should be done by members of the concerned community or from supporting organizations with whom they have long-standing and positive relationships (Shrumm & Jonas, 2012). For the same reason, in the context of Article 12 of the Nagoya Protocol to the Convention on Biological Diversity, commentators have considered that assistance from Parties in developing community protocols is not always appropriate when the concerned indigenous or local community has the capacity and the will to handle it by itself (Greiber *et al.,* 2012). It has also been acknowledged that the facilitating entity and mediators should only provide assistance if and when required by the community, that they should act with professionalism and dedication, that they should not rush or bias the process, that they should conduct background research before the process is started and that assistance could take the form of training on aspects such as documentation, data collection, legal empowerment and facilitating meetings with government (LPP & LIFE Network, 2010).

There are different actions required for developing a biocultural community protocol, such as reflecting about the interconnectedness of various aspects of the community's ways of life, including their customary norms; learning about the national and international legal regimes that regulate those aspects; articulating all this and other information in the protocol; and enhancing the community's capacity to engage with other stakeholders like government agencies, researchers and project proponents (Jonas & Bavikatte, 2009). This includes the ability to better advocate in favour of the effective implementation of and compliance with Articles 8(j) and 10(c) of the Convention on Biological Diversity, in particular the Parties' obligations to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity" and to "protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements".

8.3.3 Competencies for economic and financial instruments

A range of public and private economic and financial instruments are available to steer strategies to halt or reverse land degradation. These include, among others, payment schemes for ecosystem services, voluntary payments, subsidies, insurance schemes, taxes, tradable rights, offsets, microfinancing, eco-labeling, auctions and efforts leverage corporate social responsibility mechanism in production sectors. Chapter 6 provides an overview of these instruments and their effectiveness (see Section 6.3.2.3). Adequate institutional competencies support the design and implementation of these economic and financial instruments. Here we will discuss competencies for two

Box 8 11 **Biocultural community protocols and their importance for advancing the respect for customary norms and contributing to strategies to reduce land degradation and restore degraded land.**

A biocultural community protocol can be defined as "a document that is developed after a community undertakes a consultative process to outline their core cultural and spiritual values and customary laws relating to their traditional knowledge and resources"; but it can also been considered as being at the same time a process and a product (LPP & LIFE Network, 2010). A detailed description of community protocols and their contribution to the respect of customary law has recently been provided in the Mo'Otz Kuxtal Voluntary Guidelines adopted by Decision XIII/18 of the Conference of the Parties to the Convention on Biological Diversity. By documenting and describing aspects such as the way of life of the community, its customary laws, cultural and spiritual values, governance and decision-making structures, as well as the relevant national and international law (Bavikatte, 2011), indigenous and local communities provide clarity to external agencies and stakeholders – facilitating recognition of all the rights that are needed to secure community stewardship over their lands and waters (Bavikatte & Bennet, 2015). Biocultural community protocols can help communities gain recognition for, among other things, their territorial sovereignty, community-based natural resource management systems and community conserved areas, sui generis laws, sacred natural sites and globally-important agricultural heritage systems (Jonas *et al.,* 2010).

instruments related to ecosystem service markets in detail: payments for environmental services and offsets (see Section 8.3.3.1) and the need for standardized national-level information on ecosystems and their contribution to economic development (see Section 8.3.3.2).

8.3.3.1 Payments for ecosystem services and biodiversity offsets

For both payments for ecosystem services and biodiversity offsets, the devil is in the detail: small changes in the institutional design may have large consequences for the performance. Market offset programmes are often believed to be efficient due to the low transaction costs involved, compared to the bureaucratic case-by-case compensation procedure of Natura 2000 sites in the EU. However, if neither the seller nor the buyer have incentives to assure quality of the traded object (because this is largely a public good), and the object is extremely complex, then robust monitoring and enforcement are needed to assure intended outcomes. Hence, the institutional capacity and transaction costs associated with markets for ecosystem services (biodiversity offsets and voluntary payments for ecosystem services) are often high compared to taxes, subsidies and regulations, which suggests that a priori assumptions about cost-effectiveness of various policy tools should be avoided (Gómez-Baggethun & Muradian, 2015; Hahn *et al.,* 2015). Briggs *et al.* (2009) warn that "without careful regulation, habitat banks could offer low-cost compensation as a result of cutting corners on conservation, and the market would reward poorly managed banks and thus harm conservation efforts" (p. 117). The dichotomy of government regulations versus markets is therefore false (Vatn, 2015); the more we use markets to finance restoration of complex ecosystems, the more institutional capacity and regulations are needed to safeguard the intended outcomes (Glicksman & Kaime, 2013; Hahn *et al.,* 2015; Koh *et al.,* 2017). The institutional capacity needed to design and monitor market-type biodiversity offsets, where conservation credits are traded on market conditions, seems to be too high even for advanced market economies. For example, the German compensation scheme, in which the "trading" is conducted by municipal or private agencies appointed by the state, require less institutional capacity to create and enforce market-like trade (Eftec, 2010).

Institutional capacity includes both general governability (as opposed to incapability and corruption) and specific ability to craft regulations as well as resources (e.g., government funding to environmental agencies) to undertake monitoring and enforcement. In that sense, there is no surprise that Pigouvian-type payment for ecosystem services -- financed by environmental taxes and paid by the government as in Costa Rica – are the most common and most successful. Coasean-type payment for ecosystem services relying on voluntary private payments require advanced market institutions. As emphasised by the Millennium Ecosystem Assessment (MA, 2005), effective policy tools are those that realize synergies and minimize trade-offs. When designing payments for ecosystem services to support the restoration of degraded land, it is therefore important to evaluate the potential effects on equity, tenure rights, biodiversity and ecosystem services. An important element to consider when predicting or assessing the effectiveness of economic incentive-based tools, is their interplay with the normative systems and motivations of targeted actors. The critics of ecological compensation are concerned that such schemes may create the false impression that any impact can be compensated for, whereas ecosystems' link to livelihood opportunities and psycho-cultural well-being (Brown *et al.,* 2013; Ryan *et al.,* 2010; Weimann *et al.,* 2015) are locally specific and therefore not fully replaceable (Escobar, 2008; Forest Peoples Programme, 2011; Quétier & Lavorel, 2011).

Economic instruments provide governments and civil society with an important tool for tackling biodiversity and ecosystems services loss. They have been developed towards improved ecological targeting and improved economic incentives. When combined with a careful verification and monitoring system, they will help to improve habitats and ecosystem services. Naturally, decision makers must carefully assess their limitations and suitability within diverse social and cultural contexts.

8.3.3.2 Ecosystem accounting

The design and implementation of national policies aiming at reversing ecosystem degradation is constrained by a lack of national-level information on ecosystems and their contribution to economic development (Hein *et al.,* 2015). In all countries, the gross domestic product (GDP) and related indicators are compiled based on the System of National Accounts. The need to integrate ecosystem change into statistical frameworks is recognized (Boyd & Banzhaf, 2007; Obst & Vardon, 2014). Under auspices of the UN Statistical Commission, the System of Environmental-Economic Accounting -Experimental Ecosystem Accounting (SEEA-EEA) (UN, 2014) (in short "ecosystem accounting") has been developed as an experimental approach to systematically integrate ecosystems and ecosystem services into national accounts. Although ecosystem accounting is not yet recognized as an international standard, it complements the internationally-recognized approach described in the System of Environmental-Economic Accounting-Central Framework (SEEA-CF) (UN, 2014). Ecosystem accounting includes and provides guidance on the measurement of ecosystems in terms of condition, spatial extent, the capacity of ecosystems to supply ecosystem services and the benefits they generate (Hein *et al.,* 2016; Vargas, Hein, & Remme, 2017). Developing ecosystem accounts requires significant resources for the collection and integration of spatial, survey and statistical data, and skills needed to carried out the required spatial modelling and for the valuation of ecosystem assets and services (Hein *et al.,* 2015).

8.3.4 Competencies for social and cultural instruments

Institutional competencies and social-cultural instruments can set the scene for several key features for strategies to avoid and reverse land degradation at different levels, ranging from increased awareness of resource users to efficient national councils that implement broad-scale restoration strategies. Socio-cultural bottlenecks for successful conservation or restoration projects can often be reduced by strengthening competencies and promoting political willingness that address the following processes: poor collaboration between stakeholders; lack of well-trained local people; and single focus on short-term economic development. Competencies to address these bottlenecks are discussed in this sub-Section.

Land degradation affects many stakeholders and hence requires multi-objective strategies (see Section 8.2). Polycentric networks (Folke *et al.,* 2011) with active participation at multiple organizational levels are essential to oversee all interests (Dyer *et al.,* 2013). The ability to set up **multi-stakeholder partnerships** is considered crucial to simultaneously tackle different aspects of land degradation (Berkes, 2007; Folke *et al.,* 2011; Stringer *et al.,* 2012). Institutional mechanisms that facilitate transparent joint decision-making processes regarding environmental issues increase the efficiency of land degradation response strategies and its local adoption (see also Chapter 6, Section 6.4.2). Multi-institutional teams with the ability to foresee the possible trade-offs, offsets and/or synergies between different interests or institutions may create more win-win situations across environmental and other policies (Goldstein *et al.,* 2012), or reduce unexpected negative impacts on halting and reversing land degradation, such as unplanned land-use changes in areas with relatively healthy ecosystems. Local participation is best planned as partnerships or multilevel deliberation (Berkes, 2007) – a process where as many as possible involved parties collectively discuss land degradation and restoration issues and reflect on root problems, desired outcomes and strategies to get there. Especially indigenous and local knowledge can be of value to downscale existing broad-scale restoration strategies and adapt to local contexts (Rist *et al.,* 2010; Uprety *et al.,* 2012). Local resource users are often the first persons to detect ecosystem changes and the impacts of land degradation (Berkes, 2007), so monitoring programs and the design of restoration management plans can benefit from including local ecosystem experts (see Armitage *et al.,* 2007; Berkes, 2009; Cundill & Fabricius, 2010; Folke *et al.,* 2011; Gunderson & Light, 2006; Gunningham, 2009; more examples Schultz *et al.,* 2015).

Sufficiently-trained local people are paramount for many degradation-related processes including the design of locally-adapted restoration strategies, monitoring advances and ecosystem evolution and cost accounting. Important areas for biodiversity conservation and restoration are often remote rural areas with little access to high-quality education. The presence of a few local leaders with advanced education can create snow-ball effects and increase local awareness of nature's contributions to people and the importance of restoring degraded lands (Schmiedel *et al.,* 2016). Capacity-building goes further than knowledge and technology transfer; it also includes exchange of failures and successful experiences, training and awareness training. In addition, the competency to continuously auto-evaluate and adapt decision-making processes - and the resulting policies - creates the necessary flexibility to adjust land degradation and restoration strategies to changing realities. Ecosystems are in constant movement and can suddenly shift between different coexistent states or regimes (Folke *et al.,* 2004). Due to this spatial and temporal ecological heterogeneity, as well as changing socio-cultural contexts of large-scale projects, steady-state resource managements that aim to prevent change and reduce variability are likely to fail at some point. Instead, policies that embrace change and direct changes to desired outcomes for society and nature may yield better results (Chapin *et al.,* 2009). This can be more easily achieved with adaptive governance (Allen & Garmestani, 2015). Such a strategy combines several policies and is sufficiently flexible to adapt its goals to meet changing needs detected by reiterative monitoring (Gavin *et al.,* 2015; Guerry *et al.,* 2015; Levin *et al.,* 2013; Schultz *et al.,* 2015).

Finally, natural resources are often exploited with a short-term vision dominated by market-oriented forces (see also Chapter 2, Section 2.1). An attitude shift towards **environmental stewardship** is much needed for reducing indirect drivers of land degradation (Chapin *et al.,* 2009; Messier *et al.,* 2015). Economic drivers of land degradation, when put in context by inclusive wealth cost-benefit analyses, captures better nature's economic, social and cultural contributions to people. More and more scientists point to the shortcomings of traditional economic indicators such as countries Gross National Product and call for including mid- and long-term costs and benefits that come with exploiting or restoring natural resources (Folke *et al.,* 2011; Guerry *et al.,* 2015; Ouyang *et al.,* 2015; UNU-IHDP & UNEP, 2014). Institutional reforms may be required to better align private short-term and public long-term goals. Such approaches should be sufficiently communicated to the broader public to stress the human dependence on healthy ecosystems and direct natural resource management strategies towards community benefits, rather than self-interest of more powerful players. In this context, being able to learn from indigenous worldviews may be of particular interest. Natural elements and humans are often equallyvalued parts of the indigenous environment and natural resources and services are cared for instead of exploited (Roué & Molnár, 2016) (see also Chapter 2, Section 2.2). Nature and culture are often so closely interwoven that a reduction (degradation) or increase (restoration) in one is directly reflected in the other based on the principle "what we do the land we do to ourselves". The term "reciprocal restoration" has therefore been proposed to reflect this deep sense of stewardship among indigenous people (Kimmerer, 2011).

8.3.5 Competencies for science and technological instruments

Integrated environmental governance is an emerging scientific discipline. Several new and relatively easy-to-use modelling and support decision tools, which combine social and biophysical information, are rapidly being developed and are freely accessible online (Astier *et al.,* 2011; Bagstad *et al.,* 2013; Peh *et al.,* 2013) (see Section 8.2 and the online IPBES catalogue of policy support tools and methodologies).

On the other hand, understanding and managing land degradation, restoration and ecosystem functioning is challenged by: highly-heterogeneous contexts; complex cross-disciplinary processes with social, economic, cultural and ecological dimensions; poorly understood non-linear relations; trade-offs and amplifying or stabilizing feedbacks - often with effects and origins in different locations (Reynolds *et al.,* 2007; Simonsen *et al.,* 2014) (see Chapter 3, Section 3.2 for examples). Current important knowledge gaps include: (i) understanding environmental governance and the impact of environmental policies on land degradation and restoration in different contexts; (ii) measuring ecosystem services and natural capital as well as their changes during restoration; and (iii) understanding the links between altering ecosystem services and human well-being (Guerry *et al.,* 2015; Miteva *et al.,* 2012; Ruckelshaus *et al.,* 2013). Although commonly used simplified proxies – such as forest cover, carbon uptake rates or biological diversity – can reveal ecosystem changes (Belnap, 1998; Pereira *et al.,* 2013), they often result in misleading or partially-valid conclusions regarding ecosystem recuperation (Ferraro *et al.,* 2015). For example, indicators often reflect rapidly changing processes, while the underlying mechanisms may be evolving much more slowly and hence are more difficult to detect and monitor (Simonsen *et al.,* 2014). For these reasons, some scholars suggest that strategies to avoid and reverse land degradation require new integrative data, collected with innovative methods, to create comprehensible frameworks to guide decision-making processes (Miteva *et al.,* 2012). A current challenge is to account for spatial and temporal gaps between action and response. Therefore, continuously evaluating through time (for instance by not interrupting long-term monitoring programs when new governments are elected) and space (international or inter-regional) will create better insights into the various dynamics and changes in land degradation and restoration success.

New technologies continue to be developed for reducing implementation and monitoring costs, such as climate-smart agriculture or resource-conserving agriculture (see also Chapter 5), the use of drones for large-scale tree planting and remote monitoring (Zahawi *et al.,* 2015; http://www.biocarbonengineering.com/) or digital models to infer patterns of status, trends and detect causal mechanisms of biodiversity change (Cheung *et al.,* 2011; Franklin, 2009; Gill *et al.,* 2011; Guisan & Thuiller, 2005). However, these digital, computer-based, models can only approximate nature and human judgement and their use should not replace actual field monitoring programs, which are needed to ground-truth and calibrate the models.

The following three institutional competencies are key to develop and use sound scientific and technological instruments:

1. **Cross-institutional and interdisciplinary collaboration.** Restoration programme success requires strong, strategic and coordinated leadership among prominent government, scientific, citizen or private industry organizations – as well as sources of stable funding and adequate staff. Efforts should be participatory and cross-disciplinary (e.g., combining biophysical, social, economic and political data; Chazdon *et al.,* 2009; Ferraro *et al.,* 2015; Sassen *et al.,* 2013). The participation of the community and local land users and/or managers is paramount for collecting fine-scale local ground data and guaranteeing sufficient local labour. Local volunteers, citizen scientists and para-ecologists can implement assessment and monitoring activities (Couvet *et al.,* 2008; DeVries *et al.,* 2016; Sassen *et al.,* 2013) **(Figure 8.4)**. Formal and recurring training, tailored for the biodiversity and conservation community, is needed to build capacity within local communities and to promote the emergence of a new generation of scientists and land managers able to carry out integrated, multi-disciplinary work. Cultural and socio-political backgrounds influence levels of participation by community members and different recruitment strategies are needed for the retention of volunteers, para-ecologists, and communities (Bell *et al.,* 2008; Schmeller *et al.,* 2009; Schmiedel *et al.,* 2016; Vandzinskaite *et al.,* 2010). Participatory monitoring is most efficient when users: benefit directly from the resource; participate in conservation/management decision-making; socialize with other participants; and get rewards for their commitment and effective

monitoring (Singh *et al.,* 2014). However, although citizen science and broader participation of informally-trained scientists will yield more field data, some types of monitoring require more technical expertise (e.g., assessing chemical or radioactive contaminants). Furthermore, there needs to be well-trained staff to coordinate and oversee the data collection to ensure quality control and correct data archiving - otherwise the data are likely to not be comparable among data collectors and hence of limited utility.

