A Report of the Science-Policy Interface

The Contribution of Integrated Land Use Planning and Integrated Landscape Management to Implementing Land Degradation Neutrality: Entry Points and Support Tools
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How to cite this document:


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UNCCD-SPI Technical Series No. 06


Photographs ©

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Language editor: Peter Christie

Supported by the UNCCD, this publication was produced with the financial support of the Changwon Initiative, the European Union, and the Ankara Initiative. Its contents are the sole responsibility of the UNCCD and do not necessarily reflect the views of the donors.
A Report of the Science-Policy Interface

The Contribution of Integrated Land Use Planning and Integrated Landscape Management to Implementing Land Degradation Neutrality: Entry Points and Support Tools
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“The Contribution of Integrated Land Use Planning and Integrated Landscape Management to Implementing Land Degradation Neutrality: Entry Points and Support Tools” was prepared under the supervision of the UNCCD Science-Policy Interface (SPI) working group dedicated to Objective 1. In keeping with decision 19/COP.12 as well as with internal SPI procedures, all technical reports have undergone a scientific review by the larger SPI group (including all five Committee on Science and Technology (CST) Bureau members and all five observer organizations), a review by several former SPI members, and an international, independent review process that has included six domain experts covering all regions.

The technical report was prepared by an author team of four coordinating lead authors, two lead authors, and 16 contributing authors. A scoping meeting in February 2020 in Bonn and three authors’ meetings (November 2020 (virtual), March 2021 (virtual) and October 2021 (in Bonn, Germany)) were held. SPI members, as well as external experts, participated in these meetings.

The draft report produced by the authors underwent a two-step peer review process, including an internal review and an independent external scientific review. For the latter, six external reviewers (individual experts) from the different UNCCD regions, and two representatives of international organisations, which are relevant to the UNCCD processes on LDN were selected. The coordinating lead authors ensured that all peer review comments received appropriate consideration. The report was reviewed by the Bureau of the Conference of the Parties of the UNCCD.
Foreword

Over the past decade, several intergovernmental scientific reports—including the recent 2nd Edition of the UNCCD’s Global Land Outlook—have highlighted two overarching messages: 1. our current mismanagement and misuse of land—its soil, water, and biodiversity—threatens the health and continued existence of life on Earth, including our own; and 2. managing and using land properly is fundamental to achieving all 17 of the UN Sustainable Development Goals (SDGs).

Two distinct ideas are central to both messages: land management and land use. While sustainable land management has long been a focus of attention and investment, the sustainable use of land has received far less consideration.

This report shifts this focus. It examines how land can be more sustainably used—and for good reason. The problem of land misuse is clear. Our human use of land has transformed more than 70% of ice-free terrestrial ecosystems from their natural state. One in five of those transformed hectares is now considered no longer productive. Around the world, land use change remains a major driver in the loss of natural capital.

These alarming facts point to the need for alternatives to business-as-usual land use planning. They make clear that land use planning exists at the nexus of national land policies and healthy land. Only when land use planning is truly inclusive of all stakeholder interests and integrative across all environmental, economic, social and cultural needs will it help in our progress toward the SDGs.

This report is based on an extensive scientific assessment conducted by the UNCCD’s Science-Policy Interface. It examines the potential contribution of integrated land use planning (ILUP) and integrated landscape management (ILM) to positive transformative change, achieving land degradation neutrality (LDN) and addressing desertification, land degradation, and drought issues. In particular, it explores how ILUP and ILM can be used to integrate LDN, while recognizing that land use planning is conducted in very different ways in different countries. It describes a diverse mix of ILUP and ILM tools and approaches used around the world and examines how these support or limit effective integration of LDN. These findings inform proposals for policymakers for enhancing ILUP and ILM in the context of achieving LDN and improving land use everywhere.

Land is the substrate of hope. Improving land use can improve lives and save nature. Success requires doing the right things in the right places at the right scale with all of the right people everywhere and every time land use decisions are made. That is much easier said than done, but this report provides a foundation. It is a guide to improve how land is used into the future. My thanks to all who have been involved in this important work.

Ibrahim Thiaw
Executive Secretary
United Nations Convention to Combat Desertification
Executive Summary

The 14th Conference of the Parties (COP) of the UNCCD requested that the Science Policy Interface provide science-based evidence on the potential contribution of integrated land use planning (ILUP) and integrated landscape management (ILM) to positive transformative change for achieving land degradation neutrality (LDN) and addressing desertification/land degradation and drought issues. In response to this request, the SPI produced this technical report drawing from science-based evidence and good practices gathered from illustrative examples. The technical report follows the rules and procedures established by the COP, requiring any scientific output prepared under the supervision of the SPI to undergo an international, independent review.

The report provides an analytical overview of common tools and approaches that are used, or can be used, to support ILUP and ILM and identifies ways in which these tools and approaches can aid in achieving LDN targets. An analysis of existing planning systems provides generic key elements for a typology of these systems. The work also identifies entry points for embedding LDN actions into planning systems at different scales (i.e., national, watershed, or local). The illustrative examples show that ILUP and ILM can help reconcile multi-objective land uses, seek LDN (i.e., by balancing gains with anticipated losses), carefully consider trade-offs, and navigate possible conflicts between sectoral interests and potential uses (e.g., conservation and food production).

The SPI drew five conclusions from this evidence: (1) ILUP and ILM have integral roles to play in achieving LDN and reducing decision uncertainties associated with planning for neutrality; (2) the integration of LDN in ILUP-ILM processes should consider the unique characteristics of a country’s planning system; (3) the integration of LDN within ILUP-ILM processes relies on a combination of tools and approaches; (4) tools that can be used for simulating the LDN counterbalancing mechanism and the LDN response hierarchy within land use planning processes are scarce; and (5) ILUP-ILM that supports LDN should consider future changes that result from dynamic political, socio-cultural, and environmental contexts.

The report’s conclusions can be used to support a vision for the UNCCD 2018–2030 Strategic Framework. This vision sees a future that avoids, minimises, and reverses desertification/land degradation, mitigates the effects of drought in affected areas at all levels, and strives to achieve a land-degradation-neutral world consistent with the UN 2030 Agenda for Sustainable Development within the scope of the Convention.

This report proposes the following actions to develop inclusive measures for ILUP-ILM and to encourage positive transformative change toward a better, land-degradation-neutral future:

- Strengthen cross-sectoral governance and land use planning for transformative change that supports LDN;
- Incentivise collaboration between the academic and practitioner communities and research institutes to develop or tailor existing tools and approaches to integrate LDN within ILUP-ILM processes;
Promote knowledge generation and share approaches and tools to support ILUP and ILM to achieve LDN;

Consider the integration of LDN target-setting into ILUP-ILM processes that comprise national and subnational planning systems; and

Provide a more central role for ILUP-ILM to create synergies and inform policies for reaching major, internationally accepted sustainability goals, including LDN.
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### Abbreviations

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<th>Acronym</th>
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<tr>
<td>CIDP</td>
<td>County Integrated Development Plan</td>
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<tr>
<td>COP</td>
<td>Conference of the Parties</td>
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<td>CST</td>
<td>Committee on Science and Technology</td>
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<td>FAO</td>
<td>Food and Agricultural Organization of the United Nations</td>
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<td>GHG</td>
<td>Greenhouse gas</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<td>GIZ</td>
<td>German International Development Agency</td>
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<td>ILM</td>
<td>Integrated Landscape Management</td>
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<td>ILUP</td>
<td>Integrated Land Use Planning</td>
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<tr>
<td>IPBES</td>
<td>Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services</td>
</tr>
<tr>
<td>IPCC</td>
<td>Intergovernmental Panel on Climate Change</td>
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<tr>
<td>LADA</td>
<td>Land Degradation Assessment</td>
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<td>LDN</td>
<td>Land Degradation Neutrality</td>
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<td>LUP4LDN</td>
<td>Land Use Planning for Land Degradation Neutrality</td>
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<tr>
<td>NPP</td>
<td>Net Primary Production</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<td>RDDST</td>
<td>Resilience Diagnostic and Decision Support Tool</td>
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<td>SDGs</td>
<td>Sustainable Development Goals</td>
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<td>SHARED</td>
<td>Stakeholder Approach to Risk-Informed and Evidence-Based Decision-Making</td>
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<td>SLM</td>
<td>Sustainable Land Management</td>
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<tr>
<td>SMCE</td>
<td>Social Multi-Criteria Evaluation</td>
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<td>SPI</td>
<td>Science-Policy Interface</td>
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<tr>
<td>TSP</td>
<td>Target Setting Programme</td>
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<tr>
<td>UNCBD</td>
<td>United Nations Convention on Biological Diversity</td>
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<td>UNCCD</td>
<td>United Nations Convention to Combat Desertification</td>
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<td>UNFCCC</td>
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<td>WCBSP</td>
<td>The Western Cape Biodiversity Spatial Plan</td>
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<td>WOCAT</td>
<td>World Overview of Conservation Approaches and Technologies</td>
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Glossary of Key Terms

**Climate change adaptation** In human systems, the process of adjustment to actual or expected climate change and its effects to moderate harm or to exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate change and its effects. Human intervention may facilitate the adjustment of natural systems to expected climate change and its effects (modified from IPCC, 2019b).

**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 be achieved by increasing the capacity of carbon sinks (e.g., through reforestation) and by carbon conservation in natural vegetation and soils (adapted from IPBES, 2018).

**Co-benefits** The positive effects that a policy or measure aimed at one objective might have on other objectives, thereby increasing the total benefits for society and/or the environment. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors (IPCC, 2019b).

**Counterbalancing** A mechanism for satisfying the principle of neutrality by responding to land degradation with land use changes of an equal and opposite effect, over a specified time frame, within a biophysical domain (e.g., catchment) or administrative area (e.g., provincial spatial domain) and generally within the same land type (modified from Orr et al., 2017).

**Drought** A prolonged absence or marked deficiency of precipitation. Drought is the naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems (World Meteorological Organization, 1992). Drought represents a risk to habitat and landscape integrity, declining land productivity, and expanding soil erosion.

**Drought resilience** Increased resilience to drought risk. Drought resilience strengthens the ability of communities, ecosystems, and economies to anticipate, absorb, accommodate, or recover from the effects of drought in a timely and efficient manner, including the preservation, restoration, or improvement of natural capital (UNCCD, 2019a).

**Entry points** Windows of opportunity (e.g., situations or processes) that can occur at all levels of governance and can spur the interest of policymakers, key
stakeholders, or the broader public in cross-cutting topics, such as land degradation neutrality (LDN). Potential entry points are governance processes related to development and to the revision and/or strengthening of policy instruments and institutions (e.g., watershed committees, land use associations) (modified from GIZ, 2017).

**Integrated Landscape Management (ILM)** The long-term collaboration among different groups of stakeholders to achieve multiple objectives from the landscape. Five key features—all of which facilitate participatory development processes—characterise ILM: 1) shared or agreed upon management objectives that encompass multiple landscape benefits; 2) field practices that are designed to contribute to multiple objectives; 3) management of ecological, social, and economic interactions for the realisation of positive synergies and the mitigation of negative trade-offs; 4) collaborative, community engaged planning, management, and monitoring processes; and 5) the re-configuration of markets and public policies to achieve diverse landscape objectives (Scherr *et al*., 2013).

**Integrated Land Use Planning (ILUP)** Land use planning that seeks to balance the economic, social, and cultural opportunities provided by land with the need to maintain and enhance ecosystem services provided by land-based natural capital. ILUP also aims to blend or coordinate management strategies and implementation requirements across multiple sectors and jurisdictions (Orr *et al*., 2017; United Nations General Assembly, 1992). In practice, ILUP is applied to assessing and allocating land-based resources across a landscape, accounting for differing uses and demands from different users (Metternicht, 2017). It requires the coordination of planning and management across sectors concerned with land resources and their use within a spatial administrative or geographic unit (e.g., catchment, region, and/or country). Its purpose is to identify the combination of land uses that can meet stakeholders’ needs while safeguarding resources for the future. By examining all land uses in an integrated manner, ILUP identifies the most efficient trade-offs between land-use options and links social and economic development with environmental protection and enhancement, thus helping to achieve sustainable land management (FAO, 2018). Integrated land use planning is an umbrella term that includes more specific approaches such as—but not limited to—territorial planning and spatial planning.

**Governance** A comprehensive concept inclusive of all means for deciding, managing, implementing, and monitoring policies and measures. Whereas government is defined strictly in terms of the nation-state, the more inclusive concept of
governance recognizes the contributions of various levels of government (e.g.,
global, international, regional, national, sub-national, and local) and the
contributing roles of the private sector, nongovernmental actors, and civil society
for addressing issues facing the global community and the local context where
the effectiveness of policies and measures are determined (IPCC, 2019b).

Land Degradation Neutrality (LDN) A state whereby the amount and quality of land
resources necessary to support ecosystem functions and services and to
enhance food security remain stable or increase within specified temporal and
spatial scales and ecosystems (Decision 3/COP.12; UNCCD, 2015).

LDN Target (country level) The voluntarily adopted objective of a country to achieve
LDN at a national level. The ambition of a country with respect to achieving LDN
is no net loss of healthy and productive land for each land type compared with a
baseline, so that the LDN target equals the baseline. Countries may elect to set a
more ambitious LDN target if they envision the possibility that gains will exceed
losses. In rare circumstances, a country may set its LDN target while
acknowledging and justifying the idea that losses may exceed gains, if they
forecast that some portion of future land degradation associated with past
decisions/realities cannot be counterbalanced (Orr et al., 2017).

LDN Target (global) The objective to achieve a land degradation neutral world (United

Land The terrestrial, biologically productive system that comprises soil, vegetation, other
biota, and the ecological and hydrological processes that operate within the
system (UNCCD, 1994)

Land potential The inherent, long-term potential of land to sustainably generate
ecosystem services and that reflects the capacity and resilience of the land-based
natural capital in the face of ongoing environmental change (UNEP, WMO,
UNCCD, 2016).

Land rehabilitation Direct or indirect actions undertaken to reinstate a level of ecosystem
functionality, where the goal is the provision of goods and services rather than
ecological restoration (McDonald et al., 2016).

Land restoration The process of assisting the recovery of land from a degraded state
(McDonald et al., 2016; IPBES, 2018).

Land tenure The relationship, whether legally or customarily defined, among people as
individuals or groups with respect to land and associated natural resources
(water, trees, minerals, wildlife, etc.). Rules of tenure define how property rights in land are to be allocated within societies. Land tenure systems determine who can use what resources for how long and under what conditions (FAO, 2002).

**Land type** The class of land with respect to land potential, which is distinguished by the combination of edaphic, geomorphological, topographic, hydrological, biological, and climatic features that support the actual or historic vegetation structure and species composition on that land. Used in counterbalancing 'like for like' in land degradation neutrality (Orr et al., 2017).

**Land unit** The finest resolution spatial unit used in LDN planning and monitoring (Orr et al., 2017).

**Landscape** An area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors (Council of Europe, 2000).

**Like for like**: Refers to the principle of counterbalancing losses in one land type with equivalent (or greater) gains in the same land type elsewhere to maintain (or exceed) LDN (Orr et al., 2017).

**Multifunctional landscapes** The simultaneous pursuit of multiple goals (e.g., socio-cultural, economic, and environmental goals) across landscapes while managing multiple benefits and trade-offs among them. This entails dealing with the complexity inherit to socio-ecological systems, where ecosystem functions, values and benefits are modelled to relate to real-life socio-cultural/economic realities.