2. **High-quality information collection and sharing.** Monitoring networks with coordinated and standardized nomenclatures, concept definitions, monitoring questions and/or goals and assessment and/or monitoring protocols (data collection, analyses and dissemination) allow for more complete assessment and monitoring programmes across larger regions (Herrick *et al.,* 2016; Schmeller *et al.,* 2014)). Communicating and defining common goals with other institutions or councils can be eased when common units and metrics are used. The ability to quantify ecosystems and its services as natural capital (next to financial, manufactured, social and human capital; Aronson *et al.,* 2007; Daily *et al.,* 2009; Wu *et al.,* 2011) can pave the road for interdisciplinary collaboration. Where monetary valuation is difficult to realize or is highly contested, natural capital can be quantified in biophysical terms or in impacts on human livelihoods (Myers *et al.,* 2013). New technologies, such as mobile phones and associated apps **(Box 8.12)** (e.g., EpiCollect; see also Aanensen *et al.,* 2009; Herrick *et al.,* 2016) can be used to upload bottom-up, fine-scale data to central Internet databases, and their interface with broader-scale regional and global data. This improves accessibility to high-quality data analyses across larger spatial and temporal scales and increases knowledge sharing (Guerry *et al.,* 2015; Olson *et al.,* 2013). Social media, using natural language processing, is very promising (Lin *et al.,* 2015), as is crowd sourcing for analyzing large datasets. Online repositories with free access to results from monitoring programmes are essential, starting with baseline assessments (see "deriving baselines" in Chapter 1) and change detection through time. User-friendly, intuitive and centralized data portals enhance communication and exchange of data among scientists, policymakers and the public. Information on existing policy and conservation strategies, as well as research findings, help to ensure that conservation and environmental policy strategies are up-to-date and compatible.

3. **Holistic understanding.** Ecosystems should be seen and studied as coupled human and natural systems or socio-ecological systems and hence land restoration requires integrative approaches where political, socio-economic, ecological, cultural, legal and technical actors and processes interplay (Berkes, 2007; Ferraro *et al.,* 2015; Folke *et al.,* 2011; Liu *et al.,* 2015). The ability to use integrated social and ecological information creates a more holistic understanding of land degradation problems and can help to design restoration strategies that tackle the underlying causes of environmental degradation. Integrative cost-benefit assessments of land restoration or land degradation processes include societal impacts (Daily *et al.,* 2009). Ecological damages or benefits often

Figure 8 4 **Knowledge sharing on field techniques to classify soil types between scientists and local land owners to improve savannah rangeland management in Kenya. Photo Credit: Jayne Belnap.**

interact in two directions with social, economic and cultural changes, such as in health-water or energy-food-water networks (Liu *et al.,* 2015). Integrated studies of coupled human and natural systems are needed as such cross-disciplinary processes are often poorly understood when studied by social or natural scientists, in isolation (Liu *et al.,* 2007). Both successful stories and failures are important to extract lessons learnt and common pitfalls.

An additional challenge is to guarantee the inclusion of newly generated knowledge into the decision-making process. Continuous collaboration between different stakeholders, particularly scientific leaders and high-level decision makers, during the design, implementation and monitoring is crucial to further develop and refine scientific frameworks and technical tools.

Funding institutions and international organizations including the Society of Ecological Restoration (SER), International Union for Conservation of Nature (IUCN), World Resources Institute (WRI), The Nature Conservancy, Future Earth, Global Land Project, The Global Partnership on Forest and Landscape Restoration, IPBES, and the Natural Capital Project can play a crucial coordination role in developing the above-mentioned competencies. These institutions can set research agendas through funding priorities and promote interdisciplinary investigation. More efficient global and local collaboration can be achieved by online platforms and forums, data and experience repositories and face-to-face meetings. In addition, research funding that matches for long-term processes involved in halting and reversing land degradation is called for (Stringer & Dougill, 2013).

8.3.6 Competencies for the selection and integration of policy instruments

A combination of instruments (policy basket) is typically used to govern policy interventions as it can strengthen impact. For example, for land degradation responses legal instruments have been used in combination with market-based tools to compensate land owners for their sustainable land management practices and have benefited areas and people beyond the field. Policy instruments can also negatively impact each other, for example when market-based and social-cultural instruments produce contrasting incentives. Moreover, the effects of the resulting policy interventions can have unanticipated consequences which may be positive (co-benefits), negative (trade-offs), or even perverse (the opposite of what was intended) (Bryan & Crossman, 2013) (see Section 8.4).

To account for interactions among instruments and their impact, the selection of policy instruments to halt or reverse land degradation needs to be based on an evaluation of the current institutional framework (Barton *et al.,* 2014; Ostrom, 2005). Primmer (2017) flags that: (i) new policy instruments need to match higher-level regulations and the law; (ii) need to match the mandate and competencies of the implementing organization; and (iii) should not be constrained by rigid organizational practice. This analysis of institutional constraints should pay attention to the mandates, competencies and practices at the different levels of administration. This was exemplified by a study showing the institutional constraints of the design and operationalization of a conservation auction, as an innovative mechanism for nature conservation, in Finland (Primmer, 2017). **Box 8.12** shows how legal constraints define the search for economic incentives for nature conservation.

Box 8 12 Payments for environmental services: additionality to a legal standard.

Payments for environmental services are generally defined as a transaction between agents with the aim of using land for maintenance or restoration of certain ecological functionalities. This contractual financing mode is considered an innovative law (Bennet & Carroll, 2014), but also asks for a degree of law required to receive a payment in return for an environmental service rendered. In several countries, environmental policy is based on the polluter-pays principle and not on the protective-pay principle, a logic conveyed by the payments for environmental services. In other words, in the name of the polluter-pays principle, a minimum of environmental obligations may be required (Defra, 2013; Langlais, 2013; Leonardi, 2014). However, in some countries, some actors are paid to comply with the law and stop illegal practices (Pirard & Sembres, 2010). The NGO GRET, states in this respect that "compliance with standards may be out of the reach of communities when their livelihoods are at stake" and adds that payments for environmental services may accompany "the transition to practices, permitting compliance with the law, the time they become effective" (http://www.gret.org/2016/04/paiements-services-environnementaux-pse-de-theorie-a-pratique/)

In reality, the difficulty for law is that under the same title, it is not quite the same instrument. In the Global North, payments for environmental services, a new concept, are perceived as a potential tool for their implementation. On the other hand, in many countries in the Global South, payments for environmental services are not a novelty. They remain "classic" funding tools for conservation (Langlais, 2017a; Le Coq *et al.,* 2016; Pesche *et al.,* 2013). Moreover, it should be emphasized that there is a significant gap between the payment for environmental services theory as presented by Wunder (2005), the actual promotion of this instrument on an international scale (Langlais, 2017b; Méral, 2012) and practice. For more in the different legal aspects of payments for environmental services, see: (Greiber, 2009, www.katoombagroup.org).

8.4 INTERACTIONS AMONG LAND DEGRADATION, RESTORATION AND OTHER POLICY AREAS

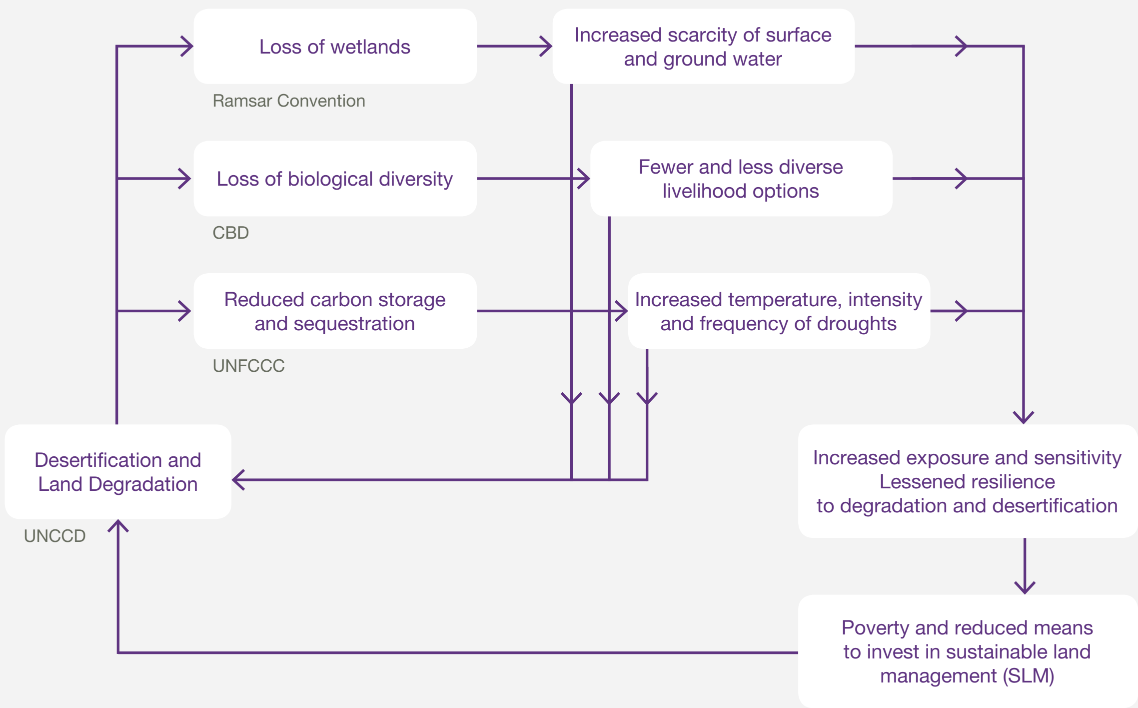
The linkages between land degradation and other global environmental challenges are increasingly recognized (Ding *et al.,* 2017; IUCN, 2015; Kumar & Das, 2014). Description of the land degradation-other global environmental challenges linkage is provided in Chapter 3 (see Sections 3.4.1 and 3.4.4), Chapter 4 (see Sections 4.2.7 and 4.2.9) and Chapter 7 (see Section 7.2.2). Degradation reduces the productivity of the land base, which in turn negatively impacts the provision of ecosystem services (e.g., food, fuel, fibre, freshwater, air and water purification and climate regulation) (MA, 2005). Land conversion and degradation are estimated to account for 4.4 Gt of CO_2e emissions each year (Matthews & Noordwijk, 2014). With each additional degraded piece of land, biodiversity loss is also exacerbated. The converse applies: addressing land degradation, for example, through restoration and prevention of degradation (action relevant to the UNCCD), can reduce greenhouse gas emissions (outcome relevant to the UNFCCC), contribute to conservation of biodiversity (outcome relevant to the CBD) (**Figure 8.5**), provide ecosystem services and enhance land productivity (outcome relevant to the SDGs).

This Section explores how various policy areas influence degradation or enhance possibilities to address land degradation and develop restoration. It also explores ways of identifying trade-offs in order to improve coherence and synergies between land and other policy areas. Other policy areas that are explored include agriculture, water, climate change and biodiversity conservation.

8.4.1 Existing multilateral agreements to harness synergy and co-benefits for land

The United Nations Convention to Combat Desertification (UNCCD), United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD) and Sustainable Development Goals (SDGs) all aim to halt or mitigate the deterioration of the ecological processes on which life depends. Effective responses to land degradation can simultaneously contribute towards the goals of the three Rio Conventions (Cowie *et al.,* 2011). They also support other multi-lateral environmental agreements such as the Ramsar

Figure 8 5 **Links between land degradation and desertification, biodiversity loss and climate change and their respective multilateral environmental agreements.**



Convention – the Strategic Plan of which has goals and targets addressing wetland loss, degradation and restoration. Effective responses also contribute to the achievement of the SDGs. Each of these international agreements and global goals operates at multiple levels. Taking a multi-level approach towards preventing and reducing land degradation and restoring degraded areas offers the potential to deliver benefits at various spatial and/or institutional levels and work across a number of policy areas and stakeholder groups (Hurni, 1998, 1997). This sub-section focuses specifically on the Rio Conventions and the SDGs. It reviews progress towards achieving the Aichi Biodiversity Targets and the SDG Targets, considering the implications for the linkages between land degradation, restoration, biodiversity and climate change.

Evaluation of relevant Aichi Biodiversity Targets indicates that progress is being made on the restoration of degraded lands and increase of forest land under sustainable forest management principles (FSC International, 2017) **(Table 8.4)**.

The 13th Conference of the Parties (COP 13) of the CBD, in 2016, also agreed upon a range of measures expected to accelerate the implementation of the Aichi Biodiversity Targets by 2020, as well as stimulate the expansion of protected areas, ecosystem restoration and sustainable wildlife management, which can contribute positively towards reducing land degradation as well as towards other policy areas like public health (FAO, 2015b). Countries further agreed on actions to integrate biodiversity in forestry, fisheries, agriculture and tourism

Table 8 4 **Land degradation and restoration relevant Aichi Biodiversity Targets and examples of progress to date.**

Aichi Target	Target description	Examples of progress made
Target 3	By 2020, at the latest, incentives, including subsidies, harmful to biodiversity are eliminated, phased out or reformed in order to minimize or avoid negative impacts, and positive incentives for the conservation and sustainable use of biodiversity are developed and applied, consistent and in harmony with the Convention and other relevant international obligations, taking into account national socio-economic conditions.	Transparent and comprehensive subsidy inventories and inventories of possible positive incentive measures were established by 2012 by all OECD countries, and an assessment of their effectiveness against stated objectives, of their cost-efficiency, and of their impacts on biodiversity, is underway.
Target 9	By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated and measures are in place to manage pathways to prevent their introduction and establishment.	Policy responses to deal with the invasive species problem have increased since the 1970s, and also the number of successful eradications; but the management implementation statistics are patchy and progress in this area less apparent (McGeoch *et al.,* 2015). Progress towards this target globally remains rather uncertain, nevertheless the importance of managing invasive alien species if land productivity is to be retained is well established (see e.g., Obiri, 2011). For example, over 560 alien species (most of them invasive) of various taxa were identified in the Southern Ocean Islands.
Target 15	By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks have been enhanced, through conservation and restoration, including restoration of at least 15% of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.	Forest and wetland restoration programmes involving positive incentive schemes are underway worldwide with signs of improvement evident in the state of forests and wetlands in many parts of the world. Such improvements can help to reduce flood risks and improve water management while also increasing carbon stocks (Locatelli *et al.,* 2015). The UN REDD programme launched in 2008 supports REDD+ activities in over 64 countries to mitigate climate change through reducing deforestation and forest degradation along with sustainable management of forests ("UN-REDD Programme," 2016). Carbon mitigation initiatives (like REDD+) also deliver substantial biodiversity benefits (Venter *et al.,* 2009). Sustainable management of forests following Forest Stewardship Council's principles and criteria has increased over the years from ca. 149 million ha in 80 countries in 2012 to over 195 million ha in 83 countries in 2016 (FSC International, 2017).

sectors, and to work towards achieving the 2030 Agenda on Sustainable Development. CBD COP 13 also included a decision to encourage Parties to consider biodiversity as they undertake climate change mitigation and adaptation actions (under the Paris Agreement 2015), and disaster risk reduction measures.

In addition to the Aichi Biodiversity Targets, halting, reducing and reversing land degradation and restoring degraded land are directly relevant to SDG 15 (sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss) and its targets **(Table 8.5)** (see also Akhtar-Schuster *et al.* 2017).

Although there have been conflicting reports about the success of sustainable agriculture practices (e.g., Garbach *et al.,* 2017), other studies (e.g., Enderton, 2014; Pretty *et al.,* 2005) suggest that sustainable agriculture practices and organic farming increase farm productivity through higher yields, higher water-use efficiency, and lower input costs compared to conventional practices **(Figure 8.6)**. Such low(-er) input approaches often involve less use of herbicides, also helping to maintain pollinator populations by having a positive effect on the abundance and diversity of the flowering plants that provide their food source (IPBES, 2016c). Sustainable land management, therefore, has potential to simultaneously address Targets 15.1, 15.2 and 15.3, and improve livelihoods while also contributing to other Sustainable Development Goals and Targets (e.g., Goal 2 Zero Hunger).