**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 (World Forum on Natural Capital, n.d.; IPBES, 2018).

**Net primary production (NPP)** The total mass of carbon taken out of the atmosphere by plant photosynthesis (gross primary production) minus the return to the atmosphere of carbon due to autotrophic respiration (IPBES, 2018).

**Neutrality principle**: In the context of LDN, the neutrality principle in integrated land use planning anticipates losses with measures designed to deliver gains to achieve an LDN target (country level). The counterbalancing mechanism for achieving neutrality could involve voluntary measures, regulatory instruments, and/or market-based incentive schemes. This mechanism should be implemented at the spatial resolution of the biophysical or administrative
domains at which land use decisions are made and be scalable so that the results can be reported nationally.

No net loss The condition wherein losses are no greater than gains. In the context LDN, this refers to the condition where land-based natural capital is maintained or enhanced between the time when the LDN framework is put in place (t0) and a future date when progress is monitored (t1) (Orr et al., 2017).

One-out, all-out A conservative principle that combines different indicators/metrics to assess status and that follows the precautionary principle (adapted from European Commission, 2003). The one-out, all-out approach is applied to land degradation neutrality (LDN) so that a loss is noted when any of the indicators shows significant negative change and, conversely, a gain is noted if at least one indicator shows a positive trend and none shows a negative trend (modified from Orr et al., 2017)

Participatory scenario development (and planning) Approaches characterised by the 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 the demands and information of each stakeholder and negotiating outcomes between stakeholders.

Resilience The ability of a system to absorb disturbance and reorganise itself so as to retain essentially the same function, structure, and feedbacks. Resilience is a neutral property, neither good nor bad (adapted from Walker et al., 2004 in Orr et al., 2017)

Scale The spatial, temporal, quantitative, and analytical dimensions used to measure and study any phenomenon. The spatial scale comprises the following: 1) spatial extent is the size of the total area of interest for a particular study (e.g., a watershed, a country, or the entire planet); and (2) spatial grain (or resolution) is 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) (IPBES, 2018).

Scenario A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts but are used to provide a view of the implications of developments and actions (IPCC, 2019b).

Social capital The mutual trust and associated norms of reciprocity that enable people to engage with one another (Helliwell and Putnam, 2004). Social capital includes
networks together with shared norms, values and understandings that facilitate co-operation within or among groups (IPBES, 2018)

**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 (IPBES, 2018)

**Response hierarchy** An overarching principle that guides decision-makers in planning measures to achieve land degradation neutrality (LDN). The response hierarchy of Avoid > Reduce > Reverse land degradation is based on the recognition that ‘prevention is (much) better than cure’ (i.e., avoiding or reducing further land degradation will maximise long-term benefits and is generally more cost-effective than efforts to reverse past degradation) (Orr *et al.*, 2017).

**Tenure security** The certainty that a person’s rights to land will be recognised by others and protected when faced with specific challenges. People with insecure tenure face the risk that their rights to land will be threatened by competing claims and even lost as a result of eviction. Without security of tenure, households are significantly impaired in their ability to secure sufficient food and to enjoy sustainable rural livelihoods (FAO, 2002).

**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 characterise most complex systems and are important to consider when making decisions that aim to improve environmental and/or socioeconomic outcomes. Trade-offs are distinct from synergies. Synergies (also referred to as ‘win-win’ scenarios) arise when the enhancement of one desirable outcome leads to enhancement of another (IPBES, 2018).

**Transformative change** A fundamental, system-wide reorganisation across technological, economic, and social factors, including paradigms, goals, and values (IPBES, 2019).
Key messages

1. Integrated Land Use Planning (ILUP) and Integrated Landscape Management (ILM) have integral roles to play in achieving land degradation neutrality (LDN) and in reducing decision uncertainties associated with planning for neutrality {Chapters 1\(^1\), Chapter 2}. LDN is more than the implementation of sustainable land management; it requires ILUP and ILM for achieving no net loss of land-based natural capital and for respecting the LDN response hierarchy of avoiding, reducing, and reversing land degradation {Chapter 1}. Planning is needed to achieve LDN targets and to avoid any unintended consequences of dealing with the food, energy, and nature trilemma. It is also important to efforts by countries to build back better in the post-COVID-19 era {Chapter 2}. Integrating LDN in existing national land use planning systems can facilitate

   i. targeting LDN interventions and better accounting for the resulting changes in natural and social capital;
   
   ii. enabling just solutions, increasing gender equity, and avoiding social conflicts that may arise when seeking optimal solutions acceptable to all actors;
   
   iii. integrating policy across multiple sectors to minimize trade-offs and concurrently achieve other commitments (e.g., SDGs, UNFCCC goals, and UNCBD targets) and ambitions set by the UN Decade on Ecosystem Restoration;
   
   iv. gaining insights into how to achieve multiple social and ecological benefits from planned LDN interventions while enhancing decision making and efficiency; and
   
   v. including multi-stakeholder perspectives, diverse local knowledge, and cross-sectoral views in the design of action plans at local, watershed, and national scales, while following the LDN response hierarchy (i.e., first avoiding, then reducing, and only after these, reversing land degradation) and recognizing power dynamics and inclusion (e.g., of different genders and ages) \{Box 2.1\}.

2. The integration of LDN in ILUP-ILM processes should consider the unique characteristics of a country’s planning system {Chapter 2, Chapter 3, Chapter 4}. The LDN framework and ILUP-ILM processes share common characteristics (e.g., science-based evidence, good governance, participatory processes, inclusiveness, and gender considerations) \{Chapter 2\}. Therefore, mapping the modules of the LDN framework onto the phases of cyclical ILUP-ILM processes helps identify entry points for integrating LDN into the planning system of a country \{Chapter 4\}.

\(^1\) \{ \} denotes chapters and case studies (Boxes) that provide evidence to the assertion.
The effective implementation of the LDN framework, including interventions, is facilitated by identifying the typological elements of national planning systems (e.g., the governance structure, land tenure, the level of vertical and horizontal integration and coordination, and the level of stakeholder participation) and the most appropriate ILUP-ILM processes to support land use planning within particular national circumstances {Chapter 3, Box 3.1, Box 3.2}.

Where systematic land use planning is non-existent or not fully functional (i.e., it exists on paper, but it is not practised and/or implemented), the systematic assessment of land and land use options required for LDN planning can function as a catalyst for enhancing and strengthening a planning system {Box 4.4}. It can also advance a country’s sustainable development goals as well as the goals of other environmental agreements {Box 3.1, Box 3.3}.

3. The integration of LDN within ILUP-ILM processes relies on a combination of tools and approaches {Chapter 5}.

ILUP-ILM processes are complex and multi-dimensional. The use of science-based ILUP-ILM tools and approaches can facilitate planning processes, helping to achieve well-informed, efficient outcomes {Box 2.1, Box 3.1, Box 3.2, Box 4.3}. Tools (e.g., for optimizing the spatial mix of land uses or participatory scenario analysis) can also be used to assess potential co-benefits and possible trade-offs {Box 4.1, Box 4.5}.

No single perfect tool or approach exists to plan for and integrate LDN interventions. The applicability and usefulness of ILUP-ILM tools and approaches depend on the political, cultural, and socio-ecological context (e.g., governance, land tenure, and human capacity). Therefore, the selection of these tools and approaches should be guided by criteria, including the land governance system, data availability, and financial and human resources levels. In many cases, a combination of tools and approaches may be necessary to conform to the guiding principles of the LDN framework.

ILUP-ILM tools that are oriented towards participatory transformation and sustainability management can facilitate participatory stakeholder processes. These participatory processes foster transparency. They also structure decision-making so that both men and women can meaningfully participate, and stakeholders are motivated to take responsibility for actions that address land degradation (i.e., they take ownership of the processes) {Box 3.3}. 
4. **Tools for simulating the LDN counterbalancing mechanism and the LDN response hierarchy within land use planning processes are scarce** (Chapter 5).

Efficient and effective integration of LDN into ILUP-ILM processes requires optimizing land uses to achieve neutrality. ILUP-ILM tools and approaches mostly determine and compare net-loss for different scenarios but do not optimize land use for neutrality. Existing ILUP-ILM tools and approaches could be improved to better address the requirements and principles of LDN (e.g., indicators, response hierarchy, ‘like for like’, and ‘one-out, all-out’; see Glossary).

Efforts to develop tools that can explicitly address land use planning for achieving neutrality need to continue, fostering initiatives to create enhanced tools that fully incorporate LDN principles {Box 5.1}.

5. **ILUP-ILM processes that help achieve LDN should account for future changes that result from dynamic political, socio-cultural, and environmental contexts {Box 2.1, Box 2.2, Box 5.3}.

Countries must ensure that land use planning fully accounts for uncertainties (including those from a changing climate) and alternative development scenarios to respond to today’s problems and to prepare for future challenges from land degradation and desertification.

Identifying entry points in a country’s planning process for interventions to achieve no net loss of natural capital is an important step for accelerating positive transformative change for achieving LDN, addressing desertification and land degradation, and meeting other sustainability goals {Box 2.1, Box 3.1, Box 3.2}.

Land use planning and interventions for achieving LDN are underpinned by cyclical, iterative processes in which monitoring enables learning for adaptive management. Learning from the concrete experiences of countries that currently integrate LDN into ILUP-ILM processes is beneficial for other nations seeking to design projects that have ‘no net loss’ in mind and that align with their land use planning systems.

ILUP-ILM processes and tools are levers that can help implement national targets for achieving LDN. However, a more transformative societal change is also required to address the drivers of increasingly competitive demands for limited land resources.
Policy proposals

This report brings together science-based evidence and good practices gathered from illustrative examples to demonstrate the potential contribution of integrated land use planning (ILUP) and integrated landscape management (ILM) for achieving or exceeding land degradation neutrality (LDN) targets.

The report provides an analytical overview of common tools and approaches that are used, or can be used, to support ILUP and ILM and identifies ways in which these tools and approaches can aid in achieving LDN targets. The work also identifies entry points for embedding LDN actions into planning systems at different scales (i.e., national, watershed, and local). To that end, an analysis of existing planning systems provides generic key elements for a typology. The illustrative examples show that ILUP and ILM can help reconcile multi-objective land uses, seek LDN (i.e., by balancing gains with anticipated losses), carefully consider trade-offs, and navigate possible conflicts between sectoral interests and potential uses (e.g., conservation and productivity).

In the context of working to achieve or exceed LDN targets, this report presents action-oriented proposals for policy- and decision-makers (and other actors involved in land use planning and landscape management). These proposals are intended to help develop inclusive measures for ILUP-ILM that encourage positive transformative change towards a better, land-degradation-neutral future.

**Proposal 1: Strengthen cross-sectoral governance and land use planning for transformative change to support LDN.**

Policy- and decision-makers of national governments and international aid agencies are advised to invest in the following:

a) Strengthening ILUP-ILM policy instruments and using them to better coordinate different sectoral policies and institutional arrangements for enhancing inclusive, multi-level governance (i.e., vertical and horizontal coordination) of land.

b) Building the capacity of groups working on the integration of cross-sectoral policies for planning (e.g., for biodiversity, climate change, and land use) to develop national-level planning instruments. These instruments should be based on an understanding of land use dynamics that facilitates the application of a counterbalancing mechanism to achieve neutrality. They should encourage strategies to adopt ILUP-ILM in planning for neutrality (i.e., no net loss) to achieve LDN targets and to build capacity for integrating LDN into ILUP-ILM processes. They should apply multiple (scientific) tools and approaches to support this integration.
c) Initiating education and awareness-raising (e.g., education and extension programmes to increase appreciation and awareness of ILUP-ILM tools and approaches useful for integrating LDN). For these, a series of dialogues, campaigns, and improvements in land governance may be prerequisites.

**Proposal 2: Incentivise collaboration between research and practitioner communities to develop or tailor existing tools and approaches for integrating LDN within ILUP-ILM processes.**

a) Incentivise and work with academics, practitioners, and research institutes specialising in ILUP and/or ILM to further develop and operationalise tools for incorporating LDN actions into ILUP-ILM decisions. These tools should combine approaches and functions that cater to the unique characteristics of each country’s planning system.

b) Continue fostering collaboration to create readily available planning tools that optimise land use to achieve neutrality, fully incorporating LDN principles and different elements of the land use planning typology, such as scale, participation, gender awareness, and inclusiveness.

**Proposal 3: Promote knowledge generation and sharing of tools and approaches to support ILUP and ILM to achieve LDN.**

The integration of LDN interventions into ILUP and ILM is a transformative change, rather than simply learning the same lessons and doing the same things incrementally or more efficiently. Therefore, the following changes are needed:

a) More investment is required to develop the capacity for the use of ILUP and ILM tools and approaches as a way to significantly increase opportunities for stakeholders (i.e., users of land, practitioners, project developers, decision-makers, and policy-makers) to appreciate and understand the potential of ILUP and ILM.

b) More investment is required to build evidence-based knowledge within national institutions that supports the development of ILUP-ILM processes based on science as well as on traditional and local knowledge.

c) Cooperation among existing repositories, platforms, and/or communities of practice is needed to encourage the sharing of knowledge about technologies and best practices relevant to ILUP and ILM. This cooperation should extend to sharing ILUP-ILM software tools made available through open-source repositories for further development and modification for specific applications.
d) The dissemination of lessons learned should be encouraged via the UNCCD Knowledge Hub and similar mechanisms of knowledge exchange to inform the design of future projects and/or programs. This entails promoting collaboration at different levels of governance and creating opportunities for academics, practitioners, civil society organisations, and land managers to share ILUP-ILM best practices that support achieving LDN targets. These opportunities will encourage two-way knowledge sharing among scientists, practitioners, and land managers.

e) Planning projects should allocate human and financial capital to knowledge management so that efforts to integrate LDN properly document the ILUP-ILM approaches and tools used, the outcomes, the benefits of their use, and the challenges and shortcomings experienced when using these tools.

Proposal 4: Consider integrating LDN target-setting into ILUP-ILM processes of national and subnational planning systems.

UNCCD has been guiding countries in LDN target-setting based on a methodological guide developed in 2016\(^2\). Updates to this technical guide are underway, and these need to include guidance on the integration of LDN into ILUP-ILM processes used in national and subnational planning systems (as described in this SPI report). Regardless of their ambition and scale, a country’s LDN targets are best achieved through ILUP-ILM processes appropriate to national and subnational contexts, using effective tools, platforms, and available data sources.

Proposal 5: Provide a more central role for ILUP-ILM to create synergies and inform policies for reaching major internationally agreed sustainability goals, including LDN.

To address today’s many related and intersecting sustainability challenges, more integrated planning is required. In addition to investing in and building appropriate governance structures and capacities, other actions are also needed:

a) Countries should be supported to use ILUP-ILM to create synergies and policy coherence among the three Rio Conventions. They should be encouraged to implement the strategies, goals, and associated development targets of these Conventions (i.e, the post-2020 global biodiversity framework and the Paris Agreement) and to pursue the UN sustainable development goals along with LDN targets.

b) Country-level institutions, development agencies, and multi- and bilateral donors should be encouraged to embed projects and programs within national planning

systems that build back better in the post-COVID-19 era. These projects and programs should apply the principles of gender-sensitive ILUP-ILM and LDN to minimise trade-offs and environmental externalities and maximise multiple benefits.
Chapter 1: Background and rationale

The goal of achieving a land-degradation neutral world first emerged at the UN Conference on Sustainable Development (Rio+20) in 2012 (Chasek et al., 2019). The concept of Land Degradation Neutrality (LDN) was subsequently adopted by the UNCCD 12th Conference of the Parties and described as “a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems” (Decision 3/COP.12, UNCCD, 2015). LDN has since been embraced globally. To date, more than 128 countries have committed to setting LDN targets. Of these, more than 80 countries have already set targets, and many have secured high-level government commitments to achieving LDN.

The UNCCD developed a scientific conceptual framework for LDN to provide a scientific basis for understanding the concept and to guide its implementation and monitoring by UNCCD Country Parties that choose to pursue LDN targets (Orr et al., 2017). A subsequent report of the UNCCD Science-Policy Interface (SPI), “Creating an Enabling Environment for Land Degradation Neutrality and its Potential Contribution to Enhancing Well-being, Livelihoods and the Environment” (Verburg et al., 2019), describes two important factors that must align for the successful operationalisation of the LDN framework: (1) an enabling environment (i.e., the combination of institutional, financial, policy/regulatory and science-policy elements that enable progress towards LDN), and (2) opportunities for multiple benefits of halting and reversing land degradation (i.e., positive environmental outcomes combined with improvements in human well-being). It further identifies Integrated Land Use Planning (ILUP) and Integrated Landscape Management (ILM) as fundamental processes for Country Parties to use in achieving LDN. Both ILUP and ILM provide spatial-temporal platforms to balance multiple demands on space and are critical for implementing and achieving LDN (Figure 1.1 and Box 1.1). Figure 1.1 shows that striving to achieve LDN requires a strategic and iterative approach. This approach involves planning and institutional support that goes beyond implementing individual sustainable land management practices and a broader coordination across landscapes and sectors. This broader coordination is needed to support the “counterbalancing mechanism” in line with LDN’s “neutrality principle.” The counterbalancing mechanism allows land users, land-use planners, and decision makers to counterbalance losses in one area or sector with equivalent (or greater) gains in another (Chasek et al., 2019).
FIGURE 1.1. **Integrated Land Use Planning** (ILUP) to achieve LDN is land use planning that seeks to balance economic, social, and cultural opportunities provided by land with the need to maintain and enhance ecosystem services provided by land-based natural capital. **Integrated Landscape Management** (ILM) is interconnected with ILUP efforts. ILM ensures the land is managed to reflect diverse stakeholders’ interests and values through a coordinated and collaborative process across sectors. In this way, a range of societal needs can be met while maintaining, enhancing, and protecting healthy functioning ecosystems. By counterbalancing gains and losses with careful consideration of trade-offs (i.e., using a counterbalancing mechanism), ILUP-ILM can avoid future land degradation, reverse degradation from the past, and address competing demands for land resources.

A recent review of LDN target-setting efforts by Party Countries committed to LDN shows limited national progress in establishing effective ILUP systems and, in particular, little progress embedding a counterbalancing mechanism within these systems (Allen et al., 2020). The review of country reports to the LDN Target Setting Programme (LDN TSP) also shows gaps in the technical capacity of each country for implementing LDN. While
sustainable land management practices are widely promoted and used by countries in setting and pursuing LDN targets, the implementation of a counterbalancing mechanism has lagged behind. The shortcomings led the authors of the review to recommend enhancing national capacities for the effective implementation of ILUP. Recommendations also include doing further work to identify entry points for the full integration of a neutrality principle and counterbalancing mechanism within the ILUP process, including adapting existing ILUP and ILM tools to the particular circumstances of individual Country Parties to achieve LDN targets.

Responding to these recommendations, Country Parties gathered at the UNCCD COP 14 requested that the UNCCD SPI provide the “science-based evidence on the potential contribution of integrated land use planning (ILUP) and integrated landscape management (ILM) to positive transformative change, achieving land degradation neutrality (LDN) and addressing desertification/land degradation and drought issues” (Decision 18/COP.14, the SPI work programme for the biennium 2020-2021, objective 1).

This SPI technical report is the result of this request. The report explores the contribution of ILUP and ILM to LDN target implementation and reviews the potential adaptation of available ILUP-ILM tools to support the mainstreaming of LDN into land use planning systems (see Figure 1.2 for the workflow and structure).

**BOX 1.1. Integrated Land Use Planning (ILUP) and Integrated Landscape Management (ILM)**

**Integrated Land Use Planning (ILUP)** refers to assessing and allocating land-based resources across a landscape, accounting for differing uses and demands from different users (Metternicht, 2017). It requires the coordination of planning and management across sectors concerned with land resources and their use within a spatial administrative or geographic unit (e.g., catchment, region, and/or country). The purpose of ILUP is to identify the combination of land uses that can meet stakeholders’ needs while safeguarding resources for the future. By examining all land uses in an integrated manner, ILUP identifies the most efficient trade-offs between land-use options and links social and economic development with environmental protection and enhancement, thus helping to achieve sustainable land management (FAO, 2018). ILUP is an umbrella term that includes more specific approaches such as — but not limited to— territorial planning and spatial planning.

**ILUP to achieve LDN** is land use planning that seeks to balance the economic, social, and cultural opportunities that land provides to various sectors and jurisdictions with the need to maintain and enhance ecosystem services provided by land-based natural capital.

**Integrated landscape management (ILM)** refers to long-term collaboration among different groups of stakeholders to achieve the multiple objectives required from the landscape. Five key features—all of which facilitate participatory development processes—characterise ILM: 1) shared or agreed upon management objectives that encompass multiple landscape benefits; 2) field practices that are designed to contribute to multiple objectives; 3) management of ecological, social, and economic interactions for the realisation of positive synergies and the mitigation of negative trade-offs; 4) collaborative, community engaged planning, management, and monitoring processes; and 5) the re-configuration of markets and
public policies to achieve diverse landscape objectives (Scherr et al., 2013). ILM is concerned with the development of management strategies for landscapes rather than with how they are spatially parcelled or zoned.

Both ILUP and ILM have integral roles to play in achieving LDN. Traditionally, land use planning (LUP) mainly involves the technical process of allocating land use rights according to land suitability. By comparison, ILUP allows a consideration of the diverse interests in the land that are increasingly recognised as key to environmental targets and to socio-economic and cultural values (Verburg et al., 2019, Annex 1). The approach strives to integrate environmental, socio-cultural, and economic data from a variety of stakeholders and users to allocate land in an optimum fashion according to its suitability. At the same time, it attends to divergent stakeholder preferences and legal standings, operating on the level of policy, regulation, zoning, and so on. Public participation, scale, and the spatial-temporal aspects are important to ILUP and ILM (Figure B1.1).

![Figure B1.1](image)

**FIGURE B1.1.** The scale of ILUP and ILM (left) and the continuum of ILUP-ILM (right). Governance at different scales (i.e., national to local) of ILUP is needed to assess and allocate land resources across a landscape. ILM fosters collaboration across actors, sectors, and scales in a manner that is essential to ILUP. The continuum between ILUP and ILM is relevant to this technical report and is indicated as “ILUP-ILM”.

### 1.1 Objectives

This report aims to demonstrate the importance of both ILUP and ILM to realising LDN targets. The overall objective is to synthesise the science-based evidence of how ILUP and ILM can contribute to positive transformative change in the context of efforts to achieve or exceed LDN, including examples of cases where these processes have been applied. To this end, the report does the following:

i. Reviews common national planning systems and identifies key elements that can be used to characterise these systems;

ii. Identifies entry points for integrating LDN into cyclical ILUP-ILM planning processes (i.e., planning cycles);

iii. Provides an overview of available ILUP approaches and tools that can support the integration of LDN into ILUP-ILM and that includes scientific analysis and knowledge to guide ILUP-ILM;
iv. Provides user guidance on the selection and application of the aforementioned approaches and tools, indicating their role within the implementation of LDN and ILUP-ILM processes, as well as their potential match with characteristics of planning systems; and

v. Identifies illustrative examples that show elements of land use planning systems and ILUP-ILM approaches and tools working together to help set LDN targets and interventions.

1.2 Methodology

This report is based on an extensive review and assessment of scientific and grey literature. Characteristics of planning systems were compiled from existing typologies and land use planning traditions. To arrive at a common typology of planning systems, these characteristics were further summarised into nine key elements deemed relevant for characterising the entire range of planning systems and situations. In addition, a generic planning cycle comprising five phases was created based on a review of the literature describing cyclical ILUP-ILM processes.

Tools and approaches informing or assisting ILUP-ILM processes were identified, categorised, and evaluated for their suitability in supporting the integration of LDN into ILUP-ILM. The scope of the review was limited to open access tools specifically designed to help ILUP-ILM processes. Other tools exist that can play an indirect role for land use planning and management. Examples of these include, tools to assess ecosystem services (e.g., INVESTA), to make land and water assessments (e.g., WaPOR), to conduct water accounting, to identify and map changes in land management and their impacts on productivity (e.g., QSWAT), and to inform other aspects of landscape management.

Keywords such as “integrated land use planning tool”, “integrated landscape management tool”, “integrated land use planning approach”, “spatial planning”, “territorial planning”, “integrated landscape management approach”, and similar combinations were used in Google Scholar, Web of Science, and Scopus search engines. Repositories from well-established institutions (e.g., the United Nations, the Food and Agriculture Organization, and the World Bank) were also searched using forward snowballing. Six broad categories of tools (i.e., tool groups) suitable for supporting countries in ILUP-ILM planning cycles were identified. All tools found in the review were allocated to one of the six groups to facilitate evaluation and recommendations for their integration with the planning system.

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2 Forward snowballing refers to identifying new papers based on the papers cited in a paper being examined (Wohlin, 2014)
The review of planning tools that can support countries implementing LDN was guided by criteria derived from the LDN scientific framework (Orr et al., 2017) (see Appendix A). Consideration was given to the requirements of the Tenure Responsive Land Use Planning framework (Chigbu et al., 2016), gender-evaluation criteria for large-scale land tools (GLTN, 2008), GLTN Youth And Land Responsiveness Criteria (Ying et al., 2015) and the UNCCD land use planning report (Metternicht, 2017). The evaluation of tools was based on the following: scientific knowledge; transparency of inputs, methods and outputs; applicability following a coherent and credible work plan; their ability to protect sensitive data (e.g., country-owned data) where relevant; and their ability to access, process, store, retrieve, and connect spatial and other non-spatial datasets.

1.3 Report structure
After introducing the rationale and aims in Chapter 1, Chapter 2 describes the ILUP-ILM continuum and the role that these two integrated processes play in encouraging transformative change towards sustainable land use in pursuit of LDN (Figure 1.2). Chapter 3 proposes a typology for land use planning systems by key elements relevant to the selection of suitable ILUP tools and approaches. Chapter 4 details the entry points for LDN in the phases typical of ILUP-ILM planning cycles. Chapter 5 analyses the tools and approaches available and suitable to support LDN integration in ILUP-ILM. This analysis offers guidance for selecting tools that best fit both a country’s planning system and the desired planning stage. The report concludes with a summary of policy proposals derived from the findings of this work.
Chapter 1: Background and rationale

Chapter 2: Interactions between Integrated Land Use Planning, Integrated Landscape Management (ILUP-ILM) and LDN

Chapter 3: Typology of ILUP-ILM: key elements

Chapter 4: Entry points for LDN integration into ILUP-ILM

Chapter 5: Tools and approaches to support the integration of LDN into ILUP-ILM

FIGURE 1.2. Workflow and structure of the report.
Chapter 2: Integrated Land Use Planning (ILUP) and Integrated Landscape Management (ILM)

2.1 Essential considerations

ILUP and ILM are cross-sectoral planning processes that build on long-term visions and commitments. Because of their cross-sectoral nature, ILUP-ILM processes provide entry points to address complex environmental concerns—notably the concerns addressed by the three Rio Conventions agreed to at the 1992 Earth Summit held in Rio de Janeiro. These are climate change adaptation and mitigation (Kuyper et al., 2018), biodiversity conservation (Le Prestre, 2017) and desertification. In particular, the ILUP-ILM processes are essential to achieving LDN and climate and biodiversity goals (Figure 2.1) (Cowie et al., 2018) and for reconciling LDN and other related societal development targets (Verburg et al., 2019). For example, achieving LDN through sustainable land management underpins and catalyses efforts to reach multiple UN Sustainable Development Goals (SDGs) related to food security, poverty reduction, environmental protection and the sustainable use of natural resources (UNCCD, 2017).

As importantly, ILUP-ILM processes can help address current cross-cutting issues for which land health is central, including the following: (1) how to build back better from the Covid-19 pandemic (which has put the spotlight on the intricate interconnections between animal health, human health, and ecosystem health); (2) how to mitigate sand and dust storms at source; (3) how to answer the food, energy, and nature trilemma (see Appendix B); (4) how to strengthen urban-rural socio-ecological systems; and (5)
how to increase resilience to climate change and its effect on extreme weather events, such as drought. Figure 2.2 and Appendix B show how ILUP-ILM processes could help address these issues of interest to the UNCCD Country Parties (UNCCD, 2019b; UNCCD, 2021).

**FIGURE 2.2.** Schematic of how ILUP and ILM processes affect current cross-cutting issues for which land health is central through land restoration and rehabilitation or by avoiding or reducing land degradation. Each theme represents a complex socio-ecological issue, and all themes are interrelated or interconnected. Tackling one problem can address others in tandem. In this way, ILUP-ILM processes enable policy integration across multiple sectors and commitments.

ILUP is the allocation or re-allocation of land-based resources to particular uses and constitutes one endpoint of a continuum of holistic, spatial planning, and land management processes. At the other end of this continuum is ILM, which involves integrated management at a landscape scale in a way that reflects diverse values and stakeholder interests (Ahmadi et al., 2012; Son et al., 2008; Mann et al., 2018).

Spatial considerations are important to both processes (see Box 1.1). ILUP addresses the question of what to do where (or “doing the right things in the right places”). For example, where is the optimal location on the landscape (relative to all other land use options) to delineate a nature reserve? ILM, meanwhile, addresses questions of how to do things where (or “doing the rights things in the right places in the right way”). For example, what sustainable farming practices fit best at specific locations within the landscape? (See
Figure 1.1.) ILM processes invest in establishing the institutions that enable collective participation of multiple stakeholders shaping the landscape (Estrada-Carmona et al., 2014; Zanzanaini et al., 2017). The “right way” is most likely a negotiated, compromised decision, co-designed, and co-developed for taking the landscape closer to a shared vision.

ILUP and ILM are interrelated processes meant to guide concerted actions across different scales. We use ILUP-ILM to refer to these interrelated planning processes. The ILUP-ILM continuum describes an ideal situation where ILUP and ILM are systematic and institutionalised. However, cases exist in which funding is insufficient and the institutionalisation and management of ILUP and ILM processes are weak when it comes to monitoring, evaluation, adaptive management, and other elements of implementing these processes. On the ILM side, in particular, institutions that oversee the implementation and monitoring of management may not be formalised or be in flux.

A variety of terms and frameworks proposed over the past three decades describe approaches along this continuum. Rather than presenting definitions of individual approaches, Figure 2.3 focuses on common features. For instance, planning and management require long-term collaboration among different stakeholder groups from multiple sectors and at different scales to solve shared problems throughout the planning, implementation, management, and monitoring phases of cyclical planning processes (see Chapter 4) (Reed et al., 2017; Redford et al., 2013). Meanwhile, good governance is critical for local stakeholders, including different local groups of men and women, to have control over key planning and management decisions.