Table 8 5 **Land degradation and restoration relevant SDGs and examples of progress to date (Information synthesized from Akhtar-Schuster *et al.,* 2017).**

SDG Target	Target description	Examples of progress
15.1	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.	By 2014, 15.2% of the world's terrestrial and freshwater environments were covered by protected areas. The percentage of terrestrial key biodiversity areas covered by protected areas increased from 16.5% in 2000 to 19.3% in 2016. Over the same period, the share of freshwater key biodiversity areas that are protected increased from 13.8% to 16.6% and the share of mountain key biodiversity areas under protection grew from 18.1% to 20.1% (UN, 2016).
15.2	By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.	Between 1990 and 2015, the world's forest area decreased from 31.7% of the world's total land mass to 30.7% (FRA, 2015). During the same period, other areas were reforested through planting, landscape restoration activities or the natural expansion of forest. As a result, the net annual global loss of forest area declined from 7.3 million ha in the 1990s to 3.3 million ha per year during the period from 2010 to 2015 (FAO, 2015).
15.3	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.	Striving towards Land Degradation Neutrality, emerged from the UN Conference on Sustainable Development (Rio+20) in 2012, and responds to the immediate challenge of how to sustainably intensify the production of food, fuel and fiber to meet future demand without the further degradation of the finite land resource base (UNCCD, 2015b). Its objective is to maintain or even improve the extent of healthy and productive land resources over time and in line with national sustainable development priorities, through efforts such as the landscape approach (Figure 8.7). Three global indicators are being used to monitor progress towards the Land Degradation Neutrality target: change in land cover; change in land productivity (net primary production) and change in soil organic carbon stocks. Although important steps forward have been made in operationalizing the concept of Land Degradation Neutrality by the UNCCD's SPI in their Land Degradation Neutrality framework (Orr *et al.,* 2017), data on progress is currently lacking despite promising indications (Akthar-Schuster *et al.,* 2017).

Figure 8 6 **Comparison of sustainable and unsustainable agriculture practice activities.**

The figure highlights the actions required to achieve land degradation neutrality. Source: UNEP/UNCCD (2016).

Climate change and land degradation and restoration are closely interlinked and have impacts on a range of ecosystems and ecosystem processes, which in turn influence the provision of nature's contributions to people (Reed & Stringer, 2016). Interaction between climate change and land degradation will be felt very differently around the world: some areas will become drier while others become wetter (Business @ Biodiversity, 2010; UNCCD, 2015a) with knock-on implications for the people living there and the ecosystems that support them. The IPCC is currently preparing a special report on climate change, desertification, land degradation, sustainable land management, food security and greenhouse gas fluxes in terrestrial ecosystems - due to be completed in September 2019. The report is expected to synthesize knowledge on the links between climate change and land issues, offering possible ways forward to harness synergy between efforts that address the two issues.

Although it is too early to evaluate the impacts of the Paris Agreement (2015) and its effect on mitigating climate change and halting land degradation, earlier evidence suggests that land-based carbon sequestration and storage objectives create strong potential synergies between the UNCCD and UNFCCC and can improve resilience and capacity to adapt to the anticipated impact of climate change (Cowie *et al.,* 2011). The UNFCCC also tackles land issues in other ways. Afforestation and reforestation programs, which are part of the Clean Development Mechanism, increase carbon storage in soils and vegetation. Soil carbon management is further considered as one of the most cost-effective mitigation options under the Kyoto protocol (Al-Juaied & Whitmore, 2009; McKinsey & Company, 2009). Sustainable land management practices, which also build soil carbon, include conservation agriculture and agroforestry practices.

Reducing Emissions from Deforestation and forest Degradation (REDD+) is another initiative at the forefront of climate change mitigation efforts. REDD+ as an approach to halt deforestation and forest land degradation is simultaneously reducing carbon emissions and enhancing biodiversity conservation, while providing financial incentives to local communities and governments in developing countries (UNCCD, 2013) as well as Sustainable Development Goals on improving livelihoods. It is too early to make overall conclusions on the effectiveness of REDD+ as there are opposing views about it in the literature (e.g., Pasgaard *et al.,* 2016). With respect to REDD+ project implementation, socio-economic assessments may be useful not only as a means to evaluate impacts on livelihoods, but also to help understand the root causes of land degradation and deforestation at the community level. In practice, not considering or addressing the social dynamics (e.g., land degradation due to poverty) can lead to leakage, conflicts and the volatility of projects (Benessaiah, 2012; Parrotta *et al.,* 2012).

Other notable initiatives that complement the Aichi Biodiversity Targets on restoration and SDG 15 span multiple levels and include the Bonn Challenge and Global Restoration Initiative – efforts aimed at restoring 150 million hectares of degraded lands by 2020 and 350 million hectares by 2030 **(Box 8.13)**. Some country and regional initiatives such as Initiatives 20x20 (to restore 20 million ha of land in Latin America and Caribbean by 2020) and AFR100 (to restore 100 million ha of land in Africa by 2030) are also evolving to complement the Bonn Challenge (GRI: http://www.wri.org/our-work/project/global-restoration-initiative).

To date, it is estimated that $1.25 billion has been committed to finance projects on the ground linked to the Bonn Challenge (Vergara *et al.,* 2016), which include improved agricultural production, enhanced food security, carbon storage, ecotourism and wood-forest and non-wood forest products production.

In summary, sustainable land management practices that conserve moisture, reduce or reverse soil degradation, maintain or enhance species diversity - simultaneously and synergistically - contribute to the objectives of the three Conventions (Cowie *et al.,* 2007). However, there are trade-offs as well, as optimization for one objective can reduce outcomes for others. For example, monoculture of exotic species may produce greatest carbon sequestration benefits, but reduce biodiversity values. At the same time, certain land-use and land-management practices are widely recognized as threats to biodiversity (CBD, 2008), including land clearing for agriculture (Losos & Schluter, 2000), overgrazing of rangelands (Tasker & Bradstock, 2006) and unsustainable harvesting of wild plant and animal species (De Roos & Persson, 2002). These kinds of challenges are explored in the next sub-Section.

Box 8 13 **Examples of restoration at multiple levels stemming from various initiatives.**

- In Tanzania, the rebirth of the traditional Ngitili management system led to the restoration of approximately 500,000 hectares of woodland between 1986 and 2001. The integration of sustainable land management and restoration activities benefited over 800 villages, providing an economic value of $14 per month per person – almost double the average level of rural consumption in Tanzania (http://sapiens.revues.org/1542).
- The internationally-funded Sustainable Land Management Programme has helped Ethiopia to make 180,000 hectares of degraded land productively usable through practices, such as terracing, crop rotation systems, improvement of pastureland and permanent green cover. These measures have benefited more than 194,000 households and contribute to increased productivity in the affected areas. They also enhance the resilience of small-scale agriculture to the impacts of climate change and related stressors (https://www.giz.de/en/worldwide/18912.html).

8.4.2 Policy interactions across sectors

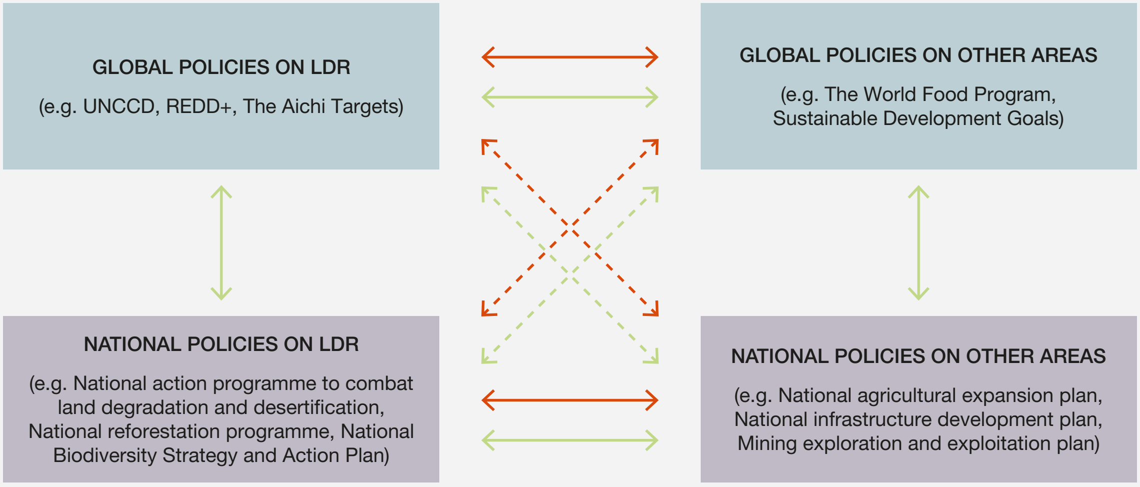
Policies to combat land degradation do not operate in isolation **(Figure 8.7)**, even though sometimes they are treated in a siloed way. Policy makers have already started integrating ecosystem health concerns into some sectoral policies with a focus on harnessing synergies between biodiversity conservation and sustainable production. However, there are other policies operating at multiple levels and over several scales that govern the drivers and impacts of land degradation and the types and distributions of benefits emerging from restoration. As the growing population places pressure on finite land resources, policies aim to ensure adequate supply of food, water, energy and shelter, and to support a country's growth. This has resulted in increased pressure on land from agriculture, forestry, livestock grazing, energy production and urbanization. Indeed, urban and industrial development that consumes land is a growing driver of changes in land use and land cover, requiring proactive management to ensure that detrimental effects on land, soil and ecosystem services do not ensue (Cerreta & De Toro, 2012) (see also Chapter 3).

While policies seek to ensure that these needs are met, they sometimes fuel land degradation, which over time reduces productivity - leading to higher demand for more land and can increase deforestation with negative impacts on climate. Identification of such interactions within policies from different sectors is key to combating land degradation and ensuring land restoration through sustainable land management.

For instance, land degradation over the next 25 years may reduce global food production by up to 12% if the land degradation trend remains unchecked (International Food Policy Research Institute, 2013). Targeted plans to increase food production often neglect taking into account the negative factors that may arise and the contribution this can make to exacerbating overall human vulnerability (Stringer, 2009). For example, projections of a required 50% increase in food production by 2050 do not take into account environmental degradation and a changing climate, which could reduce

Figure 8 7 **Relationships between decisions to combat land degradation and support restoration and other policy areas at various levels.**

Green and red arrows represent positive and negative relationships respectively, while solid and dashed arrows respectively depict direct and indirect links.



agricultural yields by 13 to 45% (UNCCD, 2012). Climate change, water scarcity, invasive pests and land degradation could cause up to 25% reduction of the world food production (Nellemann *et al.,* 2009). Additionally, even if all forests in developing countries were protected under the REDD+ policy initiative, agricultural expansion into other natural lands could lead to 50% reduction of mitigation from forest production because of emissions from "deflected" expansion into non-forested land (Terrestrial Carbon Group, 2010). These examples show the importance of having a comprehensive view of policy interactions. To efficiently balance trade-offs and link social and economic development with environmental and climatic protection and enhancement, all land uses should be examined in an integrated manner - especially because land, including freshwater and coastal systems (IPBES, 2015b), is the bond that keeps together the interdependent loop of food, water, energy and environmental health.

Assessing policy impacts across sectors often requires the use of indicators, such as impacts on productivity of the land, the extent to which the land resource is able to provide the expected ecosystem services and the availability and quality of raw materials extracted from the land (Stolte *et al.,* 2016). In some cases, shared indicators can be used across multiple sectors to provide useful information on complementary policy areas. Ecosystem services nevertheless present more complex interactions between ecosystem components which are often non-linear. Soil characteristics (e.g., soil fertility, water holding capacity, soil organic carbon) are some of the best ecosystem performance measures, because they are sensitive and specific to numerous stressors, are ubiquitous and simple to sample, and they integrate various ecological processes (Davis *et al.,* 2012; Siebielec *et al.,* 2010). To understand ecosystem changes over large areas, however, often requires enormous time and financial investment, especially if on-the-ground data monitoring and evaluation data are to be collected.

Policies regarding water, waste, chemicals, industrial pollution prevention, nature protection, pesticides, agriculture often affect and are affected by soil protection measures. The trade-offs this can create can be faced through approaches such as integrated programmes and approaches for land-use, spatial planning and land-management practices that include the implementation of renewable energy targets, forest and agricultural land use, green infrastructure, land re-use and more general holistic land resource management (EEA, 2010). It can also require some degree of policy analysis to assess the coherence of proposed actions before those actions are implemented, allowing decision makers to reduce any unintended negative effects. Policy analysis approaches can offer important insights into where different sectors are undermining or supporting one another horizontally, as well as showing where they are aligned vertically (e.g., with international treaties; Chandra & Idrisova, 2011). Conversely, policy approaches that are coherent can help to deliver greater overall effectiveness and efficiency and reduce competition between sectors for finite financial and other resources (Akhtar-Schuster *et al.,* 2011).

One approach to policy analysis is Qualitative Document Analysis (QDA) (e.g., Altheide *et al.,* 2008). It uses subjective scoring followed by validation through expert interviews and generally follows five main steps: (i) set the criteria for selection of the documents to be analyzed; (ii) obtain the selected documents; (iii) analyze the documents and undertake the scoring; (iv) validate the initial findings; and (v) finalize (Altheide *et al.,* 2008). An example of the type of scoring criteria is shown below in **Table 8.6**, in relation to an assessment of water, agriculture, national development plans, climate change strategies, national adaptation plans and Intended Nationally Determined Contributions in Malawi, Tanzania and Zambia (England *et al.,* 2017). The literature also provides methods of doing this in relation to climate change and coherence between the Intended Nationally Determined Contributions and the SDGs in member states of the Economic Community of West African States (Antwi-Agyei *et al.,* 2017).

The literature is nevertheless lacking in terms of detailed multi-sector policy coherence analyses. Coherence and trade-offs between strategies to reduce land degradation and promote restoration and environment policies, water management policies, energy and climate policies and transport policies have been explored by Stolte *et al.* (2016), while Stringer *et al.* (2009) examine policy relationships both horizontally and vertically, assessing the extent to which international- and national-level policy supports local adaptations in Botswana, Malawi and Swaziland. A detailed analysis of the impacts of various instruments is underway to identify potential incoherence, contradictions and synergies of existing national and EU policies in the RECARE project (http://www.recare-hub.eu/recare-project). Other analyses (see England *et al.,* 2017; Frelih-Larsen *et al.,* 2016) have already taken stock of existing soil protection policies and measures in the EU and its member states, helping to identify gaps with respect to selected soil threats and functions. This has led to an inventory of existing and future policy instruments at the EU level and an analysis that assess the coverage of soil threats and functions in EU policies and their strengths, weaknesses, opportunities and threats. Such assessments could usefully be provided across sectors at the national level and in other locations around the world.

Although policies to restore degraded lands may be in place, decisions made by the local communities will determine the level of implementation of the policies. For example, while policies in Vietnam guiding forest land allocation, sedentarization and reforestation programmes specifically targeted uplands management, they did not translate into action until individuals in the targeted communities abandoned fields due to low crop yields; which eventually led to the breakdown of the informal collective arrangements for farmland protection and forced others to abandon theirs due to increased cost of field protection. Only then was tree planting, a government subsidized activity, taken up as a "least bad solution" (Clement, 2006). Policy formulation is, therefore, only part of the story. Implementation and moving policy into action is needed to effect on-the-ground change.

8.4.3 Reducing trade-offs and enhancing coherence in policy

Reducing trade-offs and enhancing synergies to address land degradation and/or develop restoration includes measures such as: institutional and capacity-building, policy instruments, research and development. It is nevertheless impossible to provide an accurate and appropriate general prioritization of responses under each of these categories. Communities, countries and regions experience different political, economic, social, historical and environmental contexts (see Warren, 2002) as well as having to select from responses that consider different scales (both temporal and spatial). What is appropriate and should be prioritized in

Table 8 6 **Example of criteria to assess coherence (Adapted from Le Gouais & Wach, 2013; England *et al.,* 2017).**

Type of coherence	Description of coherence	Score
High	The policy aligns strongly across water, agriculture and climate change statements. Type of coherence and description of coherence Score High. Policy devotes specific attention to both water and agriculture inter-sector alignment and relation to climate change adaptation. It includes numerous and detailed complementary activities (including projects) for achieving that.	3
Partial	Although the policy supports both water and agriculture inter sector alignment and, in relation to climate change, adaptation (particular in the form of general statements), it is less clear and distinct on how it could be achieved. Relatively fewer details and activities are included within the policy.	2
Limited	The policy supports water and agriculture inter-sector alignment and/or in relation to climate change adaptation. Lack of relative details in terms of activities and plans.	1
None	There is no evidence in the policy to suggest that sectoral statements are coordinated and/or aligned.	0

one point in time (and in one location) to tackle degradation or advance restoration, may be entirely inappropriate in another. Recognizing this diversity, this sub-Section outlines ways in which response prioritization can be agreed amongst different groups and individuals involved in decision-making, with a view of reducing trade-offs and enhancing synergies.