![Common features of ILUP and ILM processes](image)

**Common features of ILUP and ILM processes**
- Long-term multi-stakeholder collaboration
- Planning for multiple objectives across multiple sectors
- A socio-ecological system approach
- Addressing trade-offs through spatially-explicit approaches
- Strong need for good governance and secure land rights
- Promotes multifunctional land uses
- Foster capacity building

**FIGURE 2.3.** A variety of frameworks and terms describe ILUP-ILM processes. All support multiple benefits provided by the land and present common characteristics.
A variety of sources deliver data and information needed for ILUP and ILM, including field observations, field experiments, surveys, and focus group discussions, as well as satellite-derived or modelled datasets. These data and information underpin a diverse set of tools and approaches to help optimise land use allocations, from indicator assessment tools (e.g., many remote-sensing and GIS-based tools) to process-oriented tools (e.g., participatory scenarios) (see Chapter 5).

The use of scientific, evidence-based tools and approaches that support decision making and stakeholder engagement are important for the efficient and effective integration of LDN targets into planning systems. From target setting to implementation and monitoring, these tools facilitate the integration of data across different planning sectors (e.g., environmental, agricultural, urban, and others) and different perspectives and knowledge systems, including scientific and local/traditional knowledge (Reed et al., 2013; Markkula et al., 2019). These tools and approaches ensure the most comprehensive information—built upon data reflecting land degradation status, land potential, resilience, and socio-economic situation—is used to optimise the spatial mix of possible interventions to minimise trade-offs and to increase synergies.

Evidence-based tools and approaches are a powerful means to support sound and inclusive planning efforts, which ultimately help steer land use and management towards avoiding, reducing, and reversing land degradation. These tools and approaches generally assume a situation in which national land use planning systems are in place and functional to set LDN targets, anticipate losses, and plan gains to achieve no net loss. However, there are also situations in which planning systems are non-existent or not fully functional (i.e., existent on paper but, in fact, not practised or not trusted by stakeholders). In these situations, the systematic assessment of the current condition of land—along with a measure of its resilience, the socio-economic context, and land use options required for LDN planning—could function as a catalyst for the further development of a planning system and for shaping land use planning policies in the longer term. Adaptive learning (e.g., triple-loop learning) and knowledge sharing encourage the latter. This is because initial monitoring efforts can help refine ILUP and associated LDN interventions (first-loop learning), enabling planners to revisit underlying assumptions drawn from the preliminary assessments (second loop learning), and, where necessary, influence underlying values that frame the context for achieving LDN (Orr et al., 2017).

2.2 ILUP-ILM for positive transformative change

Rather than creating incremental change in routine actions by just doing a little more or less of the usual, transformative change implies “a fundamental, system-wide reorganisation across technological, economic, and social factors, including paradigms,
goals and values” (IBPES, 2019, p.14). The concept of LDN can be considered transformational in this sense, because it strives to achieve zero net land degradation (Chasek et al., 2015; Akhtar-Schuster et al., 2017).

The zero net principle—also known as the neutrality principle—requires landscape planning and management that goes beyond a consideration of individual land parcels and sustainable land management practices to embrace national planning. This allows unavoidable losses to be compensated for and allows landscape diversity (e.g., socio-economic, ecological, and cultural) to optimise the LDN response hierarchy (i.e., avoiding, reducing, and reversing land degradation). The neutrality principle allows for trade-offs among competing interests across a landscape (Orr et al., 2017), and it helps optimise synergies between the mandates of the three Rio Conventions for which land is central (UNFCCC, UNCBD and UNCCD as shown in Figure 2.1) (Akhtar-Schuster et al., 2017; IPCC, 2019a).

Achieving LDN requires more than just scaling up sustainable land management. For example, realizing the neutrality principle is most effective when it is embedded (alongside actions relevant to the other Rio Conventions and UN Sustainable Development Goals) into existing national planning systems that govern the use of natural resources for development (see Box 2.1).

Widening the lens on LDN and exploiting synergies that are thematic (i.e., the restoration of degraded lands to fulfil multiple goals) and process-related (i.e., the development of common tools and approaches) can speed up advancement towards LDN and deliver multiple wins through concerted planning efforts. These integrated planning efforts can, in turn, improve food, water, and energy security, improve livelihoods, increase drought resilience, reduce poverty, reduce soil erosion, reduce the frequency of sand and dust storms, and contribute to habitat conservation for rare and endangered species. From a procedural perspective, ILUP-ILM can strengthen national-level coordination and cooperation (see Box 2.1).

**BOX 2.1. ILUP-ILM processes enable the integration of multi-stakeholder and cross-sectoral views for designing transformative interventions tackling LDN and drought resilience. The case of Turkana County, Kenya**

**Context:** Kenya’s second constitution (2010) introduced a shift from a centralised unitary to a decentralised unitary governance structure, devolving decision-making powers from the national government to newly formed county governments in several sectors to broaden participation, increase responsiveness to local needs, and improve public service delivery and quality. The first five-year county planning cycle (2013-2017) of the semi-arid Turkana County was marked by sectoral, ad-hoc decision-making.

To strengthen evidence-based, inclusive, and cross-sectoral decision-making for their planning cycle between 2018 and 2022, the Turkana County Government adopted a framework known as the Stakeholder Approach to Risk-Informed and Evidence-Based Decision-Making (SHARED) to aid the formulation of their new County Integrated Development Plan.
Plan (CIDP). The CIDP serves as a comprehensive guide to achieve the county’s vision of social, environmental, and economic transformation.

**Intervention:** The SHARED framework, developed by the World Agroforestry Centre (ICRAF), provides decision-makers and stakeholders with a space to share and interact with data and information to better understand the potential implications of decisions addressing multiple objectives, such as land use and development decisions. The framework enables multi-stakeholder engagement processes, and it can be tailored to the requirements of the areas where planning is sought. In this case, the Turkana County Government and the National Drought Management Authority worked with the ICRAF GeoScience Lab and co-designed and custom-built the Turkana Resilience Diagnostic and Decision Support Tool (RDDST). The RDDST is an indicator assessment tool in the form of an open-access dashboard, under the umbrella of the SHARED platform. The dashboard facilitates the integration and co-analysis of data from different sectors, institutions and knowledge systems to formulate local development plans that address complex issues, such as drought and land degradation.

Four key steps (1. contextualize, 2. integrate evidence, 3. prioritise and plan, and 4. learn and respond) characterise SHARED (Figure B2.1), making it a comprehensive approach suitable for all phases of cyclical ILUP-ILM planning processes and the corresponding modules of the LDN framework. Of the 10 themes of the dashboard, the Land Health theme is relevant to land degradation neutrality. It allows the user to visualise land health indicators (soil erosion, soil pH, soil organic carbon and vegetation condition) in maps and graphs.

![PROVISIONAL FIGURE]

FIGURE B2.1. The four phases of the SHARED framework (left) and its participatory approach in action.

The integrated use of the SHARED and the RDDST strengthened the local government’s capacity for evidence-based decision-making and fostered inclusivity. The ILUP-ILM approach facilitated by this framework and tool also fostered transformative change. It enabled the development of integrated cross-sectoral and multi-stakeholder funded initiatives to collectively address cross-sectoral issues with the participation of diverse stakeholders and partners.

The initiatives enhance sustainability, budgetary efficiency, and the effectiveness of the interventions with a focus on (1) natural resource regeneration for ecological and equitable economic empowerment and well-being; (2) increased sustainable productivity and market linkages associated with agriculture, livestock, and fisheries-based livelihoods; (3) enhanced health, education and gender equity, synergies and outcomes while promoting natural resources resilience; and (4) increased land health and productivity while providing a supply of quality water for humans, livestock and irrigation.

**Source:** Vagen et al., 2018; Chesterman and Neely, 2015
Furthermore, integrating LDN in ILUP-ILM processes allows different actors (e.g., landholders, local communities, and local governments) to attain multiple benefits while simultaneously addressing key societal, environmental, and economic challenges associated with land-use/spatial planning policies. Examples of these benefits are

- multi-functional landscapes where synergies are better explored and the trade-offs between planned uses of the same land are minimised;
- more balanced land allocation within a region, watershed, or district that considers the different uses needed in that administrative or geographic region, with the possibility of identifying areas for land restoration and/or rehabilitation;
- decreased risk of land degradation by regulating use on fragile landscapes;
- enhanced efficiency of land resource use by allocating land in an optimised manner (see Box 3.1), increasing outputs in terms of goods and services over less land;
- better accounting and tracking of changes in natural and social capital;
- improved policy coherence by holistically integrating sectoral policies and reconciling other policy objectives that play out on the same land resources (see Box 2.1);
- collectively formulated cross-sectoral initiatives that enhance sustainability, promote budgetary efficiency and effectiveness of LDN interventions (see Box 2.1); and
- the use of LDN principles, such as the neutrality principle (i.e., counterbalancing losses in one land type with equivalent gains on the same land type elsewhere), in the design of interventions.

Integrating LDN in ILUP-ILM processes also facilitates better accounting of natural and social capital changes from the start (e.g., target setting and baseline assessment) through, for example, a system of land stratification. (Land type stratification is a preparatory activity for LDN and commonly used in ILUP.) LDN interventions occurring at local or sub-national levels can be tracked and accounted for in a country’s national planning system, enabling high-level strategic planning in places where degradation should be avoided or compensated.
Chapter 3: Towards a common typology of planning systems: key elements

3.1 Integration of LDN into the ILUP-ILM continuum

National land use planning systems provide the context in which LDN targets are set and implemented. They also determine the suite of ILUP-ILM tools and approaches most suitable for LDN target setting and integration (Figure 3.1). An important first step, therefore, is to consider where and how LDN can be integrated into these national planning systems.

![Diagram showing the integration of LDN into the ILUP-ILM continuum](image)

**FIGURE 3.1.** The land use planning system of a country (right) provides the context in which LDN targets are set and implemented (left). It determines the suite of ILUP-ILM tools and approaches most suitable for LDN target setting and implementation. Specific LDN tools and approaches can also be employed outside of a land use planning system (centre) but without the benefit of capitalising on synergies with other planning processes.

The UNCCD SPI has previously identified that the integration of LDN must be achieved through a common, national, long-term vision and commitment. This commitment should be supported by a sufficient budget and finances and accompanied by an enabling land governance system (Verburg et al., 2019). The land governance system should secure land tenure and equitable access to land for men and women and ensure regulatory and policy alignment so that all dimensions of the enabling environment work effectively together (Allen et al., 2020, Okapara et al., 2018). As working effectively together entails the concurrent pursuit of economic, socio-cultural, and environmental targets within land governance frameworks, LDN and ILUP-ILM processes can be described as sharing many...
common goals. This commonality opens up several entry points for LDN into national planning systems that include ILUP-ILM processes. These entry points relate to land zoning, financial measures such as payment for ecosystem services, agricultural, conservation and landscape regeneration extension services, sustainable land management training, and regulatory instruments (e.g., through secure land tenure). Importantly, entry points differ depending on the respective loci of decision-making powers (see Section 3.4 and Figure 3.4).

Moreover, LDN integration into national planning systems can occur across the spectrum of planning decisions from newly allocating or re-allocating land use (which is within the realm of ILUP) to collaboratively modifying existing land use (which falls under the ILM part of the ILUP-ILM continuum).

3.2 The need for typologies
For planning systems that include ILUP-ILM to accommodate the integration of LDN, a basic understanding of the diversity of planning systems across and within regions is required. This is because not all tools and approaches underpinning ILUP and ILM are equally effective at integrating LDN within different planning systems. A common typology is, therefore, useful.

Culture, politics, and history influence national land use planning systems, with many different systems developed over time. Globally, planning systems have tended to transition from rigid, expert-led, top-down systems to more people-centred, participatory, bottom-up planning systems. At national levels, different systems often overlap and co-exist (Wehrmann et al., 2011; Chigbu et al., 2016), and no one blueprint defines the exact steps and procedures for all land use planning. Rather, land use planning in its many forms is flexibly adapted to suit specific national circumstances.

Comparative studies and typologies of land use planning systems have been carried out in the countries of the Organisation for Economic Co-operation and Development (OECD) (Silva and Acheampong, 2015; Berisha et al., 2021) and, to a lesser extent, in Latin America (Villagomez et al., 2020). Large knowledge gaps remain for the Global South. In a number of countries, the practice of coordinated and systematic planning is less common (Wehrmann et al., 2011). Notable exceptions are Ghana (Acheampong, 2019; Anaafo and Takyi, 2020), Mexico (Metternicht, 2018), and South Africa (Odendaal and McCann, 2016; Todes et al., 2010). Other studies of the developing world address integrated planning in the context of development planning only, with a strict focus on economic development and with a disregard for the role of environmental and broader sustainability goals (Schindler and Kanai, 2021).
3.3 How we approach the typology

Typologies (or categorisations) of planning systems found in the literature classify systems into several different types that are not necessarily mutually exclusive. For example, Silva and Acheampong (2015) propose four types: regional economic planning, comprehensive integrated planning, land-use management, and urbanism. Metternicht (2018) identifies seven common variations of land use planning: ecological land use planning, integrated land use planning, participatory land use planning, catchment-scale planning, regional land use planning, rural territorial land use planning, and spatial land use planning, including several regional variants.

Rather than developing another approach to categorise planning systems that assigns individual systems to particular types with clearly delineated boundaries, we outline nine key elements of land use planning systems, characterising the endpoints of their expression. Individual land use planning systems can be described according to the combination of elements that comprise them. Some combinations are more prevalent than others. This approach allows the characterization of a wide range of planning systems, and it avoids the difficulty of classifying country planning systems in cases for which information about one or more planning system elements is missing.

Following this method, every country, region, or landscape can appraise its own planning system using the relevant combination of key elements and the particular characteristics of those elements (Section 3.4). In some cases, the nominal situation might differ from the actual situation, as is illustrated in the case of Ethiopia. There, the country’s constitution prescribes that land use policies adopt a participatory development process, but, in fact, a top-down process is actually followed (Ariti et al., 2019).

3.4 Elements of land use planning systems

This section describes the nine key elements that can be used to characterise a country’s national planning system to create an integrated planning system typology (Figure 3.2). These elements were defined through a review of relevant literature (see Section 1.2). A systems view of how these elements interact in the planning system helps identify the elements that align with the modules and principles of the LDN scientific framework (Orr et al., 2017) and entry points in cyclical ILUP-ILM planning processes for integrating LDN. A systems view (or orientation) implies a consideration of the system and its elements as a whole rather than as individual elements. This perspective emphasizes the interlinkages between the system elements and concentrates attention on their relationships (Oliveira, 1973).
A systems view helps optimise where LDN interventions should take place (within the bounds of the LDN principle of neutrality that requires counterbalancing “like for like”) and monitors the impact of this intervention. Additionally, a systems view of the integrated planning typology helps identify tools and approaches for ILUP-ILM processes best suited for facilitating these LDN interventions.

Theoretically, any combination of the key elements outlined in Figure 3.2 is possible. In practice, some characteristics of these elements tend to co-occur. For example, the formulation of land use policies at the local level is typically associated with more active
stakeholder participation. A few of the typical combinations of co-occurrence and how they manifest themselves in a specific context are shown in a number of illustrative examples throughout this report. The key elements of the typology presented in Figure 3.2 are described below. Figure 3.3 illustrates the type of questions addressed by each of the elements to inform a planning system.

(1) Governance structure: The land use planning system in any country is embedded in and influenced by the national governance structure set in the constitution. This structure describes where decision-making power (including that of indigenous people) is concentrated and/or how it is divided between different tiers of government. Silva and Acheampong (2015) distinguished four main types of governance systems: (1) centralised unitary, (2) decentralised unitary, (3) regionalised unitary, and (4) the federal state. A fifth type, polycentric, is considered in this report to stress the important role of the state in facilitating, but not overtaking, local-level collective action in land and natural resource management (Ostrom, 2010). This type acknowledges the complexity that arises when actors at multiple levels of governance influence access to land (Pedersen, 2016) (see Table 3.1).
TABLE 3.1. Five types of national governance structures (after Silva and Acheampong, 2015, and Ostrom, 2010)

<table>
<thead>
<tr>
<th>Governance structure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralised unitary</td>
<td>Decision-making power resides mainly with the central government. Although sub-national government structures exist, they have relatively less power than the central government and enjoy a very low degree of autonomy. Example: Ireland</td>
</tr>
<tr>
<td>Decentralised unitary</td>
<td>Substantial decision-making power has been allocated to local authorities and elected regional authorities or is being allocated in an ongoing decentralisation process. Example: United Kingdom</td>
</tr>
<tr>
<td>Regionalised unitary</td>
<td>Decision-making power lies with a national government and tiers below the national level with a high degree of constitutionally guaranteed autonomy in all spheres. Example: Chile</td>
</tr>
<tr>
<td>Federal state</td>
<td>Decision-making power is shared between national and regional governments, with each having autonomy and legislative power in some spheres. Example: Australia</td>
</tr>
<tr>
<td>Polycentric</td>
<td>Many centres of decision-making power that are formally independent of one another but function as a system to the extent that they take each other into account and interact in a coherent manner with consistent and predictable patterns. Example: Tanzania</td>
</tr>
</tbody>
</table>

While a country's national governance structure may be of one type, it is not unusual that different governance structures exist at levels below the national. States, provinces, regions, and even non-administrative units, such as watersheds or landscapes, within a country have governance structures that differ significantly from that of the nation as a whole. Still, at these sub-national levels, the structure of governance may be defined following the aforementioned terminology.

(2) State-market interactions: Countries differ in how much decision-making is left to the free market versus how much is directed by state intervention. The evolving balance between these two forces sets the political and economic context for land use planning (Acheampong, 2019). In reality, the pure market-led model, in which the dominance of the market is absolute, does not exist, making some form of land use planning necessary in the first place. All countries, based on the relative importance of free markets and the welfare state, can be situated somewhere along a continuum from a market-led to a state-led system of spatial development (Berisha et al., 2021). In market economies, the interplay between the free market and government interventions in the form of planning can lead to tensions that have to be continuously (re-)negotiated, as shown in the illustrative example of the Jadar Region in Serbia (Appendix G).

(3) Land tenure: Land use planning must consider—and be responsive to—the land tenure situation of a country. This includes analysing legitimate tenure rights. Land tenure defines how individuals or groups of people socially, legally, or customarily relate to the land (FAO, 2020). Chigbu et al. (2016) describe a continuum of land tenure rights ranging from informal or customary on one end to formal or statutory land rights on the other.
Tenure security is considered a prerequisite for successful land use planning. However, formal land titling, which at present is the case for only 30% of the land in developing countries, is not the only way to secure tenure and not always effective (Chigbu et al., 2016).

Different forms of tenure regimes (e.g., state property, private property, and communal property) can co-exist on the same piece of land, either side by side or overlapping (i.e., different parties have different forms of rights) (Wehrmann et al., 2011). South Africa is the prime example of private and communal property co-existing side by side, with profound implications for land use planning and land degradation (von Maltitz et al., 2019). In many developing countries, competing claims of land ownership result when national laws define a statutory tenure system that is either ignored by local populations, who continue to apply their own customary tenure system, or that overrides what may be a traditional claim or historic practice on that land.

The tenure of other natural resources, such as water, trees, and mineral resources that could be subject to different property rights than those that apply to land, needs to be considered in the characterisation of planning systems.

(4) Level of obligation of land use plans: Land use planning systems differ in the degree to which land use plans are legally binding. On one side, indicative (Silva and Acheampong, 2015) or conformative (Berisha et al., 2021) systems strongly rely on legally binding land use plans (e.g., zoning in an urban area). On the other side, discretionary (Silva and Acheampong, 2015) or performative (Berisha et al., 2021) systems assign land use rights more flexibly with or without a formal legally binding land use plan. Most systems fall between the two extremes, incorporating characteristics of both. Of note is the capacity for enforcement by responsible agencies to apply legally binding land use plans. The level of legitimacy is also a consideration; many ILM processes develop multi-objective plans supported by multi-stakeholder dialogues that fail to be recognised as legitimate by the government and are subsequently ignored by the broader national planning system.

(5) Level of integration of land use planning: Land use planning systems vary with respect to the vertical and horizontal integration of institutions and plans. Vertical integration refers to integration and coordination between different tiers of government (from national to local), and horizontal integration refers to coordination of planning across different sectors of government and/or spatial units on the same level (e.g., neighbouring administrative units or watersheds) (Metternicht, 2018). Countries can have strong integration in both the vertical and horizontal dimensions, strong integration in one dimension but weak integration in the other, or weak integration in both dimensions.
Generally, a high level of integration can be assumed to facilitate successful land use planning that considers complex issues and targets, such as LDN.

(6) Scope and focus of land use planning: Land use planning systems differ in what aspects of sustainable development are accounted for in formal planning. The scope of land use planning varies widely from a narrow focus on single issues (e.g., zoning for a housing development) to comprehensive planning, including a range of societal, economic, and environmental goals (e.g., environmental land use planning or territorial ecological planning) (Metternicht, 2018). In addition, the focus of planning and management can be around multi-functionality (i.e., pursuing multiple socio-cultural, economic, and environmental goals simultaneously across landscapes) or be productivity- or conservation-oriented.

Comprehensive planning, for example, might be explicitly responsive to the three Rio Conventions (i.e., climate, land, and biodiversity) and to the UN Sustainable Development Goals (see Box 3.1). Comprehensive planning could thereby provide a more accessible platform for including LDN goals into land use planning and integrated landscape management.

BOX 3.1. Combining spatial modelling and participatory scenario tools for ILUP-ILM in pursuit of the UN Sustainable Development Goals. The case of the northern watersheds of Honduras

Context: The North Caribbean coastal plains of Honduras, composed of three watersheds, support the livelihoods of 3.5 million local inhabitants while contributing to the economic and environmental goals of the country. Prevailing land use systems include export-oriented intensive agriculture (i.e., bananas, pineapple, sugar cane, plantains and palm oil, which is also used as biofuel), mixed crop-livestock systems for the domestic markets, forest and agroforestry systems, and several rapidly expanding urban areas. The project Spatial Modelling of Participatory Landscape Scenarios has taken an innovative approach to planning for the sustainable development goals by linking three different simulation models to multi-stakeholder landscape planning processes (see Figure B3.1). These models address land use (CLUMondo), ecosystem service supply (MESH ES) and biodiversity impacts (GLOBIO4).

Intervention: The project establishes an integrated landscape partnership, the PaSos program (Sustainable Landscapes Programme in Honduras), which comprises a broad range of stakeholders from the palm oil, cocoa, and ecotourism sectors, as well as indigenous people, farmers, community-based organisations, municipal governments, research institutes, and universities. The landscape ambitions of this partnership include improving livelihoods and food security, increasing the sustainable production of palm oil and cocoa and sustainable watershed management. These aspirations were used to develop three landscape management scenarios (i.e., business-as-usual scenario, an accelerated agricultural export growth scenario, and an integrated landscape scenario) through a participatory exercise, and the scenarios were analysed with the help of simulation models.

The integrated landscape scenario, for example, enables an analysis of trade-offs to achieve a balance between production and conservation on a landscape characterised by a reduced expansion of intensive mono-agriculture, a significant increase in agroforestry practices, and stability in shrubland, mangrove, and wetlands when compared with the other two scenarios. These developments signify progress towards the
landscape ambitions expressed by the stakeholders, with significantly less expansion of agricultural areas into biological corridors, protected areas, riparian zones, steep slopes, and high-risk flood zones, and improvements in the delivery of ecosystem services.

The pilot study demonstrates how a combination of different tools for land use planning and landscape management can deliver a range of comprehensive future scenarios to inform local stakeholders on the anticipated impacts of land use decisions and ensuring knowledge exchange between technocrats and land owners.

![Diagram showing combination of different tools within a modelling framework](image)

**FIGURE B3.1.** Combining different tools within a modelling framework overcomes shortcomings of individual planning tools (i.e., CLUMondo, MESH ES, and GLOBIO4).

Source: Meijer et al., 2018a; 2018b

(7) **Level of stakeholder participation:** While stakeholder participation is formally part of almost all current land use planning systems, the level of actual participation can vary widely (Metternicht, 2018). Arnstein’s (1969) “ladder of citizen participation” is frequently mentioned in the public participation literature and describes the continuum of participation from mere tokenism to active control. Along similar lines, Pretty’s (1995) typology of participation distinguishes seven types of participation from manipulative to self-mobilisation with a specific focus on the development sector. A consideration of power and distributional issues (Paavvola and Hubacek, 2013) and of actors’ interest in the land are important. Also important are questions of who is a stakeholder (i.e., the
equitable representation of all population groups) and when in the planning process stakeholders are to be involved.

(8) **Decision-making/planning units**: Land use planning systems typically reflect the levels of government at which land use plans are developed and implemented. However, these two functions do not necessarily happen at the same tier/level. In addition to a hierarchy of administrative planning units, some land use planning systems explicitly allow for spatial planning units to follow biophysical boundaries, such as watersheds or landscapes (Box 3.2). These planning systems can facilitate the adoption of integrated landscape management approaches.

**BOX 3.2. A landscape approach to planning integrates biodiversity conservation objectives into ILUP. The example of Western Cape Province, South Africa.**

**Context**: The Western Cape province of South Africa, covering 130,000 km² and home to 6.5 million people, is well known for its unique and diverse flora and fauna. It comprises two internationally recognised biodiversity hotspots, the Cape Floristic Region and the Succulent Karoo hotspot. Biodiversity and ecological infrastructure are highly valued assets, and they are legally protected in more than 13% of the province (at different levels of protection). An additional 22% is considered critical for biodiversity conservation. However, increasing population pressure has led to an expansion of agriculture and residential land uses that negatively affect habitat quantity and quality.

**Intervention**: To prevent further habitat transformation, degradation, and fragmentation, South Africa has dedicated a suite of legal, policy, and planning tools to biodiversity management and conservation. The Western Cape, in particular, has a 25-year history of biodiversity spatial planning. The Western Cape Biodiversity Spatial Plan (WCBSP) (Figure B3.3) is the culmination of this effort: a state-of-the-art provincial-scale systematic biodiversity planning product that exemplifies a landscape approach to conservation. It recognises that protected areas alone are insufficient for conserving biodiversity. The plan provides spatial guidelines to integrate biodiversity management objectives into key planning processes at provincial and municipal scales (from integrated development plans to zoning schemes and sectoral plans) to maintain the integrity of landscapes beyond the boundaries of protected areas.

The WCBSP provides a spatial assessment of critical biodiversity areas and their degradation status, including information on priority protection and restoration areas derived through the application of an optimisation tool — the Marxan biodiversity priority mapping software (Pence, 2008). Marxan is an open-source, GIS-based algorithm that identifies the best configuration of planning units to meet targets for biodiversity protection, ecological sustainability, and climate resilience out of a range of options. The algorithm is guided by the principles of representation (i.e., conservation areas that represent a sample of all biodiversity features) and of persistence (i.e., conservation areas, such as corridors, needed to maintain the ecological and evolutionary processes in the long term). The configuration of priority areas identified by the tool is spatially efficient in that it requires the least amount of land to meet targets. It also attempts to avoid conflict with other land uses where conflict potential is known to exist (e.g., in areas surrounding urban development).

The WCBSP was conceived to form the basis for biodiversity protection in all Environmental Sector Plans in the Western Cape province, identified in the multi-sectoral Integrated Development Plans at the municipal level. It also provides the foundation for Spatial Development Frameworks, which indicate desired land use patterns and guide the location of development and conservation.
FIGURE B3.2. Western Cape Biodiversity Spatial Plan at the provincial scale. The design process began with protected areas “locked” and certain irreplaceable features “earmarked” into the configuration. Marxan was then run to generate options of spatial areas meeting the planning objectives. Fine-scale corridors were designed in an iterative manner. This example shows that spatial planning can support the best configuration of planning units to meet biodiversity, ecological sustainability, and climate resilience targets.

Source: Pence, 2008; Pool-Stanvliet et al., 2017; SANBI and UNEP-WCMC, 2016

(9) Suite of policy instruments: Various policy instruments are used to implement land use goals at different spatial scales. They include national guidelines and concrete land use plans for specific locations that specify broad land use zoning (Acheampong, 2019). Market-based instruments (e.g., carbon taxes, farm or fallow subsidies, and payment for ecosystem services; see Box 3.3), regulatory instruments (e.g., greenbelts, urban growth boundaries, and environmental impact assessments), voluntary agreements (e.g., “green” certification schemes and fairtrade initiatives), or a mix thereof can be deployed to achieve specific regulatory objectives. Different land use planning systems may work more effectively under different policy instruments (e.g., subsidies, taxes, and incentives), and this should be considered in the implementation of LDN interventions.
BOX 3.3 Participatory ILUP-ILM helps decide on the best mix of policy instruments to achieve a vision of sustainable development. The example of the Cuitzmala watershed, Mexico

Context: The Cuitzmala watershed is a river basin of 1,100 km² located on the Pacific Coast of Mexico. Under pressures from uncontrolled development, the watershed’s native, tropical, dry deciduous forest cover has been transformed into a mosaic of active and abandoned crops, pastures, and remnants of primary and secondary forest. The social structure in the watershed is complex, with a mix of small-scale and industrial farmers, tourism entrepreneurs, conservationists, public servants, and indigenous communities. This creates a situation where multiple interests compete for land and resources, making sustainable development challenging.

Intervention: The Cuitzmala watershed served as a pilot site for the European Commission collaborative project known as ROBIN (Role of Biodiversity in Climate Change Mitigation). A team of international researchers partnered with local stakeholders from the private and public sector to devise more sustainable management options at the watershed scale with the help of OPTamos (Options for Participatory Transformation and Sustainability Management). OPTamos is a multi-criteria analysis tool that supports a Social Multi-Criteria Evaluation (SMCE) decision-making process. Unlike conventional multi-criteria analysis tools that typically assist a single decision-maker without necessarily considering the perceptions of other actors, SMCE integrates a participatory approach to make decision-making a social process designed as a joint learning experience for a range of stakeholders and researchers. The application of the OPTamos tool was embedded in a series of stakeholder workshops. Participants identified key issues associated with the Cuitzmala watershed, causal links between elements as perceived by them, a desired future direction for the watershed decision-guiding criteria, and a list of possible interventions and developments.

The participatory stakeholder process solicited a list of interventions and developments, summarised into three land management options: (1) primarily conservation with Payment for Ecosystem Services (PES); (2) mixed land use with partial PES financing; and (3) industrial agriculture. The support for each of these options was analysed using the OPTamos tool based on a variety of stakeholder inputs solicited during the workshops. The analysis showed that the mixed land use option had the broadest support. While the other options might have contributed to improving individual aspects, stakeholders saw the mixed land use option as an opportunity to improve the sustainable use of natural resources while simultaneously promoting social equity, reducing corruption and fostering cultural identity.