Reducing trade-offs and enhancing synergies can be viewed as different sides of the same coin to some degree. From a networked and polycentric governance perspective, trade-offs can occur across time, space, sectors and different stakeholder groups. Similarly, synergies can be across different horizontal and vertical governance levels through a focus on synergy in processes, as well as focusing on outcomes that are synergistic. Reducing trade-offs and enhancing synergies is very much a governance issue. It, therefore, requires institutional coordination, multi-stakeholder engagement and the development of committees and governance structures that bridge different ministries, types of knowledge, sectors and stakeholder groups (see examples in Akhtar-Schuster & Thomas, 2011; Chasek *et al.,* 2011; Stringer *et al.,* 2012). By bringing together the necessary mixture of expertise and policymakers, it can help, for example, to ensure that restoration of degraded forests uses appropriate species that do not negatively affect surrounding land uses and livelihoods, or that rehabilitation of degraded mangroves do not cause changes to sedimentation that negatively impacts upon fisherfolks' river access. It also allows the inclusion of local knowledge in decision-making (Stringer & Reed, 2007).

Improved institutional coordination and multi-stakeholder involvement can also help to mitigate and diffuse conflict between different groups. This is especially so if they create a space for social learning to take place and to build the capacity of those involved, so that they can better understand the perspectives and needs of different stakeholders (Reed *et al.,* 2010b). Participatory and stakeholder engagement approaches can also lead to the co-development of restoration responses and jointly agreed prioritizations (see Section 8.3.4).

From an ecosystem services perspective, trade-offs can occur as a result of decisions and policies that aim to enhance delivery of some (often provisioning) ecosystem services, at the expense of others (particularly regulating, supporting and cultural services), undermining the quality of the land. This can lead to degradation as well as biodiversity loss. Often trade-offs occur and synergies are missed because decision-making and selection of options occurs at different scales by different groups.

Van der Biest *et al.* (2014) observe three distinct degrees of trade-offs between ecosystem services:

- **First level trade-offs** are linked to the land's biophysical potential (e.g., soils with high levels of organic matter have higher water holding capacities than low organic soils). Land capability assessments can play a useful role in determining land uses in such a way that degradation is minimized and can help decision makers to prioritize options.

- **Second-level trade-offs** relate to the actual delivery of potential services within a defined system, taking into account biophysical potential trade-offs as well as land-use and management based trade-offs (e.g., decisions to drain peatlands for forestry or palm oil plantations, as seen respectively in locations as diverse as Belarus and Indonesia, determines which potential services are delivered to a greater or lesser degree). Recent research in Botswana that combined quantitative and qualitative data in a Multi-Criteria Decision Analysis, showed that rangeland areas under communal tenure delivered a wider range of ecosystem services than land under private ownership in which cattle production is prioritized as a result of privatization and trade and subsidies (Favretto *et al.,* 2014, 2016). This shows the importance of policy and economic instruments (including the incentives and disincentives they create) in shaping whether land degradation occurs, and in determining where restoration is required or may be needed in future. It also highlights the utility of Multi-Criteria Decision Analysis as a tool in helping diverse groups of decision makers to prioritize options. Multi-Criteria Decision Analysis can also help to identify which groups in society will benefit and lose out from particular options.

- **Third-level trade-offs** concern the final nature's contributions to people, depending on factors such as demand, accessibility and ecosystem service flows. For example, whether provisioning services such as food are actually sold (often requiring policies to support the development of particular markets) or whether forests are accessed for recreation (requiring particular property rights that permit access). Prioritizing options at this level demands consideration of human and environmental (including climatic) processes at multiple geographical scales and multiple levels of governance. Interactions across scales and levels must also be considered if synergies are to be harnessed. Often, prioritization of decision-making options is driven by dominant political or economic agendas, even if it is known (e.g., through scenario analysis and modelling, or cost-benefit analyses) that particular choices will worsen degradation over the longer term and result in greater costs in developing restoration strategies (ELD Initiative, 2015), or increase the vulnerability of the poor.

While a growing body of literature illustrates case examples of the factors and opportunities that can promote synergy between policies and policy processes at the international and national level (e.g., Chasek *et al.,* 2011; Cowie *et al.,* 2007; Cowie *et al.,* 2011; Gomar *et al.,* 2014; Gomar 2016), concrete examples and empirical evidence of synergistic outcomes are still lacking, and in many cases are in need of further research. Nevertheless, responses to land degradation that manage the interactions between different types of ecosystem services have been noted to produce better outcomes for society (MA, 2005) and can enhance synergy in outcomes. For example, sustainable land management in the form of conservation agriculture is one approach that takes a more holistic view of ecosystem services. Conservation agriculture practices have been widely used in countries including Zimbabwe, Zambia and Malawi, and include reduced soil tillage, permanent coverage of the soil with organic matter and crop rotation and/or intercropping, all of which are reported to yield multiple benefits (Whitfield *et al.,* 2015). These benefits include enhanced crop yields (provisioning services), enhanced soil carbon storage (regulating services), reduced soil erosion and improved soil water retention (aiding both provisioning and regulating services) (Thierfelder & Wall, 2009). Similarly, Altieri and Toledo (2011) report the use of new multi-stakeholder approaches and technologies that combine agroecological science and indigenous knowledge systems in Latin America. Outcomes from these approaches are delivering enhanced food security while conserving natural resources, and empowering peasant organizations and movements at a range of different scales. Examples in the literature complement those presented in Chapter 1, which showed how land conservation and restoration measures have helped to deliver improvements in livelihoods, reduce poverty and strengthen long-term sustainability of land use and the extraction of natural resources.

We now have at our disposal a greater range of approaches, tools and actions to understand and act upon land degradation than at any other time in human history. These are supported by lessons learned from a wide variety of different contexts, indigenous and local knowledge and practices that sustain the environment, and experiences gained in the restoration and rehabilitation of degraded areas. As we proceed further into the Anthropocene, it is clear that conceptualizing humans as an integral part of nature is vital (Warren, 2002) if we are to prevent, reduce and reverse degradation – furthering the shift away from outdated views of people as external to ecosystems. Harnessing the potential of the available tools, policies and instruments to make informed decisions and responses that minimize trade-offs and harness synergy – to deliver more efficient, sustainable, effective and equitable outcomes – necessitates consideration of the needs of stakeholders within local production systems, as well as the expectations that they (and society at large) place upon the land.

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ANNEXES

ANNEX I

Glossary

A

Abundance (ecological)
The size of a population of a particular life form in a given area.

Acceptance
Acceptance of IPBES outputs at a session of its Plenary signifies that the material has not been subjected to line-by-line discussion and agreement, but nevertheless presents a comprehensive and balanced view of the subject matter.

Acidification
Ongoing decrease in pH away from neutral value of 7. Often used in reference to oceans, freshwater or soils, as a result of uptake of carbon dioxide from the atmosphere.

Acid deposition (acid rain)
Precipitation with a low pH (acid) caused by atmospheric pollutants.

Acid sulfate soils
Common name for soils that contain metal sulphides.

Active restoration
See "restoration".

Adaptive capacity
The general ability of institutions, systems and individuals to adjust to potential damage, to take advantage of opportunities, or to cope with the consequences.

Adaptive management
A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices.

Aerobic
A condition in which molecular oxygen is freely available.

Afforestation
Converting grasslands or shrublands into tree plantations. Afforestation is sometimes suggested as a tool to sequester carbon, but it can have negative impacts on biodiversity and ecosystem function, for example by reducing runoff and so decreasing water production.

Agenda setting
One of four phases in the policy cycle. Agenda setting motivates and sets the direction for policy design and implementation.

Agribusiness
Collective business activities that are performed from farm to table. It covers agricultural input suppliers, producers, agroprocessors, distributors, traders, exporters, retailers and consumers. Agro-industry refers to the establishment of linkages between enterprises and supply chains for developing, transforming and distributing specific inputs and products in the agriculture sector. Consequently, agro-industries are a subset of the agribusiness sector. Agribusiness and agro-industry both involve commercialization and value addition of agricultural and post-production enterprises, and the building of linkages among agricultural enterprises. The terms agribusiness and agro-industries are often associated with large-scale farming enterprises or enterprises involved in large-scale food production, processing, distribution and quality control of agricultural products.

Agricultural commodity
A primary agricultural product that can be bought and sold.

Agricultural extensification
The process (or trend) of developing a more extensive production system, i.e., one which utilizes large areas of land, but with minimal inputs and expenditures of capital and labour.

Agricultural Intensification
An increase in agricultural production per unit of inputs (which may be labour, land, time, fertilizer, seed, feed or cash).

Agricultural orientation index (AOI)
The Agriculture Orientation Index (AOI) for Government Expenditures is defined as the Agriculture Share of Government Expenditures, divided by the Agriculture Share of Gross Domestic Product (GDP), where Agriculture refers to the agriculture, forestry, fishing and hunting sector.

Agrisilvicultural systems
A land-use system in which growing of trees and agriculture crops occur together in same lands.

Agrisilvipastoral systems
A land-use system, implying the combination or deliberate association of a woody component (trees or shrubs) with cattle in the same site.

Agrobiodiversity (or agricultural biodiversity)
A broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes (CBD COP decision V/5, appendix). Agricultural biodiversity is the outcome of the interactions among genetic resources, the environment and the management systems and practices used by farmers, in some cases over millennia.

Agrochemical
Any substance used to help manage an agricultural ecosystem, or the community of organisms in a farming area. Agrochemicals include: (i) fertilizers; (ii) liming and acidifying agents; (iii) soil conditioners; (iv) pesticides; and (v) chemicals used in animal husbandry, such as antibiotics and hormones.

Agroecology
The science and practice of applying ecological concepts, principles and knowledge (i.e., the interactions of, and explanations for, the diversity, abundance and activities of organisms) to the study, design and management of sustainable agroecosystems. It includes the roles of human beings as a central organism by way of social and economic processes in farming systems. agroecology examines the roles and interactions among all relevant biophysical, technical and socioeconomic components of farming systems and their surrounding landscapes.

Agroecosystem
An ecosystem, dominated by agriculture, containing assets and functions such as biodiversity, ecological succession and food webs. An agroecosystem is not restricted to the immediate site of agricultural activity (e.g. the farm), but rather includes the region that is impacted by this activity, usually by changes to the complexity of species assemblages and energy flows, as well as to the net nutrient balance.

Agroforestry
A collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos and so on) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. Agroforestry can enhance the food supply, income and health of smallholder farmers and other rural people.

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

Alien species
See "invasive alien species".

Alluvial soil
Soils deposited by water.

Amorphous
Without a clearly defined shape or form.

Anaerobic
Descriptive of a condition in which molecular oxygen is not available.

Anthrome
Neologism for Anthropogenic biome, i.e. an ecosystem produced by humans.

Anoxic
Depleted of dissolved oxygen.

Anthropocentric value
See "Values".

Anthropocentrism (or anthropocentric)
In an anthropocentric view of nature, nature is valued for its benefits to human beings. See "Ecocentric".

Anthropogenic
Originating from human activity.

Anthropogenic assets
Built-up infrastructure, health facilities, or knowledge - including indigenous and local knowledge systems and technical or scientific knowledge - as well as formal and non-formal education, technology (both physical objects and procedures), and financial assets. Anthropogenic assets have been highlighted to emphasize that a good quality of life is achieved by a co-production of benefits between nature and people.

Approval
Approval of IPBES outputs signifies that the material has been subject to detailed, line-by-line discussion and agreement by consensus at a session of the Plenary.

Aqueous slurries
A semi-liquid mixture, typically of fine particles of manure, cement, or coal suspended in water.

Aquifer
A body of permeable rock which can contain or transmit groundwater.

Arid ecosystem
Those in which water availability severely constrains ecological activity.

Aridification
A chronic reduction in soil moisture caused by an increase of mean annual temperature or a decrease in yearly precipitation.

Assessment reports
Published outputs of scientific, technical and socioeconomic issues that take into account different approaches, visions and knowledge systems, including global assessments of biodiversity and ecosystem services with a defined geographical scope, and thematic or methodological assessments based on the standard or the fast-track approach. They are composed of two or more sections including a summary for policymakers, an optional technical summary and individual chapters and their executive summaries. Assessments are the major output of IPBES, and they contain syntheses of findings on topics that have been selected by the IPBES Plenary.

Assisted colonization
Also known as assisted migration or managed relocation, is the act of deliberately moving plants or animals to a different habitat. The destination habitat may have either historically held the species or it may not have hosted the species, but the habitat provides the bioclimatic requirements to support it. Assisted colonization may also supplement an existing population in a site where their numbers are dwindling (McLachlan et al, 2007). This is especially the case where the assisted species are unable to disperse at a rate which keeps pace with the shifting bio-climatic, bio-physical envelope.

Available water capacity
Soil water content useable by plants, based on the effective root penetration depth.

B

Badlands
Areas where most soil has been eroded away.

Bare soil
A land cover class that includes any geographic area dominated by natural abiotic surfaces (bare soil, sand, rocks and so on) where the natural vegetation is absent or almost absent (covers less than 2%).

Baseline
A minimum or starting point with which to compare other information (e.g., for comparisons between past and present or before and after an intervention).

Behavioural economics
The study of the influence of emotions and opinions on the decisions people and organizations make in spending and saving. Behavioural economics suggests that human decisions are strongly influenced by context, including the way in which choices are presented to us. Behaviour varies across time and space, and it is subject to cognitive biases, emotions, and social influences. Decisions are the result of less deliberative, linear and controlled processes.

Beneficiary pays principle
The beneficiary pay principle aims to compensate providers for costs involved in production of beneficial environmental goods and services.

Benefit sharing
Distribution of benefits between stakeholders.

Benefits
Advantage that contributes to wellbeing from the fulfilment of needs and wants
Advantage that contributes to wellbeing from the fulfilment of needs and wants.

In the context of nature's contributions to people (see "Nature's contributions to people"), a benefit is a positive contribution. (There may also be negative contributions, dis-benefits, or costs, from Nature, such as diseases).

Bioaccumulation
The accumulation of environmental pollutants such as isotopes of elements, inorganic and organic compounds in organisms or the environment.

Biocapacity
The capacity of a country, a region, or the world, to produce useful biological materials for its human population and to absorb waste materials.

Biocentrism
See "Ecocentrism"

Biochar
Charcoal made from biomass via pyrolysis and used for soil enhancement.

Biocultural diversity
The diversity exhibited collectively by natural and cultural systems. It incorporates three concepts: firstly, that the diversity of life includes human cultures and languages; secondly, that links exist between biodiversity and human cultural diversity; and finally, that these links have developed over time through mutual adaptation and possibly co-evolution between humans, plants and animals.

Biodegradation
Physical and chemical breakdown of a substance by living organisms, mainly bacteria and/or fungi.

Biodiesel
A fuel that is similar to diesel fuel and is derived from usually vegetable sources (such as soybean oil).

Biodiversity
The variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Biodiversity dilution effect
A high number of species present in defined areas protects humans from infection from pathogens with an animal reservoir.

Biodiversity hotspot
A generic term for an area high in such biodiversity attributes as species richness or endemism. It may also be used in assessments as a precise term applied to geographic areas defined according to two criteria (Myers et al 2000): (i) containing at least 1,500 species of the world's 300,000 vascular plant species as endemics; and (ii) having lost 70% of its primary vegetation.

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

Biodiversity offset
A tool proposed by developers and planners for compensating for the loss of biodiversity in one place by biodiversity gains in another.

Biodynamic agriculture (or biodynamics)
A holistic, ecological, and ethical approach to farming, gardening, food, and nutrition. Biodynamic agriculture has been practiced for nearly a century, on every continent on Earth. Biodynamic principles and practices are based on the spiritual insights and practical suggestions of Dr. Rudolf Steiner, and have been developed through the collaboration of many farmers and researchers since the early 1920s. See also "Conservation Agriculture".

Bioenergy
Energy for industrial or commercial use that is derived from biological sources (such as plant matter or animal waste).

Bioenergy with Carbon Capture and Storage (BECCS)
A future greenhouse gas mitigation technology which produces negative carbon dioxide emissions by combining bioenergy (energy from biomass) use with geologic carbon capture and storage.

Biofuel
Fuel made from biomass.

Biological control (or biocontrol)
A method of controlling pests such as insects, mites, weeds and plant diseases using other organisms. It relies on predation, parasitism, herbivory, or other natural mechanisms, but typically also involves an active human management role. It can be an important component of integrated pest management (IPM) programs.

Biomass
The mass of non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms in a given area or volume.

Biome
Global-scale zones, generally defined by the type of plant life that they support in response to average rainfall and temperature patterns. For example, tundra, coral reefs or savannahs.

Bioprospecting
The process of searching for and subsequently developing new drugs based on biological resources.

Bioremediation
The use of microorganisms to clean up polluted soil and water.

Biosecurity
Strategy, efforts and planning to protect human, animal and environmental health against biological threats

Biosphere
The sum of all the ecosystems of the world. It is both the collection of organisms living on the Earth and the space that they occupy on part of the Earth's crust (the lithosphere), in the oceans (the hydrosphere) and in the atmosphere. The biosphere is all the planet's ecosystems.

Bio-technical stabilization
A method for mitigating land degradation using mechanical (structures) and biological elements to prevent severe erosion.

Biotechnology
A method for mitigating land degradation using mechanical (structures) and biological elements.

Bioterrorism
The deliberate, private use of biological agents to harm and frighten the people of a state or society, is related to the military use of biological, chemical, and nuclear weapons.