The transparency and structure of the decision-making process facilitated by OPTamos led to a shared understanding of the Cuitzmala system and helped to motivate the stakeholders to take responsibility for the actions identified as necessary towards their common goal. Identified actions included, among others, integrating local communities’ input into new regional land use planning, establishing an inter-municipal management organisation, developing organic agriculture workshops for farmers, and environmental education courses in communities and primary schools.

Source: Grima et al., 2017; Singh et al., 2016
Chapter 4: Entry points for LDN integration in ILUP-ILM

4.1 Linking the phases of cyclical ILUP-ILM planning processes with the LDN framework

Effective planning and decision-making processes are cyclical and iterative, allowing learning from experience and implementing course corrections where necessary (Dalal-Clayton and Bass, 2009; Wehrmann et al., 2011).

Different phases of a land use planning cycle offer entry points for integrating LDN into on-going land use planning and landscape management efforts. Over the long term, opportunities to ensure that LDN is a regular consideration within national planning systems—or to implement systematic land use planning in the first place—often occur with changes of government and with unpredictable natural or socio-economic events that create pressure for change and trigger new policy directions (McGonigle et al., 2020).

There are multiple ways of breaking a planning cycle down into its basic phases (Briassoulis, 2019; Metternicht, 2018; Wehrmann et al., 2011; Chigbu et al., 2016; Willemen et al., 2014), but all of them roughly comprise aspects of plan formulation, implementation, and evaluation. Figure 4.1 illustrates an example of a planning cycle broken into five generic phases, including (1) description and assessment, (2) visioning, (3) planning, (4) implementation and (5) monitoring and evaluation. The outcome of the monitoring and evaluation phase feeds into subsequent planning processes in the form of new knowledge and understanding. Actually, the boundaries between the phases may be blurred, and, depending on the planning systems (Chapter 3), not all phases are necessarily distinctive or involve the same actors. Feedbacks and learning occur among all phases (thin arrows), sometimes disrupting or shortcutting the cyclical process. For example, obstacles arising in the implementation phase (e.g., a new actor is added, unforeseen pressures are applied from interest groups, or natural disasters occur) may require going back to the assessment and planning phases to accommodate the new information or situation (Briassoulis, 2019).
FIGURE 4.1. The five phases of a cyclical ILUP-ILM planning process. While the general ILUP-ILM process is cyclical, feedbacks and learning happen among all phases. The outer circle represents the modules of the LDN scientific framework (Orr et al., 2017) with arrows pointing to entry points into the phases of the ILUP-ILM cycle.

The following sections introduce the five phases of cyclical ILUP-ILM planning processes and describe entry points for integrating modules of the LDN scientific framework (Orr et al., 2017).

**Phase 1: Description and assessment.** The socio-ecological landscape (e.g., gender considerations, human development, institutional frameworks, and tenure regimes) and the spatial patterns of problematic (or beneficial) landscape areas need to be understood to set realistic, location-specific goals. This is also important for planning pathways to reach these goals (see Box 4.1). The description and assessment phase involves taking stock of current actors, formal and informal, whose decisions impact the planning region. The implementation of this phase needs to capture land tenure arrangements, governance structures, conflict over land, and access to ecosystem services. In short, the description and assessment phase should predict the possibility of changes to circumstances and governance structures that can influence this phase and all other phases, including the anticipated outcomes and impacts.

**Suitability for integrating LDN:** This phase offers an entry point for Module B of the LDN framework, which involves setting a baseline against which neutrality is assessed (Orr et
The counterbalancing mechanism requires a baseline-setting period to establish a reference against which achieving LDN through this mechanism can be evaluated. In addition to establishing a land degradation baseline, the description and assessment phase involves preliminary assessments that assist with planning for and integrating LDN. These assessments include land potential and resilience assessments, land stratification assessments, socio-economic assessments and assessments of the role that gender and inclusion may play.

BOX 4.1 Optimising land restoration benefits for improving water and sediment retention. The example of Espirito Santo State, Brazil.

Context: In recent years, the State of Espirito Santo in southeastern Brazil has experienced ongoing and severe droughts combined with above-average temperatures. These conditions have led to a widespread household and agricultural water crisis and sharp declines in coffee production—one of the state’s main exports. Deforestation and land degradation have exacerbated the impacts of the precipitation shortfalls, which are expected to become more frequent with global climate change.

Intervention: Strict water-use restrictions helped buffer the immediate shortages, but the state aspired to sustainable, longer-term solutions that would reduce runoff and promote water and sediment retention. It also wanted to meet its international commitment under the Bonn Challenge to restore 80,000 ha of its native Atlantic Forest. A sub-national assessment, based on land cover, water yield, and sediment delivery data, identified 120,000 ha with potential for forest landscape restoration. A computer-based decision-making tool, called the Restoration Opportunities Optimization Tool (ROOT), was then used to determine which areas, if restored, would provide the largest potential landscape-scale benefits for water and sediment retention while specifically targeting low-income populations within priority watersheds.

ROOT—an optimisation tool developed by the International Union for Conservation of Nature (IUCN) and The Natural Capital Project—supports decision-makers across sectors using an assessment of multiple ecosystem services. The tool visualises an “agreement map” that shows how frequently each area is selected as a restoration opportunity among multiple model iterations (Figure B4.1). Higher agreement corresponds with areas where restoration interventions would provide optimal benefits for the modelled ecosystem services.

Applied in Espirito Santo State, ROOT shows that the area of both “very high” and “high” agreement amounts to 78,903 ha, meaning that almost the entire Bonn Challenge commitment could be met in a way that optimally increases ecosystem services. About half of that area was spatially clustered, forming hotspots for the implementation of forest landscape restoration. Adjacent areas emerged as optimal as well. The ROOT analysis helped to build political support for restoration by incorporating convergent interests into a single vision. The analysis results provided a quantitative foundation for strengthening the state’s Payment for Ecosystem Services (PES) program by identifying areas where low-income populations affected by the drought could receive monetary support for their conservation or restoration efforts that optimally support long-term water conservation.
FIGURE B4.1. Optimisation of restoration opportunities using the ROOT tool. Only areas previously identified as opportunity-areas were included. Higher agreement among the model iterations indicates greater benefits from restoration (left). Cluster analysis showed where optimal restoration opportunities co-occur in space (i.e., high-high clusters), signifying the most optimal restoration opportunities as opposed to high opportunity sites surrounded by a low opportunity area (i.e., high-low outliers) (right).

Source: Beatty et al., 2018; IUCN and WRI, 2014

Phase 2: Visioning and goal setting. Target-setting by negotiating desired landscape outcomes is the objective of this land use planning phase. Depending on the land use planning system, this phase can take place formally or informally, and it may be prescribed top-down or negotiated through a participatory process (see Box 2.1 and Box 4.2). Different sets of actors might be involved, with the most dominant actors influencing
priorities among different goals (FAO, 2016; Briassoulis, 2019). These actors can include non-locals, such as multinational firms and lenders or donors, such as the World Bank.

**BOX 4.2. ILUP-ILM and participatory processes. Striking the right balance and inclusiveness.**

Developed in response to the shortcomings of the top-down approach to planning (i.e., to level the imbalances of power inherent in it), participatory approaches are nevertheless not without criticism (Cooke and Kothari, 2001). Rather than mitigating unequal power relations, some participatory processes related to ILUP-ILM risk inadvertently reproducing them (Turnhout et al., 2020). For example, treating local communities as homogeneous entities when, in fact, they are an aggregation of sub-groups can mean ignoring differing interests and perspectives on land use and its management.

Getting stakeholder participation right can be challenging (Glicken, 2000), and processes can present pitfalls. Some voices may not be invited to the decision table in the first place as various forms of power (i.e., political, economic, gender, or cultural) are at play in defining who is a stakeholder (Sprain, 2017). Sometimes representatives of a group or sector of society do not necessarily represent the interests of those stakeholders (Butler and Adamowski, 2015). Even among those represented at the negotiation table, inclusive outcomes are not guaranteed, particularly when the aim of achieving consensus hides potential conflicts.

Land inequality can put women, indigenous people, and the poor at risk of being excluded or not having their voices heard. This can be an important obstacle to inclusive stakeholder engagement in ILUP-ILM (e.g., if stakeholders are defined as landowners only) (Anseeuw and Baldinelli, 2020). Hence, ILUP-ILM processes that avoid, reduce or reverse land degradation can be affected by political and socio-cultural contexts and so can the participatory processes themselves (Mubita et al., 2017).

The protection of land resources is one of several environmental and socio-economic goals of a land use planning vision. While this goal is synergistic with some of the other goals, it also competes with still others. Visioning is not a one-off activity; instead, goals are often revised and modified (see Box 4.3).

**Suitability for integrating LDN:** The global vision defined in Module A of the LDN framework is to maintain or exceed no net loss of healthy productive land as measured from an established baseline (Figure 4.1). This vision informs national voluntary targets for no net loss of healthy and productive land for each land type. Countries can decide to set a more ambitious target, where gains exceed losses. In rarer cases and where implications of past decisions preclude a complete counterbalancing of future land degradation, countries can acknowledge and justify these projected losses and settle for a lower target (Orr et al., 2017).
BOX 4.3. Participatory decision-making on interventions to reduce and reverse land degradation and increase drought resilience in customary land tenure systems. The examples of Tanzania and Malawi.

Context: As is the case in much of rural Africa, smallholder farmers in Tanzania and Malawi are confronted with the challenge of sustaining their livelihoods on increasingly degraded land. This degradation is exacerbated by the already evident effects of climate change, notably drought and other irregular weather patterns. In both countries, the majority of the land is vested in the president as custodian on behalf of all citizens, and it is de facto occupied and used by smallholders under customary tenure.

Intervention: The AGORA (Acting Together Now for Pro-poor Strategies Against Soil and Land Degradation) project was motivated by the need for a better understanding of how farmers decide when considering the adoption of sustainable land management practices that would improve the lives of the rural poor by mitigating or reversing land degradation. Although smallholder farmers in rural Tanzania and Malawi are knowledgeable about sustainable farming technologies and practices, many are nevertheless confronted by contradictions. These contradictions arise between what research recommends, what projects promote, and what donors support, on one side, and what sustainable land management options are available on the other.

The project developed the Evaluating Land Management Options (ELMO) tool for investigating farmers’ preferences and perceptions of the advantages, disadvantages and trade-offs between different land management practices, such as grass strips, on-farm trees, terraces, composting and others (Figure B4.3). Through structured and unstructured discussion, checklists, ranking, scoring, and weighting, ELMO helps decision-makers understand the key conditions and relative importance of different factors in determining farmers’ choices. When designing and implementing equitable solutions to land degradation, it is important that farmers taking part in the participatory process are an equal mix of men and women of different age and wealth categories.

As a participatory stakeholder engagement tool, ELMO is applicable in different phases of the land use planning cycle and their corresponding modules of the LDN framework. By addressing the adoption of possible interventions by land users, the tool can support the understanding of drivers and pressures in the visioning phase of the planning cycle and the resilience assessments in the planning phase. It can also be a useful tool in the monitoring and evaluation phase to shed light on why or why not certain interventions were successful, especially in situations where farmers’ input was not already sought in the visioning and planning phases. Although the AGORA project concluded in 2017, a stakeholder forum founded with AGORA’s support, the Usambara Ecological Forum, lives on as an important institutional innovation, registered under Tanzanian law.
Phase 3: Planning. This phase considers concrete landscape changes, including the prioritisation of interventions and their locations (see Boxes 3.1, 3.2 and 4.4). A variety of alternative land use plans are usually proposed to match current and future land resource demands and supply (Briassoulis, 2019). To help select the preferred plan among a set of alternatives, scenarios (see Box 3.1) are formulated and their economic and environmental effects analysed. In this highly politically charged land use planning phase, economic considerations are often prioritised over those related to the environment and social justice. Whereas land resources are considered common-pool resources to be preserved for the benefit of current and future generations, irrespective of their property status (Ostrom et al., 2002), land ownership influences final decisions on land use allocation or re-allocation.

Suitability to support LDN: The planning phase is an entry point into ILUP-ILM planning processes for the counterbalancing mechanism (Module C) of the LDN framework. Counterbalancing is to be managed within the same land type (see Glossary) and within a biophysical (e.g., catchment) or administrative (e.g., province) spatial domain for which land use decisions are made. To maintain or exceed neutrality, actions aimed at positive
changes need to be negotiated to compensate for projected losses over an equal area of the same land type\(^3\). The latter requires an accurate representation of land types and their estimated productive potential (Tamba et al., 2021). When planning to counterbalance, the resilience of counterbalancing interventions in the long term and likely trade-offs between ecosystem services need to be considered. Following the LDN response hierarchy (i.e., avoid > reduce > reverse land degradation; Orr et al., 2017), prevention is viewed as better than the cure. Thus, planning specific interventions should prioritise land where the prevention of land degradation is possible, followed by mitigation through improved land management practices, before targeting land for restoration interventions. Planning is guided by preliminary assessments (i.e., Phase 1 of cyclical ILUP-ILM processes) as well as by the LDN targets set by a country (i.e., during Phase 2).

Integrating LDN into the overall land use planning framework, rather than planning and tracking progress towards LDN separately, allows a consideration of the cumulative impacts of all land use decisions on LDN. This strategy has the added advantage of emphasising, \textit{a priori}, the benefits of avoiding land degradation (i.e., in the planning phase when land uses are selected), rather than relying solely on \textit{ex post facto} monitoring (i.e., when prevention of land degradation will no longer be an option).

\textbf{BOX 4.4. Sustainable spatial planning at a regional scale with a spatial optimisation tool. The example of Poyang Lake Region, China.}

\textbf{Context:} China’s fast economic progress and urban growth since its 1978 economic reform have been accompanied by problems of environmental degradation and deteriorating land productivity. China’s current land use planning system, which is based on hierarchical master plans that prescribe quotas of different land use types, has proven deficient when it comes to guiding a sustainable process of urbanisation. This is because it lacks a mechanism for spatially allocating different land uses, especially at regional (provincial and city) levels. Instead, land allocation takes place in an ad hoc fashion and is driven mainly by economic interests at the local level.

\textbf{Intervention:} Most decision-support tools for optimising land use patterns are ill-equipped to deal with the Chinese planning system, which is characterised by centralised and top-down decision-making. Thus, a land use optimisation tool has been adapted to the Chinese planning context by including a land use quota system. In the Poyang Lake region of Jianxi Province—an area of almost 20,000 km\(^2\)—the tool is used to demonstrate multi-objective land use optimisation. Fed by five major rivers, Poyang Lake is the largest freshwater lake in China. Its wetlands are of ecological significance as an overwintering spot for many migratory bird species. The densely populated area also plays an important role in national food security, being one of China’s main rice-growing areas. However, the agricultural area has diminished since the 1980s due to industrial and urban expansion.

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\(^3\) Ideally, the counterbalancing mechanism would consider not just the direction of change but also the magnitude of change. It would be theoretically possible to integrate LDN into a planning system based on anticipated gains and losses in some measure of land-based natural capital, rather than based on the area of land where gains or losses are anticipated. Under LDN, countries may exercise the option to implement a more refined counterbalancing mechanism that also categorizes and guides land use decisions according to the anticipated magnitude of change in the indicator results and plans interventions to deliver a similar magnitude of gains (see Orr et al., 2017, Sections 5.2 and 7.4).
The optimization tool considered three land use scenarios consisting of a set of conversion rules designed to maximise food security, nature conservation, and economic growth. The conversion rules considered predicted demand and land suitability and were tailored to the Chinese context (i.e., taking into account the land use quotas and policies). For example, the area of land reclaimed from arable land for urban development could not exceed the amount of arable land reclaimed from non-developed land. Each scenario resulted in a single-objective optimisation map. The maps were subsequently overlaid to highlight patches with and without conversion conflicts. In the final multi-objective optimisation map (Figure B4.4), demand was first allocated to patches without conversion conflict. Lastly, conflicted patches were allocated in a stepwise ranking process reflecting priorities stipulated in the National Chinese land management policy and regional policy objectives.

A group of 12 experts and planning practitioners evaluated the tool and its results. Despite differences in opinion between local and provincial government representatives, they agreed that the planning tool could support more coherent and sustainable planning than is currently practised at the regional level.

The outputs from the tool can serve as a basis for multi-sectoral and multi-scale discussion. However, the successful implementation of the land use allocations will require financial incentives and compensation mechanisms. This is because to achieve more sustainable land use at regional level, some local administrations will be required to safeguard more arable land and natural resources, whereas others will be able to allow more economic development.

Source: Chen et al., 2015

Phase 4: Implementation. This phase constitutes a real test of whether—and to what extent—a selected land use plan is viable under actual conditions. Policy instruments for implementing land use plans range from command-and-control tools to financial incentives and information campaigns to increase understanding of a new land use plan's benefits (Verburg et al., 2019). Effective implementation of land use plans depends on the spatial coordination of these policy instruments and cooperation among actors from various domains and sectors.

Acknowledging and profiling the role of local actors to ensure ownership of such plans is essential to effective implementation because it ensures compliance. Compliance can be
achieved by applying appropriate enforcement mechanisms, such as penalties and fines, or by involving a broad range of actors in participatory planning early in the process (e.g., see Box 2.1 and Box 4.3). Acknowledging the role of local actors helps ensure the ongoing participation of local populations and institutions in the adaptive management of land-based resources in terms of ILM.

Implementation roadblocks are common and point to omissions during the planning phase (e.g., past planning and other legacies, conflicts between proposed and customary practices, or unexpected events). They also suggest evolving demographic, socio-economic and/or environmental circumstances that could not be foreseen in the planning phase (Briassoulis, 2019). Addressing these roadblocks requires revisiting prior planning phases, often multiple times, and using principles of adaptive management embedded in ILM processes.

**Suitability for integrating LDN:** The LDN framework stresses the selection of suitable interventions and the crucial role of an enabling environment for the successful implementation of the neutrality principle using the counterbalancing mechanism. The implementation phase of a land use planning cycle offers an entry point for direct interventions geared towards avoiding, reducing, or reversing land degradation and for actions that ensure an enabling environment (Orr *et al.*, 2017).

Integrating LDN within existing planning systems allows the leveraging of investments, avoids duplication of efforts to foster an enabling environment, and helps achieve multiple benefits (see Box 4.5 and Box 3.1).

**BOX 4.5. ILUP-ILM implementation to achieve multiple ecological, economic, and social benefits.** The example of China’s Three-North Shelterbelt Program (TNSP).

**Context:** China’s drylands make up 40% of the world’s third largest country. The Three North comprises the semi-arid and arid lands of Northeast, North, and Northwest China, an area covering 13 provincial districts and stretching across 4 million km². Hundreds of millions of people live in this ecologically vulnerable part of the country and face threats from desertification, especially in the form of soil erosion and dust storms. These threats hinder economic development and the improvement of livelihoods. Given these concerns, the central government of China has been proactive in designing large-scale environmental programs in the area since the 1970s. The China case is unique in size and time horizon, and it pre-dates the LDN framework by decades.

**Intervention:** The Three-North Shelterbelt Program (TNSP) is the largest ecological afforestation program in the world. The program is comprehensive, and its planning is highly integrated—both vertically (between different tiers of government) and horizontally (across different sectors). A Bureau of the TNSP manages the program and coordinates the planning and implementation of the afforestation targets between forestry departments, water resource departments, agriculture departments, and research institutions. TNSP also capitalises on synergies with multi-lateral environmental agreements, such as the global forest goals and sustainable development goals.

A zoning approach is used in spatial planning. Four first-level zones are divided into a total of 29 second-level planning zones (regional protection system zones). These, in turn, are sub-divided into third-level zones (shelterbelt type zones) in the provincial regions. Forest types are prioritised in different zones to maximise ecological, economic, and social
benefits. These forest types include shelter forests, cash trees, fuelwood forests, timber forests, and trees that are planted along roads and rivers and surrounding settlements in the form of connected networks, patches and belts.

By 2018, the TNSP completed 301,400 km$^2$ of afforestation, and forest cover increased from 5% in 1979 to 13.5%. The program has moved from its initial motivation of sand control towards a diversified portfolio of interventions to promote transformative change in the area. These interventions include vegetation restoration, prevention of soil and water erosion, change in microclimatic conditions, increasing crop and forestry production, employment opportunities for local populations, and poverty reduction.

Equally diversified has been its investment mechanism. Where the central government provided a significant part of the financing in the beginning, financial inputs from various sources (i.e., state-owned enterprises, private enterprises, foreign enterprises, public-private partnerships, individuals, and social organisations) have since taken over. Top-down planning and management approaches have increasingly been complemented by bottom-up approaches, and the collective forest tenure system was reformed so that every tree and patch of plantation were allocated to the planters.

![FIGURE B4.5. A map of the extent of the Three North Shelterbelt Program (TNSP). Also known as the “Great Green Wall”, the TNSP is China’s first key forestry ecological program and one of the largest ecological engineering programs in the world.](image)

Source: Wang et al., 2010

In addition to increased forest cover, the TNSP has created an annual ecological service value of 2.23 trillion yuan. Shelterbelt forests have protected 44% of farmland in the program area; grain output has increased by a total of 423 million tonnes over 40 years; 48 million tonnes of fruits and nuts are harvested annually from economic forests; and about 15 million people have been lifted out of poverty. Global outreach from the program has reached more than 1,000 trainees from 76 countries in 38 training courses on desert control, shelter forest establishment, ecological restoration and economic development.

Source: Li et al., 2012; Zhu, 2013; Zhu and Zheng 2019; Zhu and Song, 2020; Wang et al., 2010; Ministry of Forestry PRC, 1993

**Phase 5: Monitoring and evaluation.** Any issues hindering the successful implementation of ILUP-ILM processes can be identified in this phase, and corrective action can be initiated where necessary. Effective monitoring depends on reliable baseline
data and assessment models. Evaluation requires a thorough understanding of factors other than land use interventions that may have contributed to change. Monitoring and evaluation may involve the same or a different set of actors. Depending on the land use planning system, monitoring and regular land use plan revisions may be prescribed in the legislation or not.

**Suitability for integrating LDN:** Monitoring and evaluation that are part of a land use planning cycle present an entry point for monitoring progress towards LDN as outlined in Module E of the LDN framework. Three global indicators (i.e., trends in land cover, land productivity, and soil organic carbon stocks) for which baseline values have been assessed form the centrepiece of a monitoring strategy. The three global indicators do not always provide conclusive evidence of changes in land health status (Sims *et al.*, 2020; Herrmann and Tappan, 2013; von Maltitz *et al.*, 2019). Therefore, complementary indicators are recommended to support the interpretation of the global metrics as well as to provide additional context, especially in the context of considerations not covered by the global indicators, such as social and economic impacts.

### 4.2 Equitable and values-based, people-centred ILUP-ILM processes for LDN

Population groups excluded from ILUP-ILM decisions—even during participatory processes aimed at inclusivity—tend to be those who are particularly vulnerable to the impacts of desertification, land degradation, and drought. The UNCCD Party Countries agreed to adopt a values-based approach to land stewardship, which also supports more equity for these vulnerable groups, including women (UNCCD, 2019b).

Indigenous communities are a frequently cited example of these vulnerable groups. These communities play an important role in natural resource conservation by managing—or possessing tenure rights to—about 40% of all terrestrial protected areas and ecologically intact landscapes across the globe (Garnett *et al.*, 2018). While often excluded from the negotiating table, these communities have traditionally embraced the values-based land stewardship approach that decision-makers are now committing to. Hence, their consent and partnership are important for achieving effective and inclusive resource conservation outcomes. Furthermore, their knowledge and belief systems rooted in respect for nature can inspire conservation and LDN actions driving transformative change (Appiah-Opoku, 2007; Artelle *et al.*, 2019).

For community participation in ILUP-ILM processes to be more equitable and socially just, heterogeneity within local communities has to be recognised and considered. This needs an improved understanding of social dynamics and power relationships (including gender power that often holds women back compared to their male counterparts, including in land rights and decisions on land use), and how these dynamics and relations influence the construction and use of local knowledge. Herein lies the importance of including
and/or elevating the role of the social sciences and humanities. Emphasising political, social and cultural contexts and indigenous and local knowledge systems does not minimise the importance of the science-based counterbalancing mechanism of LDN and LDN’s three global indicators (i.e., trends in land cover, land productivity, and soil organic carbon stocks). Rather, it is about embedding them in their contexts so that they enrich and inform, rather than dominate, the discussion and/or assessment.

In ILUP-ILM processes that integrate LDN, win-win situations may be desired and planned for, but it should also be recognised that there may be winners and losers (Marques et al., 2021). Rather than encouraging consensus, there should be room to allow discussions of the ambivalence, dilemmas, unpleasant choices, and social conflicts that arise during the process of seeking optimal solutions that all actors can accept as being in their collective interest (Sprain, 2016). Although allowing for pluralism does not necessarily result in actionable knowledge (as much as consensus does), it is nonetheless important for enabling transformative change (Turnhout et al., 2020).

Lastly, participatory approaches are not a panacea. Depending on the context of the planning system (see Chapter 3), a bottom-up, participatory approach with multi-stakeholder platforms might not be suited to all situations. Therefore, the evaluation of tools and approaches for integrating LDN into ILUP-ILM processes needs to strike a balance of participation and inclusiveness (see Box 4.2). Sometimes top-down approaches have more equitable results than ostensibly participatory approaches that fail to consider heterogeneity and power relationships—including gender power—within local communities. There is considerable evidence that a combination of top-down and bottom-up processes can be more effective in many circumstances (Mansuri and Rao, 2013).
Chapter 5: Tools and approaches to support the integration of LDN into ILUP-ILM planning processes

5.1 Categorisation of tools and approaches that support ILUP-ILM

This chapter provides an overview of tools and approaches that support the integration of LDN into cyclical ILUP-ILM planning processes by facilitating the inclusion of scientific analysis and knowledge—including local knowledge. This chapter uses the term “tools and approaches” as an umbrella term for framework, approach, method, technique, tool, model or other methodologies. These terms are often used interchangeably and lack consistent definition in the literature. In the context of this report, all tools that inform or assist the process of land use planning are considered equally relevant.

Figure 5 illustrates a broad categorisation of groups of available tool types. Tool groups are briefly described by their characteristics, by their applicability and constraints, and by their potential role within the relevant phases of ILUP-ILM processes (see Chapter 4). An analysis based on the overall functionalities of each of the tool groups reveals how these groups (e.g., optimisation, forward-looking, etc.) can support countries in the integration of LDN into ILUP-ILM processes. The chapter concludes with guidance for land planners and decision-makers on the selection of appropriate tools for the implementation of LDN interventions articulated with national planning systems, considering the ILUP-ILM phase(s) targeted for integrating LDN.
FIGURE 5.1. A classification of tool groups along two axes capturing differences between participatory and expert analysis and temporal dynamics. Dashed outlines indicate that tool groups are (mostly) not spatially explicit. Examples of tools are given in grey.

5.2 Characterisation of tool groups and their suitability for supporting LDN integration into ILUP-ILM

Table 5.1 synthesises tool groups, their main characteristics, and the phases of the ILUP-ILM planning cycle they have the potential to inform. A description of each tool group follows, including their relevance and applicability to the phases of the ILUP-ILM cycle (Chapter 4).

<table>
<thead>
<tr>
<th>Tool group</th>
<th>Characteristics</th>
<th>Potential application</th>
<th>ILUP-ILM phase it can inform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator-assessment tools</td>
<td>• Calculate selected indicators based on (spatial) dataset(s) on biophysical (e.g., soil organic carbon content and trends, land degradation status) or socio-economic properties (e.g., land tenure, census data on land owners and users)  • Analyse current conditions and/or historical trends</td>
<td>Risk and vulnerability analysis, ecosystem service and quality of life assessments</td>
<td>• Assessment  • Monitoring  Example in this report: Box 2.1</td>
</tr>
<tr>
<td>Forward-looking tools</td>
<td>• Extrapolate or forecast the future development of land uses and/or land properties  • Often used to compare different scenarios and desired pathways and to identify drivers of development</td>
<td>Land use change modelling, socio-economic impact analysis, urban growth modelling,</td>
<td>• Visioning  • Planning  Examples in this report: Box 2.1</td>
</tr>
</tbody>
</table>
### Multi-criteria analysis tools

- Search for the best solution for complex problems with competing objectives and interests
- Represent priorities of different stakeholders using different weights for criteria, options and alternatives
- Evaluate alternatives and their consequences and rank them to select the most desirable
- Define either the best option for a location, or the best locations for an option, but multiple objectives at a landscape level are not addressed

**Crop yield forecasting**  
Box 3.1, Box 4.5

**Urban planning, locational analyses, policy implementation analysis**

- **Examples in this report:** Box 2.1, Box 3.3

### Optimisation tools

- Similar to multi-criteria analysis tools, these tools address complex problems with competing objectives of different actors
- Instead of location-specific analysis, these tools conduct landscape-wide mathematical optimisation
- Alternatives are usually indefinite and the solution with the smallest distance to an optimal situation is aimed for
- Aim to find (spatial) solutions with the least trade-offs or costs at regional/landscape levels

**Land allocation planning, trade-off assessments**

- **Examples in this report:** Box 3.1, Box 3.2, Box 4.1, Box 4.4

### Rapid-appraisal tools

- Gather information through consulting and working together with local actors/communities
- Focus mainly on socio-economic conditions and how local people perceive their environment, including land condition and uses

**Land tenure, land condition and impact assessments**

- **Examples in this report:** Box 2.1, Box 4.3

### Process-oriented tools

- Facilitate negotiation, interaction, and decision-making for policy implementation
- Are particularly useful for mainstreaming and negotiating topics that often remain at the periphery of planning, including land rights and arrangements related to gender, indigenous people and communities
- Local actors decide together which activities are pursued to achieve a desired outcome

**Stakeholder negotiations for local empowerment**

- **Examples in this report:** Box 3.1, Box 2.1, Box 4.3

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*The review and evaluation are representative—rather than comprehensive—of the tools that belong to the groups defined. Appendix C lists tool examples, and these are further synthesised in Appendix E. Appendix D provides an overview of modules of LDN and the phases of ILUP-ILM processes supported by the tools.