Biota
All living organisms of an area; the flora and fauna considered as a unit.

Bog
An entirely rainfed wetland area that typically accumulates peat.

Brackish water
Inland water with a high salt concentration.

Built environment
Comprises urban design, land use and the transportation system, and encompasses patterns of human activity within the physical environment.

Bureau
The IPBES Bureau is a subsidiary body established by the Plenary which carries out the governance functions of IPBES. It is made up of representatives nominated from each of the United Nations regions and is chaired by the Chair of IPBES.

Bush encroachment
An increase in density of shrubby or bushy tree vegetation in savannah or grassland systems.

Bushmeat
Meat for human consumption derived from wild animals.

Bushmeat (or wild meat) hunting
A form of subsistence hunting that entails the harvesting of wild animals for food and for non-food purposes, including for medicinal use.

C

Cap-and-trade
An economic policy instrument in which the State sets an overall environmental target (the cap) and assigns environmental impact allowances (or quotas) to actors that they can trade among each other.

Capacity-building (or capacity development)
Defined by the United Nations Development Programme as "the process through which individuals, organisations and societies obtain, strengthen and maintain their capabilities to set and achieve their own development objectives over time". IPBES promotes and facilitates capacity-building, to improve the capacity of countries to make informed policy decisions on biodiversity and ecosystem-services.

Carbon cycle
The process by which carbon is exchanged among the ecosystems of the Earth.

Carbon sequestration
The long-term storage of carbon in plants, soils, geologic formations, and the ocean. Carbon sequestration occurs both naturally and as a result of anthropogenic activities and typically refers to the storage of carbon that has the immediate potential to become carbon dioxide gas.

Carbon storage
The technological process of capturing waste carbon dioxide from industry or power generation and storing it so that it will not enter the atmosphere.

Carrying capacity
In ecology, the carrying capacity of a species in an environment is the maximum population size of the species that the environment can sustain indefinitely. The term is also used more generally to refer to the upper limit of habitats, ecosystems, landscapes, waterscapes or seascapes to provide tangible and intangible goods and services (including aesthetic and spiritual services) in a sustainable way.

Catalogue of policy support tools and methodologies
The IPBES catalogue of policy support tools and methodologies is an evolving online resource with two main goals. The first goal is to enable decision-makers to gain easy access to information on policy support tools and methodologies to better inform and assist the different phases of policy-making and implementation. The second goal is to allow a range of users to provide input to the catalogue and assess the usability of tools and methodologies in their specific contexts, including resources required and types of outputs that can be obtained, thus helping to identify and bridge gaps with respect to available tools and methodologies.

Causal chains
When the cause produces its effects in a remote and indirect manner, an explanation has to rely on causal chains, i.e., a continuous chain of causal mechanisms, where each step links a cause or combination of causes with its direct outcome, the latter being a direct cause of the subsequent outcome.

Causal effect
A causal effect can be defined in many ways, but essentially it amounts to the change in an outcome Y brought about by the change in a factor X. If X is a cause of Y then knowing something about X should help to predict something about Y that cannot be provided by another variable.

Certainty
In the context of IPBES, the summary terms to describe the state of knowledge are the following:

- **Well established** (certainty term): comprehensive meta-analysis or other synthesis or multiple independent studies that agree.
- **Established but incomplete** (certainty term): general agreement although only a limited number of studies exist but no comprehensive synthesis and, or the studies that exist imprecisely address the question.
- **Unresolved** (certainty term): multiple independent studies exist but conclusions do not agree.
- **Inconclusive** (certainty term): limited evidence, recognising major knowledge gaps.

Civil society
"Civil society", according to Gramsci, is broader than the institutionally recognized organizations, unions, associations and other pressure groups. It considers citizens as historical subjects capable of both understanding and changing the world around them, instead of being passive recipients of a readymade ideology. The Internet and other new information and communication technologies facilitate the rise of self-organized, leaderless movements, allowing a rapid and efficient mobilization of citizens.

Clean Development Mechanism (CDM)
Defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tone of CO_2, which can be counted towards meeting Kyoto targets.

Climate change
Refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Climate change adaptation
Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Climate change mitigation
A set of actions to limit the magnitude or rate of long-term climate change. Climate change mitigation generally involves reductions in human (anthropogenic) emissions of greenhouse gases (GHGs). Mitigation may also be achieved by increasing the capacity of carbon sinks, e.g., through reforestation. Mitigation policies can substantially reduce the risks associated with human-induced global warming.

Climate envelope
A subset of the more general family of species distribution models that correlate species occurrence or abundance with climate variables to make spatially-explicit predictions of potential distribution.

Climate regulation
The influence of land cover and biological mediated processes that regulate atmospheric processes and weather patterns which in turn create the microclimate in which different plants and animals (including humans) live and function.

Climate smart agriculture
Aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gas emissions, where possible.

Co-management
Process of management in which government shares power with resource users, with each given specific rights and responsibilities relating to information and decision-making.

Comminution
The action of reducing a material, especially a mineral ore, to minute particles or fragments.

Commons
A concept whereby some forms of wealth belong to all, and that these community resources must be actively protected and managed for the good of all. It consists of land and services of common property (forests, rivers, fields and arable land) used and managed by a given community (mainly traditional, local or indigenous). The commons also consist of gifts of nature such as air, oceans and wildlife (“global commons”) as well as shared social creations such as libraries, public spaces, scientific research and creative works. See also “Common Pool Resources” and “Tragedy of the commons”.

Common Pool Resource (CPR)
Resources for which the exclusion of users is difficult (referred to as excludability), and the use of such a resource by one user decreases resource benefits for other users (referred to as subtractability). Common CPR examples include fisheries, forests, irrigation systems, and pastures. Global CPR examples include the earth’s oceans and atmosphere. Difficulty in excluding users, combined with a CPR’s subtractability, create management vulnerabilities that can result in resource degradation, often referred to as the “tragedy of the commons”. See also “Tragedy of commons” and “Commons”.

Community-based natural resource management (CBNRM)
An approach to natural resource management that involves the full participation of indigenous peoples’ and local communities and resource users in decision-making activities, and the incorporation of local institutions, customary practices, and knowledge systems in management, regulatory, and enforcement processes. Under this approach, community-based monitoring and information systems are initiatives by indigenous peoples and local community organisations to monitor their community’s well-being and the state of their territories and natural resources, applying a mix of traditional knowledge and innovative tools and approaches.

Concepts
The second stage of cognitive process. Perceptions are selected, organized, classified and hierarchized into concepts. This process is influenced by collective filters which are human systems of values, norms, and beliefs. Concepts do not come alone, but as integrated networks. See also ‘Reality’; “Perceptions”; “Worldviews”.

Conceptual Framework
The Platform’s conceptual framework is a tool for building shared understanding across disciplines, knowledge systems and stakeholders of the interplay between biodiversity and ecosystem drivers, and of the role they play in building a good quality of life.

Confidence
See “certainty”.

Conservation agriculture
Approach to managing agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base and the environment. It is characterized by three linked principles, namely: (i) continuous minimum mechanical soil disturbance; (ii) permanent organic soil cover; and (iii) diversification of crop species grown in sequences and/or associations. This covers a wide range of approaches from minimum till to permaculture/“mimicking nature”.

Conservation tender (or conservation auction)
A financial mechanism to deliver funding to community groups and individuals for conservation works and, sometimes, permanently protect biodiversity (Australian Government, Department of the Environment and Energy).

Contaminant
Substance or agent present in the soil as a result of human.

Corridor
A geographically-defined area which allows species to move between landscapes, ecosystems and habitats, natural or modified, and ensures the maintenance of biodiversity and ecological and evolutionary processes.

Cost-benefit analysis
A technique designed to determine the feasibility of a project or plan by quantifying its costs and benefits.

Cropland
A land cover/use category that includes areas used for the production of crops for harvest.

Cross-scale analysis
Cross-scale effects are the result of spatial and/or temporal processes interacting with other processes at another scale. These interactions create emergent effects that can be difficult to predict.

Cross-sectoral
Relating to interactions between sectors (that is, the distinct parts of society, or of a nation's economy), such as how one sector affects another sector, or how a factor affects two or more sectors.

Cultural (ecosystem) services
The Millennium Ecosystem Assessment (Sarukhán & Whyte, 2005) defined cultural ecosystem services as "the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences". Cultural ecosystem services have been included in many other typologies of ecosystem services and referred to variously as cultural services (Constanza, 1997), life-fulfilling functions (Daily, 1999), information functions (de Groot *et al.*, 2002), amenities and fulfilment (Boyd & Banzhaf, 2007), cultural and amenity services (de Groot *et al.*, 2010, Kumar 2010), or socio-cultural fulfilment (Wallace, 2007).

Cumulative impacts
An impact produced over a period of time.

Customary law
Law based on tradition in communities where the authority of traditional leadership is recognised. It exists where there is a commonly repeated practice which is accepted as law by the members of a community.

Customary practices
See "Customary law".

D

Decision support tools
Approaches and techniques based on science and other knowledge systems, including indigenous and local knowledge, that can inform, assist and enhance relevant decisions, policy-making and implementation at the local, national, regional and international levels.

Decomposition
Breakdown of complex organic substances into simpler molecules or ions by physical, chemical and/or biological processes.

Deflation (wind)
Wind erosion.

Deforestation
Human-induced conversion of forested land to non-forested land. Deforestation can be permanent, when this change is definitive, or temporary when this change is part of a cycle that includes natural or assisted regeneration.

Degraded land
Land in a state that results from persistent decline or loss of biodiversity and ecosystem functions and services that cannot fully recover unaided.

Degrowth (or downscaling)
A theoretical frame invoking the necessity of downscaling and re-localizing production.

Denitrification
A heterotrophic process of anaerobic microbial respiration conducted by bacteria. Denitrification is the microbial oxidation of organic matter in which nitrate or nitrite is the terminal electron acceptor, and the end product is N_2.

Densification
The increase in woody plants in a savanna, grassland or woodland.

Depositional sites
The places where eroded soils are deposited.

Desertification
Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities.

Direct driver
See "driver".

Disability-Adjusted Life Year (DALY)
One DALY can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.

Disaster Risk Reduction
The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Downscaling
The transformation of information from coarser to finer spatial scales through statistical modelling or spatially nested linkage of structural models.

Drivers
In the context of IPBES, drivers of change are all the factors that, directly or indirectly, cause changes in nature, anthropogenic assets, nature's contributions to people and a good quality of life. Direct drivers of change can be both natural and anthropogenic. **Direct drivers** have direct physical (mechanical, chemical, noise, light etc.) and psychological (disturbance etc.) impacts on nature and its functioning, and on people and their interaction. Direct drivers unequivocally influence biodiversity and ecosystem processes. They are also referred to as 'pressures'. Direct drivers include, inter alia, climate change, pollution, land use change, invasive alien species and zoonoses, including their effects across regions.

Indirect drivers are drivers that operate diffusely by altering and influencing direct drivers as well as other indirect drivers (also referred to as 'underlying causes'). Interactions between indirect and direct drivers create different chains of relationship, attribution, and impacts, which may vary according to type, intensity, duration, and distance. These relationships can also lead to different types of spill-over effects. Global indirect drivers include economic, demographic, governance, technological and cultural ones, among others. Special attention is given, among indirect drivers, to the role of institutions (both formal and informal) and impacts of the patterns of production, supply and consumption on nature, nature's contributions to people and good quality of life.

Dry forest
Tropical and sub-tropical dry forests occur in climates that are warm year-round, and may receive several hundred centimetres or rain per year, they deal with long dry seasons which last several months and vary with geographic location.

Drylands
Tropical and temperate areas with an aridity index (annual rainfall/annual potential evaporation) of less than 0.65.

E

Ecocentrism (or biocentrism)
A concept that nature and natural things have a value in and of themselves, independent of any benefits they may have for human beings. See also "Anthropocentrism" and "Reality".

Ecological (or socio-ecological) breakpoint or threshold
The point at which a relatively small change in external conditions causes a rapid change in an ecosystem. When an ecological threshold has been passed, the ecosystem may no longer be able to return to its state by means of its inherent resilience.

Ecological footprint
A measure of the amount of biologically productive land and water required to support the demands of a population or productive activity. Ecological footprints can be calculated at any scale: for an activity, a person, a community, a city, a region, a nation or humanity as a whole.

Ecological infrastructure
The natural or semi-natural structural elements of ecosystems and landscapes that are important in delivering ecosystem services. It is similar to "green infrastructure", a term sometimes applied in a more urban context. The ecological infrastructure needed to support pollinators and improve pollination services includes patches of semi-natural habitats, including hedgerows, grassland and forest, distributed throughout productive agricultural landscapes, providing nesting and floral resources. Larger areas of natural habitat are also ecological infrastructure, although these do not directly support agricultural pollination in areas more than a few kilometres away from pollinator-dependent crops.

Ecological integrity
The ability of an ecosystem to support and maintain ecological processes and a diverse community of organisms.

Ecological marginalization
The take-over of local natural resources by private and/or state interests, and the gradual or immediate disorganization of the ecosystem via withdrawals and additions.

Ecological solidarity
As explained by Thompson *et al.* (2011): "From ecology based on interactions to solidarity based on links between individuals united around a common goal and conscious of their common interests and their moral obligation and responsibility to help others, we define ecological solidarity as the reciprocal interdependence of living organisms amongst each other and with spatial and temporal variation in their physical environment".

Economic and financial instruments
Economic and financial instruments can be used to change people's behaviour towards desired policy objectives. Instruments typically encompass a wide range of designs and implementation approaches. They include traditional fiscal instruments, including for example subsidies, taxes, charges and fiscal transfers. Additionally, instruments such as tradable pollution permits or tradable land development rights rely on the creation of new markets. Further instruments represent conditional and voluntary incentive schemes such as payments for ecosystem services. All these can in principle be used to correct for policy or/and market failures and reinstate full-cost pricing. They aim at reflecting social costs or benefits of the conservation and use of biodiversity and ecosystem services of a public good nature ("getting the price right"). Financial instruments, in contrast, are often extra-budgetary and can be financed from domestic sources or foreign aid, external borrowing, debt for nature swaps and so on. It should be noted that economic instruments do not necessarily imply that commodification of environmental functions is promoted. Generally, they are meant to change behaviour of individuals (e.g., consumers and producers) and public actors (e.g., local and regional governments).

Economic valuation
See "values".

Ecoregion
A large area of land or water that contains a geographically distinct assemblage of natural communities that:
(a) Share a large majority of their species and ecological dynamics;
(b) Share similar environmental conditions, and;
(c) Interact ecologically in ways that are critical for their long-term persistence.

In contrast to biomes, an ecoregion is generally geographically specific, at a much finer scale. For example, the "East African Montane Forest" ecoregion of Kenya (WWF ecoregion classification) is a geographically specific and coherent example of the globally occurring "tropical and subtropical forest" biome.

Ecosystem
A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

Ecosystem degradation
A persistent (long-time) reduction in the capacity to provide ecosystem services.

Ecosystem function(s)
The flow of energy and materials through the biotic and abiotic components of an ecosystem. It includes many processes such as biomass production, trophic transfer through plants and animals, nutrient cycling, water dynamics and heat transfer.

Ecosystem health
A state or condition of an ecosystem that expresses attributes of biodiversity within "normal" ranges, relative to its ecological stage of development. Ecosystem health depends inter alia on ecosystem resilience and resistance. Note that there is no universally accepted benchmark for a healthy ecosystem. Rather, the apparent health status of an ecosystem can vary, depending upon which metrics are employed in judging it, and which societal aspirations are driving the assessment.

Ecosystem management
An approach to maintaining or restoring the composition, structure, function and delivery of services of natural and modified ecosystems for the goal of achieving sustainability. It is based on an adaptive, collaboratively developed vision of desired future conditions that integrates ecological, socioeconomic, and institutional perspectives, applied within a geographic framework, and defined primarily by natural ecological boundaries.

Ecosystem services
The benefits people obtain from ecosystems. In the Millennium Ecosystem Assessment, ecosystem services can be divided into supporting, regulating, provisioning and cultural.

Ecotone
A transition area between two biomes or vegetation types.

Ecotourism
Sustainable travel undertaken to access sites or regions of unique natural or ecological quality, promoting their conservation, low visitor impact, and socio-economic involvement of local populations.

Enabling conditions
The institutional, policy and governance responses to create enabling conditions to implement direct responses or actions on the ground to halt land degradation or to restore degraded lands.

Endemism
The ecological state of a species being unique to a defined geographic location, such as an island, nation, country or other defined zone, or habitat type; organisms that are indigenous to a place are not endemic to it if they are also found elsewhere.

Energy security
Access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses.

Environmental hazards
The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.

Environmental Impact Assessment (EIA)
An assessment that assesses the impacts of planned activity on the environment in advance, thereby allowing avoidance measures to be taken: prevention is better than cure.

Environmental incomes
An extraction from non-cultivated sources: natural forests, other non-forest wildlands such as grass-, bush- and wetlands, fallows, but also wild plants and animals harvested from croplands.

Environmental Kuznets Curves (EKC)
A hypothesized relationship between environmental quality and economic development: various indicators of environmental degradation tend to get worse as modern economic growth occurs until average income reaches a certain point over the course of development.

Epizootics
A disease outbreak affecting a species' population at the same time.

Erodibility
The ease with which a soil erodes, defined by its resistance to two energy sources: the impact of raindrops on the soil surface, and the shearing action of runoff between clods in grooves or rills.

Erosion hotspots
Places identified with as having a high erosion potential

Eutrophic (or eutrophication)
A condition of an aquatic system in which increased nutrient loading leads to progressively increasing amounts of algal growth and biomass accumulation. When the algae die off and decompose, the amount of dissolved oxygen in the water becomes reduced. In lakes, eutrophication leads to seasonal algal blooms, reduced water clarity, and, often, periodic fish mortality as a consequence of oxygen depletion.

Ex-ante assessment
The use of policy-screening scenarios to forecast the effects of alternative policy or management options (interventions) on environmental outcomes.

Ex-post assessment
The use of policy-evaluation scenarios to assess the extent to which outcomes actually achieved by an implemented policy match those expected based on modelled projections, thereby informing policy review.

Extensive grazing (lands)
A form of grazing in which livestock are raised on food that comes mainly from natural grasslands, shrublands, woodlands, wetlands and deserts. It differs from intensive grazing, where the animal feed comes mainly from artificial, seeded pastures.

Externality
A positive or negative consequence (benefits or costs) of an action that affects someone other than the agent undertaking that action and for which the agent is neither compensated nor penalized through the markets.

Extinction debt
The future extinction of species due to events in the past, owing to a time lag between an effect such as habitat destruction or climate change, and the subsequent disappearance of species.

F

Fire regime
A term used to describe the characteristics of fires that occur in a particular ecosystem over a period of time. Fire regimes are characterized based on a combination of factors including the frequency, intensity, size, pattern, season and severity of fires.

Food security
When all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Food self-sufficiency
The ability of a region or country to produce enough food (especially staple crops) without needing to buy or import additional food.

Food sovereignty (paradigm)
The right to define own policies and strategies for the sustainable production, distribution and consumption of food that guarantee the right to food for the entire population, on the basis of small and medium-sized production, respecting their own cultures and the diversity of peasant, fishing and indigenous forms of agricultural production, marketing and management of rural areas, in which women play a fundamental role.

Forest
A minimum area of land of 0.05 - 1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 m at maturity in situ. A forest may consist either of closed forest formations where trees of various stories and undergrowth cover a high proportion of the ground or open forest.

Forest transition
A shift, usually assessed at the national scale, from net forest loss to net forest gain, whether through natural recovery or planted forests.

Fossil fuel
Fuels such as petroleum derived for fossil oil sources.

Functional diversity
Value, range and relative abundance of functional traits in a given ecosystem.

G

General Circulation Models (GCMs)
A numerical representation of the physical processes in the atmosphere, ocean, cryosphere and land surface based on the physical, chemical and biological properties of their components, their interactions and feedback processes, and accounting for all or some of its known properties.

Geographic Information Systems (GIS)
A computer-based tool that analyses, stores, manipulates and visualizes geographic information on a map.

Geographic range
The geographic range of a species is the geographic boundary within which it occurs.

Gini index
In economics, the Gini coefficient (sometimes expressed as a Gini ratio or a normalized Gini index) is a measure of statistical dispersion intended to represent the income or wealth distribution of a nation's residents and is the most commonly used measure of inequality.

Good quality of life
Within the context of the IPBES conceptual framework – the achievement of a fulfilled human life, a notion which may vary strongly across different societies and groups within societies. It is a context-dependent state of individuals and human groups, comprising aspects such as access to food, water, energy and livelihood security, and also health, good social relationships and equity, security, cultural identity, and freedom of choice and action. "Living in harmony with nature", "living-well in balance and harmony with Mother Earth" and "human well-being" are examples of different perspectives on a "good quality of life".

Governance
The way the rules, norms and actions in a given organization are structured, sustained and regulated.

Grassland
A land cover class that includes any geographic area dominated by natural herbaceous plants (grasslands, prairies, steppes and savannahs) with a cover of 10% or more, irrespective of different human and/or animal activities (e.g., grazing).

Grazing land management
The strategies used by people to promote both high quality and quantity of forage for domesticated livestock.

Green Revolution
A set of research and the development of technology transfer initiatives occurring between the 1930s and the late 1960s (with prequels in the work of the agrarian geneticist Nazareno Strampelli in the 1920s and 1930s), that increased agricultural production worldwide, particularly in the developing world, beginning most markedly in the late 1960s. The initiatives resulted in the adoption of new technologies, including: new, high-yielding varieties (HYVs) of cereals, especially dwarf wheats and rices, in association with chemical fertilizers and agro-chemicals, and with controlled water-supply (usually involving irrigation) and new methods of cultivation, including mechanization. All of these together were seen as a "package of practices" to supersede "traditional" technology and to be adopted as a whole.

Green water
Water transpired through plants to the atmosphere.

Greenhouse Gas
Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. This property causes the greenhouse effect.

Grey water
Any wastewater that is not contaminated with faecal matter.

Gross primary production (GPP)
Total terrestrial Gross Primary Production (GPP) is the total mass of carbon taken out of the atmosphere by plant photosynthesis.

H

Habitat
The place or type of site where an organism or population naturally occurs. Also used to mean the environmental attributes required by a particular species or its ecological niche.

Habitat connectivity
The degree to which the landscape facilitates the movement of organisms (animals, plant reproductive structures, pollen, pollinators, spores and so on) and other environmentally important resources (e.g., nutrients and moisture) between similar habitats. Connectivity is hampered by fragmentation.

Habitat degradation
A general term describing the set of processes by which habitat quality is reduced. Habitat degradation may occur through natural processes (e.g. drought, heat, cold) and through human activities (forestry, agriculture, urbanization).

Habitat ecosystem functions
The ability of soil or soil materials to serve as a habitat for micro-organisms, plants, soil-living animals and their interactions.

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

Habitat Service
The importance of ecosystems to provide living space for resident and migratory species (thus maintaining the gene pool and nursery service).

Homogenization
When used in the ecological sense "homogenization" means a decrease in the extent to which communities differ in species composition.

Human appropriation of net primary production (HANPP)
The aggregate impact of land use on biomass available each year in ecosystems.

Human capital
All the knowledge, talents, skills, abilities, experience, intelligence, training, judgment and wisdom possessed individually and collectively by individuals in a population.

Human rights
Rights inherent to all human beings, regardless of race, colour, sex, language, religion or other opinion, national or social origin, property,

birth or any other status. These rights are interrelated, interdependent and indivisible.

Human rights-based approach
A conceptual framework for the process of human development that is normatively based on international human rights standards and operationally directed to promoting and protecting human rights.

Human Rights Instruments
Instruments for the protection and promotion of human rights, including general instruments, instruments concerning specific issues, and instruments relating to the protection of particular groups.

Humification
Decomposition of organic material followed by a synthesis of humic substances.

Humanistic economics
Humanistic economics intend to show that humankind is perfectly capable of living without the profit motive, and has done so for most of its history. It goes again the tendency to consider the profit motive as self-evident, an idea that underlies many political decisions. See also "Behavioural economics".

Hydraulic fracturing (or fracking)
An oil and gas well development process that typically involves injecting water, sand, and chemicals under high pressure into a bedrock formation via the well. This process is intended to create new fractures in the rock as well as increase the size, extent, and connectivity of existing fractures. Hydraulic fracturing is a well-stimulation technique used commonly in low-permeability rocks like tight sandstone, shale, and some coal beds to increase oil and/or gas flow to a well from petroleum-bearing rock formations.

I

Immaterial patrimony
Non-tangible aspects of cultural value that are passed from one human generation to the next.

Impact assessment
A formal, evidence-based procedure that assesses the economic, social and environmental effects of public policy or of any human activity

Indicators
A quantitative or qualitative factor or variable that provides a simple, measurable and quantifiable characteristic or attribute responding in a known and communicable way to a changing environmental condition, to a changing ecological process or function, or to a changing element of biodiversity.

Indigenous and local knowledge (ILK) systems
Social and ecological knowledge practices and beliefs pertaining to the relationship of living beings, including people, with one another and with their environments. Such knowledge can provide information, methods, theory and practice for sustainable ecosystem management.

Indigenous peoples and local communities (IPLC)
Typically, ethnic groups who are descended from and identify with the original inhabitants of a given region, in contrast to groups that have settled, occupied or colonized the area more recently. IPBES does not intend to create or develop new definitions of what constitutes "indigenous peoples and local communities".

Indirect driver
See "driver".

Institution
Encompasses all formal and informal interactions among stakeholders and social structures that determine how decisions are taken and implemented, how power is exercised, and how responsibilities are distributed.

Institutional competencies
The set of abilities which a given institution can use to achieve policy goals. Examples include the ability to collaborate with local communities, design scientifically sound restoration interventions, or foresee secondary effects of policies.

Integrated assessment model (IAM)
Interdisciplinary models that aim to describe the complex relationships between environmental, social, and economic drivers that determine current and future state of the ecosystem and the effects of global change, in order to derive policy-relevant insights. One of the essential characteristics of integrated assessments is the simultaneous consideration of the multiple dimensions of environmental problems.

Integrated landscape management
Refers to long-term collaboration among different groups of land managers and stakeholders to achieve the multiple objectives required from the landscape.

Integrated pest management (IPM) (or integrated pest control)
A broadly-based approach that integrates various practices for economic control of pests. IPM aims to suppress pest populations below the economic injury level (i.e., to below the level that the costs of further control outweigh the benefits derived). It involves careful consideration of all available pest control techniques and then integration of appropriate measures to discourage development of pest populations while keeping pesticides and other interventions to economically justifiable levels with minimal risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.

Invasive alien species
Species whose introduction and/or spread by human action outside their natural distribution threatens biological diversity, food security, and human health and well-being. "Alien" refers to the species' having been introduced outside its natural distribution ("exotic", "non-native" and "non-indigenous" are synonyms for "alien"). "Invasive" means "tending to expand into and modify ecosystems to which it has been introduced". Thus, a species may be alien without being invasive, or, in the case of a species native to a region, it may increase and become invasive, without actually being an alien species.

Intensive grazing lands
Grazing lands that are managed primarily for livestock production with few other uses of the land other than dispersed crops.

IPBES conceptual framework
The IPBES conceptual framework has been designed to build shared understanding across disciplines, knowledge systems and stakeholders of the interplay between biodiversity and ecosystem drivers, and of the role they play in building a good quality of life.

K

Knowledge systems
A body of propositions that are adhered to, whether formally or informally, and are routinely used to claim truth. They are organized structures and dynamic processes (a) generating and representing content,

components, classes, or types of knowledge, that are (b) domain-specific or characterized by domain-relevant features as defined by the user or consumer, (c) reinforced by a set of logical relationships that connect the content of knowledge to its value (utility), (d) enhanced by a set of iterative processes that enable the evolution, revision, adaptation, and advances, and (e) subject to criteria of relevance, reliability and quality.

L

Land abandonment
Land abandonment occurs when a particular land use ceases, and there is no clearly-defined subsequent land use practice. It is often associated with poorly defined ownership and/or land use governance.

Land cover
The observed (bio)physical cover on the earth's surface.

Land degradation
Refers to the many processes that drive the decline or loss in biodiversity, ecosystem functions or services and includes the degradation of all terrestrial ecosystems.

land degradation neutrality
A state whereby the amount of healthy and productive land resources, necessary to support ecosystem services, remains stable or increases within specified temporal and spatial scales.

Land grabbing
The large-scale acquisition of land (especially in developing countries), driven primarily by concerns about food and energy security of high-income countries and often executed by the private sector.

Land sharing
A situation where low-yield farming enables biodiversity to be maintained within agricultural landscapes.

Land sparing
Land sparing, also called "land separation" involves restoring or creating non-farmland habitat in agricultural landscapes at the expense of field-level agricultural production - for example, woodland, natural grassland, wetland, and meadow on arable land. This approach does not necessarily imply high-yield farming of the non-restored, remaining agricultural land. (From Rey Benayas & Bullock, 2012). See also "Conservation agriculture" in this Glossary.

Land tenure
The relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land.

Land transformation
A process whereby the biotic community of an area is substantially altered or substituted by another, along with the underlying ecological and human processes responsible for its persistence, often as a result of a deliberate decision to change the purpose for which the land is used.

Land use
The human use of a specific area for a certain purpose (such as residential, agriculture, recreation, industrial, and so on). Influenced by, but not synonymous with, land cover. Land-use change refers to a change in the use or management of land by humans, which may lead to a change in land cover.

Landscape
A human-defined area ranging in size from c. 3 km^2 to c. 3002 km. Landscape is spatially heterogeneous in at least one factor of interest and often consists of a mosaic of interacting ecosystems.

Landscape socio-ecological approach
The landscape scale approach incorporates the socio-ecological system, including natural and human-modified ecosystems, influenced by ecological, historical, economic, and socio-cultural processes. The landscape includes an array of stakeholders small enough to be manageable, but large enough to deliver multiple functions for stakeholders with differing interests.

Livelihood resilience
The capacity of all people across generations to sustain and improve their livelihood opportunities and well-being despite environmental, economic, social and political disturbances.

Livelihood security
Adequate and sustainable access to income and resources to meet basic needs (including adequate access to food, potable water, health facilities, educational opportunities, housing, time for community participation and social integration).

M

Mangrove
Group of trees and shrubs that live in the coastal intertidal zone. Mangrove forests only grow at tropical and subtropical latitudes near the equator because they cannot withstand freezing temperatures.

Marginal lands
Lands less suited for crop or livestock production.

Mass balance (analysis)
Comparison between input and output mass of materials to solve for losses such as oxidation.

Meta-analysis
A quantitative statistical analysis of several separate but similar experiments or studies in order to test the pooled data for statistical significance.

Millennium Ecosystem Assessment
The Millennium Ecosystem Assessment is a major assessment of the human impact on the environment published in 2005.

Mineral resource extraction
The removal of a mineral resource in or on the Earth's crust, which has appropriate form, quality and quantity to allow economic extraction.

Mineralization
Mineralization in soil science is the decomposition or oxidation of the chemical compounds in organic matter releasing the nutrients contained in those compounds into soluble inorganic forms that may be plant-accessible.

Mitigation
In the context of IPBES, an intervention to reduce negative or unsustainable uses of biodiversity and ecosystems.

Models
Qualitative or quantitative representations of key components of a system and of relationships between these components. Benchmarking (of models) is the process of systematically comparing sets of model predictions against measured data in order to evaluate model performance. Validation (of models) typically refers to checking model outputs for consistency with observations. However, since models cannot be validated in the formal sense of the term (i.e. proven to be true), some scientists prefer to use the words "benchmarking" or "evaluation".

A dynamic model is a model that describes changes through time of a specific process.

A process-based model (also known as "mechanistic model") is a model in which relationships are described in terms of explicitly stated processes or mechanisms based on established scientific understanding, and model parameters therefore have clear ecological interpretation, defined beforehand.

Hybrid models are models that combine correlative and process-based modelling approaches.

A correlative model (also known as "statistical model") is a model in which available empirical data are used to estimate values for parameters that do not have predefined ecological meaning, and for which processes are implicit rather than explicit.

Integrated assessment models are interdisciplinary models that aim to describe the complex relationships between environmental, social, and economic drivers that determine current and future state of the ecosystem and the effects of global change, in order to derive policy-relevant insights. One of the essential characteristics of integrated assessments is the simultaneous consideration of the multiple dimensions of environmental problems.

Monitoring
The repeated observation of a system in order to detect signs of change.

Monoculture
The agricultural practice of producing or growing a single crop, plant, or livestock species, variety, or breed in a field or farming system at a time.

Moral economy
A moral economy, initially based on peasants' sense of belonging and sharing, is an economy that is based on goodness, fairness, and justice. Such an economy is generally only stable in small, closely knit communities, where the principles of mutuality operate.

Mosaic restoration
Landscape scale restoration efforts that do not rely on a single restoration mechanism for an entire landscape, or it is a single mechanism, deploying it in a spatially variable manner that creates patches of restored and non-restored landscape units.

Mother Earth
An expression used in a number of countries and regions to refer to the planet Earth and the entity that sustains all living things found in nature with which humans have an indivisible, interdependent physical and spiritual relationship (see "nature").

Multifunctional agriculture
The concept was adopted by FAO (1999) to foster an approach integrating landscape, biological connections, and less damageable practices. Multifunctional agriculture is meant to integrate the economic, social and ecological aspects of land management.

N

Native forests
Forests that are made up of native tree species, and are either primary (have never been clear-cut) or secondary (regenerating naturally).

Native species
Indigenous species of animals or plants that naturally occur in a given region or ecosystem.

Natural capital
The world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this natural capital that humans derive a wide range of services, often called ecosystem services, which make human life possible.

Natural Capital Accounts (NCA)
Sets of linked accounts that contain information about the type and quantities and, where possible, the value of the stocks of natural assets and the flows of services generated by them (ONS, 2017,). The accounts contain two main components: physical accounts - types, quantities and condition of assets; and monetary accounts - application of monetary units of valuation to selected flows of services on an annual basis and associated values of stocks.

Naturalized species/naturalization
A species that, once it is introduced outside its native distributional range, establishes self-sustaining populations.

Nature
In the context of the Platform, refers to the natural world with an emphasis on its living components. Within the context of Western science, it includes categories such as biodiversity, ecosystems (both structure and functioning), evolution, the biosphere, humankind's shared evolutionary heritage, and biocultural diversity. Within the context of other knowledge systems, it includes categories such as Mother Earth and systems of life, and it is often viewed as inextricably linked to humans, not as a separate entity (see "Mother Earth").

Nature's non-material benefits
Benefits from nature that do not take a physical form such as spiritual enrichment, intellectual development, recreation and aesthetic values.

Nature's contribution to people (NCP)
All the contributions, both positive and negative, of nature (i.e., biodiversity, ecosystems, and their associated ecological and evolutionary processes) to good quality of life of people. Beneficial contributions from nature include such things as food provision, water purification, flood control, and artistic inspiration, whereas detrimental contributions include disease transmission and predation that damages people or their assets. Many NCP may be perceived as benefits or detriments depending on the cultural, temporal or spatial context.

Near surface ozone
Ozone near the earth surface formed photochemically during the oxidation of hydrocarbons in the presence of nitrogen oxides.

Net Biome Production (NBP)
The amount of carbon accumulating or lost in ecosystems at the regional scale is the Net Biome Production (NBP), defined as the NEP corrected for lateral transfers of carbon to adjacent biomes, due to process such as trade in agricultural products, export of organic matter in rivers and losses due to disturbances, including land clearing and wildfire.

Net Ecosystem Production (NEP)
The amount of NPP left in the ecosystem after the additional respiration by microbes and animals is the Net Ecosystem Production (NEP).

Net Positive Impact (NPI)
A net gain to biodiversity features measured in quality hectares (for habitats), number or percentage of individuals (for species), or other metrics appropriate to the feature.

Net Primary Production (NPP)
The total mass of carbon taken out of the atmosphere by plant photosynthesis (Gross Primary Production) minus return to the atmosphere of carbon due to autotrophic respiration.

Night Light Development Index (NLDI)
A spatially explicit and globally available empirical measurement of human development derived solely from night-time satellite imagery and population density.

Non-anthropogenic
A non-anthropocentric value is a value centred on something other than human beings. These values can be non-instrumental (e.g. a value ascribed to the existence of specific species for their own sake) or instrumental to non-human ends (e.g. the instrumental value a habitat has for the existence of a specific species).

Non-Indigenous Species or Non-native species or Alien species
See "Invasive Alien Species".

Non-timber resource
A multitude of natural products (excluding timber) selectively harvested from the terrestrial environment for subsistence and commercial purposes.

O

Opportunity costs
"The added cost of using resources (as for production or speculative investment) that is the difference between the actual value resulting from such use and that of an alternative (such as another use of the same resources or an investment of equal risk but greater return)".

Organic agriculture
Any system that emphasizes the use of techniques such as crop rotation, compost or manure application, and biological pest control in preference to synthetic inputs. Most certified organic farming schemes prohibit all genetically modified organisms and almost all synthetic inputs. Its origins are in a holistic management system that avoids off-farm inputs, but some organic agriculture now uses relatively high levels of off-farm inputs.

Overstocking
Placing a number of animals on a given area that will result in overuse if continued to the end of the planned grazing period.

P

Paleological data
Information on environment event and trends (e.g., paleoclimate).

Participatory governance
A variant or subset of governance which puts emphasis on democratic engagement, in particular through deliberative practices.

Passive restoration
See "restoration".

Participatory scenario development (and planning)
Approaches characterized by more interactive, and inclusive, involvement of stakeholders in the formulation and evaluation of scenarios. Aimed at improving the transparency and relevance of decision-making, by incorporating demands and information of each stakeholder, and negotiating outcomes between stakeholders.

Payments for Ecosystem Services (PES)
A payment mechanism that involves a series of payments to land or other natural resource owners in return for a guaranteed flow of ecosystem services or certain actions likely to enhance their provision over-and-above what would otherwise be provided in the absence of payment.

Peatland(s)
Wetlands which accumulate organic plant matter in situ because waterlogging prevents aerobic decomposition and the much slower rate of the resulting anaerobic decay is exceeded by the rate of accumulation.

Pedosphere
A part of the Earth's surface that contains the soil layer.

Perceptions
The first stage of the human cognitive process. Perceptions are not neutral as they pass through rational and emotional filters which assess and interpret the relevancy of what people see. These filters are conditioned by individual experience, education, and by collective worldviews. See also "Reality"; "Concepts"; "Worldviews".

Permaculture
See "Conservation agriculture".

Permafrost
Perennially frozen ground that occurs wherever the temperature remains below 0°C for several years. Ground (soil or rock and included ice and organic material) that remains at or below 0°C for at least two consecutive years.

Permeability
The porosity of soils to allow water to pass through it.

Persistent organic pollutants (POPs)
Chemicals of global concern due to their potential for long-range transport, persistence in the environment, ability to bio-magnify and bio-accumulate in ecosystems, as well as their significant negative effects on human health and the environment.

Phenology
The timing of seasonal activities of animals and plants such as bud burst, flowering, fruiting, migration. Also used to refer to the study of such natural phenomena that recur periodically (e.g., development stages, migration) and their relation to climate and seasonal changes.

Phenotypic plasticity
An ability to alter growth form to suit current conditions without genetic change.

Plenary
Within the context of IPBES – the decision-making body comprising all of the members of IPBES.

Planetary boundaries
The safe operating space for humanity with respect to the Earth system and are associated with the planet's biophysical subsystems or processes.

Planning and zoning
Zoning is a planning control tool for regulating the built environment and creating functional real estate markets.

Plantation forests
Forests where trees have been deliberately planted (i.e., have not regenerated naturally) and are typically grown for the production of wood or fibre, in some cases they may replace grasslands or other non-forest vegetation types. They are often of exotic tree species.

Policy coherence
The systematic promotion of mutually reinforcing policy actions across government departments and agencies creating synergies towards achieving the agreed objectives.

Policy instrument
Set of means or mechanisms to achieve a policy goal.

Policy support tools
Approaches and techniques based on science and other knowledge systems that can inform, assist and enhance relevant decisions, policymaking and implementation at local, national, regional and global levels to protect nature, thereby promoting nature's benefits to people and a good quality of life.

Polluter-pays principle
The commonly accepted practice that those who produce pollution should bear the costs of managing it to prevent damage to human health or the environment. A polluter pays principle aims at preventing anybody from reaping the benefits at the expense of (or even considerable harm to) other members of the society.

Poverty
A state of deprivation that is multidimensional in nature. Poverty is more than the lack of income and resources to ensure a sustainable livelihood. Its manifestations include hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion as well as the lack of participation in decision-making

Precautionary principle
Pertains to risk management and states that if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is not harmful, the burden of proof that it is not harmful falls on those taking an action. The principle is used to justify discretionary decisions when the possibility of harm from making a certain decision (e.g., taking a particular course of action) is not, or has not been, established through extensive scientific knowledge. The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk or if a potential plausible risk has been identified.

Preventive response
Conservation measures that maintain land and its environmental and productive functions.

Prior informed consent (PIC)
Consent given before access to knowledge or genetic resources takes place, based on truthful information about the use that will be made of the resources, which is adequate for the stakeholders or rights holders giving consent to understand the implications.

Protected area
A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

Public-private partnerships (PPP)
A long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility and remuneration is linked to performance.

R

Radiative forcing (RF)
The measurement of the capacity of a gas or other forcing agents to affect that energy balance, thereby contributing to climate change. Put more simply, RF expresses the change in energy in the atmosphere due to GHG emissions.

Ramsar site(s)
A wetland site designated of international importance especially as Waterfowl Habitat under the Ramsar Convention, an intergovernmental environment treaty established in 1975 by UNESCO, coming into force in 1975. Ramsar site refers to wetland of international significance in terms of ecology, botany, zoology, limnology or hydrology. Such a site meets at least one of the criteria of identifying wetlands of international importance set by Ramsar Convention and is designated by appropriate national authority to be added to Ramsar list.

Rangeland
Natural grasslands used for livestock grazing.

Reality
Current state of biodiversity and ecosystem functions independent of human knowledge and perceptions and ecosystem services (Nature in IPBES conceptual framework). See also "Perceptions"; "Concepts"; "Worldviews".

Reclamation
The stabilization of the terrain, assurance of public safety, aesthetic improvement, and usually a return of the land to what, within the regional context, is considered to be a useful purpose.

REDD+
Reducing emissions from deforestation and forest degradation (REDD+) is a mechanism developed by Parties to the United Nations Framework Convention on Climate Change (UNFCCC). It creates a financial value for the carbon stored in forests by offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. Developing countries would receive results-based payments for results-based actions. REDD+ goes beyond simply deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

Reforestation
Intentional replanting of trees and re-establishing a forest in areas that have been deforested.

Regime shift
Substantial reorganization in system structure, functions and feedbacks that often occurs abruptly and persists over time.

Rehabilitation
Restoration activities that may fall short of fully restoring a biotic community to its pre-degradation state, including natural regeneration and emergent ecosystems.

Remediation
Any action taken to rehabilitate ecosystems.

Renewable energy
Energy derived from natural processes (e.g., sunlight and wind) that are replenished at a faster rate than they are consumed. Solar, wind, geothermal, hydro, and some forms of biomass are common sources of renewable energy.

Replexity
Rapid and complex change.

Representative Concentration Pathways (RCPs)
Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover. The word representative signifies that each RCP provides only one of many possible

scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome. RCPs usually refer to the portion of the concentration pathway extending up to 2100, for which Integrated Assessment Models produced corresponding emission scenarios.

Resilience
The level of disturbance that an ecosystem or society can undergo without crossing a threshold to a situation with different structure or outputs. Resilience depends on factors such as ecological dynamics as well as the organizational and institutional capacity to understand, manage and respond to these dynamics.

Restoration
Any intentional activity that initiates or accelerates the recovery of an ecosystem from a degraded state. **Active restoration** includes a range of human interventions aimed at influencing and accelerating natural successional processes to recover biodiversity ecosystem service provision.

Passive restoration includes reliance primarily on natural process of ecological succession to restore degraded ecosystems, but may include measures to protect a site from processes that currently prevent natural recovery (e.g., protection of degraded forests from overgrazing by livestock or unintentional human-induced fire).

Rewilding
Rewilding ensures natural processes and wild species play a much more prominent role in the land-and seascapes, meaning that after initial support, nature is allowed to take more care of itself. Rewilding helps landscapes become wilder, whilst also providing opportunities for modern society to reconnect with such wilder places for the benefits of all life.

Rotational grazing
A grazing scheme where animals are moved from one grazing unit (paddock) in the same group of grazing units to another without regard to specific graze: rest periods or levels of plant defoliation. cf. grazing system.

Rubin Causal Model (RCM)
Also known as the Neyman–Rubin causal model, is an approach to the statistical analysis of cause and effect based on the framework of potential outcomes, named after Donald Rubin.

S

Salinization
The process of increasing the salt content in soil is known as salinization. Salinization can be caused by natural processes such as mineral weathering or by the gradual withdrawal of an ocean. It can also come about through artificial processes such as irrigation.

Savannah
Ecosystem characterized by a continuous layer of herbaceous plants, mostly grasses, and a discontinuous upper layer of trees that may vary in density.

Scale
The spatial, temporal, quantitative and analytical dimensions used to measure and study any phenomenon. The temporal scale is comprised of two properties: (i) temporal extent – the total length of the time period of interest for a particular study (e.g., 10 years, 50 years, or 100 years); and 2) temporal grain (or resolution) – the temporal frequency with which data are observed or projected within this total period (e.g. at 1-year, 5-year or 10-year intervals). The spatial scale is comprised of two properties: 1) spatial extent – the size of the total area of interest for a particular study (e.g., a watershed, a country, the entire planet); and (ii) spatial grain (or resolution) – the size of the spatial units within this total area for which data are observed or predicted (e.g., fine-grained or coarse-grained grid cells).

Scale paradox
Process in which land use outcomes vary (often counterintuitively) according to the geographic location and spatial scale under consideration.

Scenarios
Representations of possible futures for one or more components of a system, particularly for drivers of change in nature and nature's benefits, including alternative policy or management options.

Exploratory scenarios (also known as “explorative scenarios” or “descriptive scenarios”) are scenarios that examine a range of plausible futures, based on potential trajectories of drivers – either indirect (e.g., socio-political, economic and technological factors) or direct (e.g., habitat conversion, climate change).

Target-seeking scenarios (also known as “goal-seeking scenarios” or “normative scenarios”) are scenarios that start with the definition of a clear objective, or a set of objectives, specified either in terms of achievable targets, or as an objective function to be optimized, and then identify different pathways to achieving this outcome (e.g., through backcasting).

Intervention scenarios are scenarios that evaluate alternative policy or management options – either through target seeking (also known as “goal seeking” or “normative scenario analysis”) or through policy screening (also known as “ex-ante assessment”).

Policy-evaluation scenarios are scenarios, including counterfactual scenarios, used in ex-post assessments of the gap between policy objectives and actual policy results, as part of the policy-review phase of the policy cycle.

Policy-screening scenarios are scenarios used in ex-ante assessments, to forecast the effects of alternative policy or management options (interventions) on environmental outcomes.

Sector
A distinct part of society, or of a nation's economy.

Sedentarization
The process by which a nomadic group transitions to a lifestyle of living in one place.

Shared socioeconomic pathways (SSPs)
Narratives outlining broad characteristics of the global future and country-level population, Gross Domestic Product (GDP), urbanisation projections based on five alternative socio-economic developments (i.e., sustainable development), regional rivalry, inequality, fossil-fuelled development, and middle-of-the-road development. The SSPs are supported by key quantitative indicators and metrics, describing trends in demographics, human development, economy and lifestyle, policies and institutions, technology, environment and natural resources.

Silviculture
The applied science of forest ecology and management. The foundation is based on silvics, which is concerned with the development and growth of trees and forests. The practice of silviculture is rooted in a broad understanding of forested

ecosystems, which includes biometeorology, hydrology, geology and soils and ecology.

Social capital
Networks together with shared norms, values and understandings that facilitate co-operation within or among groups. Social capital represents the capacity of a community (local or international like the UN) to gather and achieve common goals.

Social inequality
A state whereby resources in a given society are distributed unevenly, typically through norms of allocation, that engender specific patterns along lines of socially defined categories of persons.

Social marginalization
The process in which individuals or people are systematically blocked from (or denied full access to) various rights, opportunities and resources that are normally available to members of a different group, and which are fundamental to social integration and observance of human rights within that particular group (e.g., housing, employment, healthcare, civic engagement, democratic participation and due process).

Social-ecological resilience
The capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions. It describes the degree to which the system is capable of self-organization, learning and adaptation (Holling, 1973, Gunderson & Holling, 2002, Walker *et al.* 2004).

Socioecological system
An ecosystem, the management of this ecosystem by actors and organizations, and the rules, social norms, and conventions underlying this management.

Soil
The upper layer of the Earth's crust transformed by weathering and physical/chemical and biological processes. It is composed of mineral particles, organic matter, water, air and living organisms organized in genetic soil horizons.

Soil acidification
Soil acidification is caused by a number of factors including acidic precipitation and the deposition from the atmosphere of acidifying gases or particles, such as sulphur dioxide, ammonia and nitric acid. The most important causes of soil acidification on agricultural land, however, are the application of ammonium-based fertilizers and urea, elemental S fertilizer and the growth of legumes.

Soil biodiversity loss
Decline in the diversity of (micro- and macro-) organisms present in a soil. In turn, this prejudices the ability of soil to provide critical ecosystem services.

Soil compaction
An increase in density and a decline of porosity in a soil that impedes root penetration and movements of water and gases.

Soil contamination
An increase of toxic compounds (heavy metals, pesticides and so on) in a soil that constitute, directly or indirectly (via the food chain), a hazard for human health and/or for the provision of ecosystem services assured by the soil.

Soil degradation
The diminishing capacity of the soil to provide ecosystem goods and services.

Soil ecosystem functions
A description of the significance of soils to humans and the environment. Examples are: (i) control of substance and energy cycles within ecosystems; (ii) basis for the life of plants, animals and man; (iii) basis for the stability of buildings and roads; (iv) basis for agriculture and forestry; (v) carrier of genetic reservoir; (vi) document of natural history; and (vii) archaeological and paleo-ecological document.

Soil fertility
The quality of a soil that enables it to provide compounds in adequate amounts and proper balance to promote growth of plants when other factors (such as light, moisture, temperature and soil structure) are favourable.

Soil formation rates
The process of rock weathering though which soil is formed.

Soil health
The continued capacity of the soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal and human health (Doran, Stamatiadis and Haberern, 2002).

Soil organic carbon (SOC)
A summarizing parameter including all of the carbon forms for dissolved (DOC: Dissolved Organic Carbon) and total organic compounds (TOC: Total Organic Carbon) in soils.

Soil organic matter (SOM)
Matter consisting of plant and/or animal organic materials, and the conversion products of those materials in soils.

Soil pollution
Process of soil contamination by chemicals (fertilizers, petroleum products, pesticides, herbicides, mining) which has affected agricultural productivity and other ecosystem services negatively.

Soil processes
Physical or reactive geochemical and biological processes which may attenuate, concentrate, immobilize, liberate, degrade or otherwise transform substances in soil (ISO, 2013).

Soil quality
All current positive or negative properties with regard to soil utilization and soil functions.

Soil salinization
Increase in water-soluble salts in soil which is responsible for increasing the osmotic pressure of the soil. In turn, this negatively affects plant growth because less water is made available to plants.

Soil structure
The arrangement of soil particles in a variety of recognized shapes and sizes.

Soil sealing
The covering of the soil surface with materials like concrete and stone, as a result of new buildings, roads, parking places, but also other public and private space.

Sovereignty principle
Sovereignty in the sense of contemporary public international law denotes the basic international legal status of a state that is not subject, within its territorial jurisdiction, to the governmental, executive, legislative, or judicial jurisdiction of a foreign state or to foreign law other than public international law. A sovereign entity can decide and administer its own laws, can determine the

use of its land and can do pretty much as it pleases, free of external influence (within the limitations of international law).

Soil stability
The integrity of soil aggregates, degree of soil structural development, and erosion resistance.

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

Species composition
The array of species in a specific region, area, or assembly.

Species richness
The number of species within a given sample, community, or area.

Species/ecological community
An assemblage or association of populations of two or more different species occupying the same geographical area and in a particular time.

Stakeholder(s)
Any individuals, groups or organizations who affect, or could be affected (whether positively or negatively) by a particular issue and its associated policies, decisions and action.

Strategic environmental assessment (SEA)
A mechanism that attempts to assess systematically the environmental impacts of decisions made at, what is conventionally called, levels of strategic decisions.

Summary for policymakers
Is a component of any report, providing a policy-relevant but not policy prescriptive summary of that report.

Surface mining
Includes strip mining, open-pit mining and mountaintop removal mining, is a broad category of mining in which soil and rock overlying the mineral deposit (the overburden) are removed.

Sustainable Development Goals (SDGs)
Also, the "Global Goals," are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. These 17 Goals build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The goals are interconnected; often the key to success on one will involve tackling issues more commonly associated with another.

Sustainable forest management (SFM)
Can mean many things to many people – yet a common thread is the production of forest goods and services for the present and future generations. The concept provides guidance on how to manage forests to provide for today's needs (as best as possible) and not compromise (i.e., reduce) the options of future generations.

Sustainable intensification
A process or system where agricultural yields are increased without adverse environmental impact and without the conversion of additional non-agricultural land.

Sustainable intensive agriculture
Process or system where agricultural yields are increased without adverse environmental impact and without the conversion of additional non-agricultural land.

Sustainable land management
The use of land resources, including soils, water, animals and plants for the production of goods to meet changing human needs while ensuring the long-term productive potential of these resources and the maintenance of their environmental functions

Sustainable land use
The land use that serves the needs (for food, energy, housing, recreation etc.) of all human beings living on Earth today and in the future, respecting the boundaries and the resilience of ecological systems.

Sustainable soil management
Sets of activities that maintain or enhance the supporting, provisioning, regulating and cultural services provided by soils without significantly impairing either the soil functions that enable those services or biodiversity.

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

Sustainability
A characteristic or state whereby the needs of the present and local population can be met without compromising the ability of future generations or populations in other locations to meet their needs.

Swidden/slash and burn agriculture
Swidden farming, also known as shifting cultivation or milpa in Latin America, is conventionally defined as an agricultural system in which temporary clearings are cropped for fewer years than they are allowed to remain fallow.

T

Target
A choice by people of a desired contemporary or future outcome.

Target condition
A condition that maximizes the desired mix of ecosystem services.

Telecoupling
Socioeconomic and environmental interactions over distances. It involves distant exchanges of information, energy and matter (e.g., people, goods, products, capital) at multiple spatial, temporal and organizational scales.

Tenure security
An agreement between an individual or group to land and residential property, which is governed and regulated by a legal and administrative framework includes both customary and statutory systems.

Terrestrial productivity
Net Primary Production (NPP) from the terrestrial environment.

Thermodynamics
The science of the relationship between heat, work, temperature, and energy. In broad terms, thermodynamics deals with the transfer of energy from one place to another and from one form to another. The key concept is that heat is a form of energy corresponding to a definite amount

of mechanical work. The behaviour of a complex thermodynamic system, such as Earth's atmosphere, can be understood by first applying the principles of states and properties to its component parts—in this case, water, water vapour, and the various gases making up the atmosphere. By isolating samples of material whose states and properties can be controlled and manipulated, properties and their interrelations can be studied as the system changes from state to state.

Threatened species
In the IUCN Red List terminology, a threatened species is any species listed in the Red List categories critically endangered, endangered, or vulnerable.

Tillage
In agriculture, the preparation of soil for planting and the cultivation of soil after planting.

Tipping point
A set of conditions of an ecological or social system where further perturbation will cause rapid change and prevent the system from returning to its former state.

Topsoil
The upper part of a natural soil that is generally dark coloured and has a higher content of organic matter and nutrients when compared to the (mineral) horizons below. It excludes the litter layer.

Trade-off
A situation where an improvement in the status of one aspect of the environment or of human well-being is necessarily associated with a decline in or loss of a different aspect. Trade-offs characterize most complex systems, and are important to consider when making decisions that aim to improve environmental and/or socio-economic outcomes. Trade-offs are distinct from synergies (the latter are also referred to as "win-win" scenarios): synergies arise when the enhancement of one desirable outcome leads to enhancement of another.

Traditional knowledge
See "Indigenous and local knowledge".

Tragedy of the Commons
Title of an influential 1968 essay by biologist Garrett Hardin, which argued that overuse of common resources is a leading cause of environmental degradation. This was interpreted by some, especially economists and free-market libertarians, to mean that private ownership is preferable to the commons for the stewardship of land, water, minerals, etc. Yet in recent years many have challenged this view on both empirical and philosophical grounds. Professor Elinor Ostrom of Indiana University has been a leading figure in demonstrating the practical utility and sustainability of commons governance regimes, particularly in developing countries. This suggests that the vision of human behaviour implicit in the tragedy of the commons metaphor is not as immutable as many economists assert, and that collective management is an eminently practical governance strategy in many circumstances. The tragedy of the "anti-commons" is now frequently invoked to describe the problems associated with excessive privatization and fragmentation of property rights, such that collective action for the common good is thwarted. See also "Commons" and "Common pool resources".

Transboundary pollution
Pollution that originates in one country but, by crossing the border through pathways of water or air, can cause damage to the environment in another country.

Transformation
See "land transformation".

Transhumance
Form of pastoralism or nomadism organized around the migration of livestock between mountain pastures in warm seasons and lower altitudes the rest of the year.

Tree-covered area
A land cover class that includes any geographic area dominated by natural tree plants with a cover of 10 percent or more. Areas planted with trees for afforestation purposes and forest plantations are included in this class.

Trends
A general development or change in a situation or in the way that people are behaving.

Trophic level
The level in the food chain in which one group of organisms serves as a source of nutrition for another group of organisms.

Uncertainty
Any situation in which the current state of knowledge is such that:

(i) the order or nature of things is unknown;
(ii) the consequences, extent, or magnitude of circumstances, conditions, or events is unpredictable; and
(iii) credible probabilities to possible outcomes cannot be assigned.

Uncertainty can result from lack of information or from disagreement about what is known or even knowable. Uncertainty can be represented by quantitative measures (e.g., a range of values calculated by various models) or by qualitative statements (e.g., reflecting the judgment of a team of experts).

Upscaling
The process of scaling information from local, fine-grained resolution to global, coarse-grained resolution.

Urban heat island effect
The term "heat island" describes built up areas that are hotter than nearby rural areas.

V

Values
- Values systems: Set of values according to which people, societies and organizations regulate their behaviour. Value systems can be identified in both individuals and social groups.
- Value (as principles): A value can be a principle or core belief underpinning rules and moral judgments. Values as principles vary from one culture to another and also between individuals and groups.
- Value (as preference): A value can be the preference someone has for something or for a particular state of the world. Preference involves the act of making comparisons, either explicitly or implicitly. Preference refers to the importance attributed to one entity relative to another one.
- Value (as importance): A value can be the importance of something for itself or for others, now or in the future, close by or at a distance. This importance can be considered in three broad classes. 1. The importance that something has subjectively, and may be based on experience. 2. The importance that something has in meeting objective needs. 3. The intrinsic value of something.
- Value (as measure): A value can be a measure. In the biophysical sciences, any quantified measure can be seen as a value.
- Non-anthropocentric value: A non-anthropocentric value is a value centred on something other than human beings.

These values can be non-instrumental or instrumental to non-human ends.

- Intrinsic value: The value inherent to nature, independent of human experience and evaluation, and therefore beyond the scope of anthropocentric valuation approaches.
- Anthropocentric value: Human-centred, the value that something has for human beings and human purposes.
- Instrumental value: The direct and indirect contribution of nature's benefits to the achievement of a good quality of life. Within the specific framework of the total economic value, instrumental values can be classified into use (direct and indirect use values) on the one hand, and non-use values (option, bequest and existence values) on the other. Sometimes option values are considered as use values as well.
- Non-instrumental value: The value attributed to something as an end in itself, regardless of its utility for other ends.
- Relational value: The values that contribute to desirable relationships, such as those among people and between people and nature, as in "living in harmony with nature".
- Integrated valuation: The process of collecting, synthesizing, and communicating knowledge about the ways in which people ascribe importance and meaning of nature's contribution, to facilitate deliberation and agreement for decision making and planning.

Vector-borne pathogens
Disease causing agents that are spread from host to host by living or non-living agent. For example, malaria is transmitted to humans by mosquitos.

Virtual water
The volume of freshwater used to produce the commodity, good or service, measured at the place where the product was actually produced.

Virtual water balance
In global trade, the difference between water used to produce export products and the water used to produce import products.

Volatilization
The process of converting a chemical substance from a liquid or solid state to a gaseous or vapour state.

Vulnerability reduction
The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

W

Water footprint
The measure of humanity's use of fresh water as represented in volumes of water consumed and/or polluted.

Water logging
An excess of water on top and/or within the soil, leading to reduced air availability in the soil for long periods.

Water purification
Vegetation, and specially aquatic plants, can assist in removing sediments and nutrients and other impurities from water.

Water security
The capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution, water-related disasters, and for preserving ecosystems.

Water Security Index (WSI)
The ratio of total water withdrawal to the water availability including environmental flow requirements. Higher WSI values lead to decreasing water security.

Water table
The upper surface of the zone of ground water.

Well-being
A perspective on a good life that comprises access to basic resources, freedom and choice, health and physical well-being, good social relationships, security, peace of mind and spiritual experience. Human well-being is a state of being with others and the environment. Well-being is achieved when individuals and communities can act meaningfully to pursue their goals and everyone can enjoy a good quality of life. The concept of human well-being is used in many Western societies and its variants, together with living in harmony with nature, and living well in balance and harmony with Mother Earth.

Western cultures/western science
(Also called modern science, Western scientific knowledge or international science) is used in the context of the IPBES conceptual framework as a broad term to refer to knowledge typically generated in universities, research institutions and private firms following paradigms and methods typically associated with the "scientific method" consolidated in Post-Renaissance Europe on the basis of wider and more ancient roots. It is typically transmitted through scientific journals and scholarly books. Some of its central tenets are observer independence, replicable findings, systematic scepticism, and transparent research methodologies with standard units and categories.

Wetlands
Areas that are subject to inundation or soil saturation at a frequency and duration, such that the plant communities present are dominated by species adapted to growing in saturated soil conditions, and/or that the soils of the area are chemically and physically modified due to saturation and indicate a lack of oxygen; such areas are frequently termed peatlands, marshes, swamps, sloughs, fens, bogs, wet meadows and so on.

Woody encroachment
Increasing dominance of shrubs in grasslands and trees in shrublands.

Worldviews
Defined by the connections between networks of concepts and systems of knowledge, values, norms and beliefs. Individual person's worldviews are moulded by the community the person belongs to. Practices are embedded in worldviews and are intrinsically part of them (e.g. through rituals, institutional regimes, social organization, but also in environmental policies, in development choices, etc.). See also "Perceptions"; "Concepts"; "Reality".

ANNEX II

Acronyms

ADB	Asian Development Bank
ASSOD	Assessment of Soil Degradation in South and Southeast Asia
BAU	Business-as-usual
BBOP	Business and Biodiversity Offsets Programme
BECCS	Bioenergy with Carbon Capture and Storage
BRC	UK Biological Records Centre
C	Carbon
CBA	Cost–Benefit Analysis
CBD	Convention on Biological Diversity
CGIAR	Consultative Group for International Agricultural Research
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
EC	European Commission
EEA	European Environment Agency
ELD	Economics of Land Degradation Initiative
EPA	Environmental Protection Agency (USA)
ESVD	Ecosystem Service Valuation Database
EU	European Union
EVRI	Environmental Valuation Reference Inventory
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FSC	Forest Stewardship Council
GBO4	4th Global Biodiversity Outlook
GDP	Gross Domestic Product
Gg	Gigagram (1g x 10^9)
GHG	Greenhouse Gas
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GLADA	Global Assessment of Land Degradation and Improvement
GLADIS	Global Land Degradation Information System
GLASOD	Global Assessment of Human-induced Soil Degradation
GLOBIO	Global Biodiversity model
GMO	Genetically Modified Organism
Ha	Hectare (10,000 square meters, 0.01 km^2)
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IAM	Integrated Assessment Model
ICMM	International Council on Mining and Metals
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
IIFB	International Indigenous Forum on Biodiversity
IIPFCC	International Indigenous Peoples Forum on Climate Change
ILK	Indigenous and Local Knowledge
ILKP	Indigenous and Local Knowledge and Practices
IMAGE	Integrated Model to Assess the Environment
InVEST	Integrated Valuation of Ecosystem Services and Tradeoffs
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPES-Food	International Panel of Experts on Sustainable Food Systems
IPLC	Indigenous Peoples and Local Communities
ITPS	Intergovernmental Technical Panel on Soils
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature
LADA	Land Degradation Assessment in Drylands
LCA	Life Cycle Analysis
MCDA	Multi-Criteria Decision Analysis
MEA or MA	Millennium Ecosystem Assessment
MIMES	Multi-scale Integrated Models of Ecosystem Services
MODIS	Moderate-resolution Imaging Spectroradiometer
MSA	Mean Species Abundance
NCP	Nature's Contributions to People
NDVI	Normalized Difference Vegetation Index
NGOs	Non-Governmental Organizations
NPP	Net Primary Productivity
OECD	Organization for Economic Co-operation and Development
ONS	Office for National Statistics (UK)
PA	Protected Area

PBL Planbureau voor de Leefomgeving/Netherlands Environmental Assessment Agency

PEFC Programme for the Endorsement of Forest Certification

PES Payments for Ecosystem/Environmental Services

Pg Petagram (1g x 10^{15} or 1 Gigatonne)

PPP Public-Private Partnerships

RCP Representative Concentration Pathway

RECARE Preventing and Remediating degradation of soils in Europe through Land Care

REDD+ Reducing Emissions from Deforestation and forest Degradation

RUSLE Revised Universal Soil Loss Equation

SDGs Sustainable Development Goals

SOC Soil Organic Carbon

SolVES Social Values for Ecosystem Services

SPLASH Simple process-led algorithms for simulating habitats

SSP Shared Socioeconomic Pathway

Tg Teragram (g x 10^{12})

TNC The Nature Conservancy

UKNEA UK National Ecosystem Assessment

UN United Nations

UNCCD United Nations Convention to Combat Desertification

UNCTAD United Nations Conference on Trade and Development

UNDP United Nations Development Programme

UNECE United Nations Economic Commission for Europe

UNEP United Nations Environment Programme

UNEP-FI United Nations Environment Programme - Finance Initiative

UNFCCC United Nations Framework Convention on Climate Change

UNICEF United Nations Children's Fund

UNISDR United Nations International Strategy for Disaster Risk Reduction

UNPFII United Nations Permanent Forum on Indigenous Issues

UN-WATER United Nations Water

USA United States of America

USLE Universal Soil Loss Equation (also RUSLE: Revised, and MUSCLE: Modified)

WHO World Health Organization

WOCAT World Overview of Conservation Approaches and Technologies

WRI World Resources Institute

WTO World Trade Organization

Yr Year

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