### 5.2.1 Indicator-assessment tools

Indicator-assessment tools can appraise the current state or historical trends of selected biophysical metrics (e.g., trends in soil organic carbon) or socio-economic indicators (e.g., land tenure). While indicators are often used as input for assessments and can be part of other tools, this tool group includes tools that serve to derive and/or assess an indicator, either by measuring values, analysing and summarising the relationship between indicators, and/or evaluating spatial or temporal trends. One or several, often quantitative variables are usually combined, and the relationship between variables is determined statistically or by experts (Metternicht *et al.*, 2010). An example in the context of LDN is...*
the land degradation status of an area, which is determined by analysing and combining
trends in soil organic carbon, net primary productivity and potentially other region-specific
metrics.

Indicator-assessment tools used for ILUP-ILM are often applied within a geographic
information system (GIS) environment. Computer-based mapping of indicator values
based on Earth Observation or other spatial data can provide a representation of current
land conditions and the spatial extent of environmental issues. It can also enable
systematic, repeatable assessments over time and space. Field measurements, census
data from national statistics and/or surveys are other sources of spatial and non-spatial
data input.

Relevance to phases in the ILUP-ILM cycle

Indicator-assessment tools can be used in the assessment phase of the ILUP-ILM cycle
to help understand current land conditions and historical trends of land health and land
use (including its users and uses). The tools can also identify areas that require
interventions (e.g., see Box 2.1). Analysis of past trends can inform land uses or policy
implementation that drives positive or negative change. This can be useful for future
planning and for setting goals for indicator values and directions of change (e.g., Arnous,
El-Rayes and Helmy, 2017). Additionally, indicator-assessment tools can be combined
with forward-looking tools and multi-criteria analysis tools to assess projected future
conditions and evaluate scenarios for implementation (Abelson et al., 2021). This can
support the monitoring phase of the ILUP-ILM cycle, revealing whether set targets are
met and whether chosen actions are suitable and sufficient.

Suitability of indicator-assessment tools to support LDN integration

Indicator-assessment tools can support countries in assessing land degradation status
and monitoring change. To be suitable, tools of this group should be able to track three
key metrics considered to be global indicators of LDN: trends in land cover, soil organic
carbon and land primary productivity (Orr et al., 2017). The tools should be capable of
assessing these three indicators potentially together with other national- or region-specific
indicators. The land degradation status in the baseline year should be assessed using
average values from the preceding 10-15 years. The option of adjusting data based on
local knowledge should be available. This local knowledge can be gathered with the help
of rapid-appraisal or process-oriented tools. For monitoring change, tools must identify
changes in relation to the assessment in the baseline year.

Global spatial data and time series data on land cover, soil organic carbon, and net
primary productivity are freely available from different sources (for an overview, see
Anderson and Johnson, 2016). Thus, GIS programs can be used to map the status of
indicators. Some readily available tools have been developed that specifically address
LDN and facilitate assessments of LDN indicators (e.g., Trends.Earth). Tools using on-the-ground measurements (e.g., visual soil or vegetation guides or siting) can assist in the validation of land degradation assessments conducted at regional or national levels (top-down) or be used for local applications when high-resolution spatial data and/or technical facilities are lacking.

By overlaying trends in land degradation indicators with trends in environmental, socio-economic, or land use variables, indicator-assessment tools can be used to determine drivers and pressures of land degradation. Thus, the tools must account for changes in the three global indicators and potentially region-specific indicators (Sims et al., 2021) and consider both natural and anthropogenic drivers and pressures (e.g., biophysical and socio-economic factors). The relation between variables and decreasing or increasing trends mapped by the indicator-assessment tools can be based on a systematic assessment by local experts (e.g., WOCAT-LADA-DESIRE mapping tool) or on statistical analysis in combination with expert judgement (e.g., desertification vulnerability index).

Lastly, indicator-assessment tools can be used for socio-economic analyses that are part of the preliminary assessments of the LDN framework. They can be combined with rapid-appraisal tools (Figure 5.1) to validate and contextualise results and inform evidence-based policy initiatives (e.g., Social Tenure Domain Model). If possible and pertinent, input data and analysis should be gender and age disaggregated.

5.2.2 Forward-looking tools

Forward-looking tools estimate or explore future conditions and the development of either the biophysical aspects of land, the socio-economic context, or a combination of the two (Tamba et al., 2021). Future changes can be forecasted by extrapolating past trends or processes. However, under non-stationary scenarios (e.g., those that involve climatic change, including its impact on vegetation, soil, and other environmental conditions), future trajectories cannot be considered linear and simple forecasting cannot represent likely future projections, making it unsuitable for integrating LDN into ILUP-ILM. Alternatively, assumptions about future trajectories can be used that are based on comparisons with regions that experienced similar stages of development (e.g., the modelling of forest transitions; Newman, McLaren and Wilson, 2018). Forward-looking tools are often used to explore and compare scenarios that result from different interventions, including those for LDN. These scenarios can help to understand the drivers and dynamics of future development and to find the most desirable narrative (Xiang and Clarke, 2003). Tamba et al. (2021) used a stochastic impact evaluation approach to forecast socio-ecological outcomes of interventions to restore a degraded forest landscape in Ethiopia. Such tools could help prioritise interventions using a risk-return analysis of LDN interventions.
A variety of forward-looking tools described in the literature have different thematic focuses, scales, and complexities. For ILUP-ILM, land use or land development models that allow the user to project different land use scenarios are of high interest. Van Soesbergen (2016) groups these land use models as (1) spatially-explicit land use models, which can spatially allocate different land-use types, (2) economic land use models, which focus primarily on the impact of changes in the demand, supply, and trade functions of land-use but are mostly not spatially-explicit, (3) integrated land use models, which commonly combine both, environmental, and economic models and (4) other model types, such as urban growth, agent-based, or machine-learning-based models.

Future scenarios can be co-developed with local stakeholders (e.g., spatial modelling and participatory scenario methodology) (see Box 3.1) using rapid-appraisal and/or process-oriented tools to guide an understanding of landscape characteristics and stakeholder objectives. In this way, the scenarios can better represent socio-economic, cultural, and ecological local conditions.

**Relevance to phases in the ILUP-ILM cycle**

Within the ILUP-ILM planning cycle, forward-looking tools can be used in the visioning phase, where forecasting the behaviour of selected indicators and comparing among different scenarios can help to (1) explore the range of feasible future trajectories; (2) delineate potential areas of conflict between land uses; and (3) help determine necessary actions and their level of impact. In the planning phase, these tools can be used for exploring the impact of concrete policy interventions and to develop timelines for necessary landscape or land use changes.

Furthermore, future projections can estimate reference values for the monitoring phase, helping to determine whether development is following a desired trajectory. Forward-looking tools usually build on data from indicator-assessment and/or rapid-appraisal tools.

**Suitability to support LDN integration**

Forward-looking tools can support countries integrating LDN into planning by forecasting changes in land degradation indicators driven by natural and anthropogenic causes. The tools can forecast outcomes and impacts, including any return on investment of LDN interventions, site prioritization, and matching with ILM options. Scenarios of land degradation development, with or without policy implementation, can reveal the effectiveness and efficiency of policies, the need for additional actions, and the size of unavoidable losses. Simulating future trajectories of indicators can also feed into the monitoring phase. When used to forecast land degradation, forward-looking tools should consider the global indicators of LDN described above (i.e., land cover change, soil organic carbon and net primary productivity) and consider natural and anthropogenic drivers of land degradation.
Forward-looking tools can support planning for neutrality by projecting future land uses following the achievement of no-net-loss of natural capital. Thus, the tools can identify the extent of land degradation (e.g., arising from different scenarios of socio-economic development) and delineate areas for land restoration projects to counterbalance simulated degradation. This can support the planning of concrete actions and highlight conflict areas, where it might be necessary to negotiate with stakeholders, weigh objectives and provide compensation.

Spatially-explicit (or geographic) land use models can simulate future land use patterns that might result from a full implementation of LDN. Commonly, these models are based on demands for land-based commodities, suitability of locations, and constraints (e.g., due to policies or local conditions). Preferably, such models should be able to simulate no-net-loss using a counterbalancing mechanism suitable for supporting LDN integration and determine locally suitable locations for restoration projects. However, this has rarely been the case, with the CLUMondo model being one of such exceptions (see Box 3.1). The difference between land degradation and restoration can be subsequently calculated for different scenarios, assessing if the LDN target is reached following different strategies (e.g., LANDSCAPE model4).

Compensating ‘like-for-like’ is another challenge for geographic land use models, as it increases the complexity of the modelling and the required computational power. So far, no land use model has implemented the counterbalancing mechanism to the full extent envisioned by the LDN framework. Neutrality must be achieved within the same land type to ensure that the neutrality principle is followed. Different strategies could thereby be applied to different land use types.

Other types of land use models are usually less suitable for projecting the LDN indicators or planning for neutrality. This is because they may not be spatially-explicit and, hence, do not reflect local contexts needed for LDN planning. However, they can be used to prepare more detailed land demand and supply scenarios, which can more distinctly capture the impact of different policy interventions (e.g., CGELUC model5). These scenarios can then feed into spatially-explicit land use models or optimisation tools.

5.2.3 Multi-criteria analysis tools
Multi-criteria analysis tools support decision-making in complex situations involving different actors with competing interests and objectives (Mateo, 2012). Multi-criteria analysis tools seek to find the best solution by compromising between different objectives.

4 LANDSCAPE stands for LAND System Cellular Automata. See Appendix C
5 CGELUC (Computable General Equilibrium of Land Use Change) model analyses how the structure of regional land use is influenced by socio-economic factors (Deng, 2011).
Different ultimate and immediate goals of the involved actors are outlined, the options to achieve these are identified, and criteria that can evaluate the performance towards meeting the objectives are defined (Dodgson et al., 2009). The tools also help to structure the problem and to increase the understanding of a conflict. Prioritisation by the involved actors sets the weight for different criteria, facilitating the formulation and ranking of options. Different methods exist for merging criteria and priorities and for ranking options. The advantages, disadvantages and applicability of each of these methods have been widely documented (e.g., Dodgson et al., 2009; Mateo, 2012; Velasquez and Hester, 2013; Ceballos, Lamata and Pelta, 2016).

Relevance to phases in the ILUP-ILM cycle
Multi-criteria analysis tools can support planners in the visioning phase of the ILUP-ILM planning cycle by helping to set medium- and long-term goals for the landscape. Additionally, they can inform the implementation phase, aiding decisions about which actions are most suitable based on local conditions and stakeholder preferences (see Box 3.3).

Suitability to support LDN integration
Multi-criteria analysis tools can support the integration of LDN by structuring and ranking the preferences of stakeholders and facilitating negotiations (see Box 2.1). A multi-stakeholder workshop often precedes and potentially follows a multi-criteria analysis, allowing stakeholders to express their preferences and rank their priorities. Thus, it is important that participants represent the composition of land users and owners in terms of different gender, ages, economic, cultural, and political groups. However, despite a consideration of different stakeholder preferences, it is not uncommon that a decision process solely involves experts and authorities (Gamper and Turcanu, 2007).

Multi-criteria analysis tools can address complex decision problems and address multi-stakeholder negotiations (e.g., Multi-Attribute Utility Theory and its variants). They often combine conflicting preferences in a compensatory way, meaning the non-fulfillment of one criteria does not lead to exclusion and can be compensated by a strong performance in other criteria (Cinelli, Coles and Kirwan, 2014). For some decision problems within ILUP-ILM, a non-compensatory approach might be more suitable (e.g., Outranking tools). Especially in negotiations involving local land-owners with commercial stakeholders and/or governmental decision-makers, non-compensatory methods can be considered

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6 Methods range from simple and intuitive, such as weighted summation or hierarchical assessment of decisions, to more complex and computationally advanced models, such as assessments of ‘distance’ to the ideal solution or hybrid methods, comparing several different ratios and sub-criteria.

7 Importantly, the categorisation of Multi-Attribute Utility Theory and its variants is fuzzy, as they can be regarded as both multi-criteria analysis tools (e.g., Gamper and Turancu, 2007) or optimisation tools (e.g., Briassoulis, 2020).
more just, as strong preferences or aversions of minority groups still significantly affect the outcome.

Next to supporting stakeholder negotiations, multi-criteria analysis tools can be used to assess the degradation risk and what actions are most suitable for restoration. The assessment should include the three global LDN indicators and other potential region-specific indicators. When assessing land degradation likelihood or restoration potential, the weight between variables can be unknown. It is important that selected tools can account for this (e.g., Analytical Hierarchy Process).

5.2.4 Optimisation tools

Optimisation tools, like multi-criteria analysis tools, seek the best solution to problems in complex environments. However, instead of ranking multiple options, these tools solely seek out an optimal solution, disregarding options considered as inferior. These tools work best in instances in which options are unknown or too manifold to be evaluated separately and/or when inferior options are not relevant (Kaim, Cord and Volk, 2018). Often, this is the case when working in agricultural land allocation planning or when assessing trade-offs between different ecosystem services (Peltonen-Sainio et al., 2019). For answering spatially explicit questions, optimisation algorithms are usually coupled with geographic information systems (Greene et al., 2011). Interactive methods, which involve stakeholders during the optimisation process (see Box 3.1), allow for the inclusion and negotiation of stakeholder preferences.

Relevance to stages in the ILUP-ILM cycle

Optimisation tools use mathematical algorithms to find the optimal land use and/or land management solution for a landscape or region. They can support the visioning phase of the ILUP-ILM planning cycle by informing stakeholder negotiations of the impact of different preferences and by providing a range of possible scenarios (see Box 4.1). These tools can also help in the planning phase by finding the best possible solution for land use allocation.

Suitability to support LDN integration

Optimisation tools can address decision problems at wider scales (e.g., at a national level) and be used to find the best solution for the allocation of land resources for achieving neutrality\(^8\). The choice of a tool within this category depends on the level of complexity between land use objectives (e.g., competing demands) and whether an optimal solution can be identified.

\(^8\) Following from the principles of the LDN framework, the location of restoration projects should be planned based on anticipated improvements of the three land-based indicators, as well as within the same land type where degradation occurred.
Optimisation tools can support stakeholder negotiations and highlight the impact of different stakeholder preferences and policies by allocating land use according to different scenarios. Engagement and consultation with stakeholders through workshops or interviews can elicit preferences and priorities for input in the optimisation tools.

5.2.5 Rapid-appraisal tools
Rapid-appraisal tools encompass all participatory tools that collect information on the condition, use, and ownership of land and its socio-economic environment through the involvement of local people (Townsley, 1996). Unlike process-oriented tools, rapid-appraisal tools focus mainly on enabling an outsider to gain information rather than empowering local decision-making (Chambers, 1994). Therefore, rapid-appraisal tools have some similarities with indicator-assessment tools. These tools, however, rely on local knowledge rather than technical measurements or statistical analysis. Information is gathered verbally (e.g., surveys and interviews) or visually (e.g., participatory mapping exercises and photo-elicitation) and, potentially, in a group setting (Campbell, 2002).

Rapid-appraisal tools can be used to derive socio-economic indicators and associated metrics that are not captured by spatially-explicit or census data. Rapid-appraisal tools can be based on context mapping, interviewing and group discussions (e.g., focus groups, locality mapping), questionnaires (e.g., Questionnaire on Sustainable Land Management Technologies), observations (e.g., transect walks) or a combination of these (Campbell, 2002) (see Box 4.3). Crowd-sourcing tools, where participants autonomously enter observations or knowledge in web applications (e.g., Land PKS, LDSF), fall within this category.

Relevance to phases in the ILUP-ILM cycle
Within the ILUP-ILM planning cycle, rapid-appraisal tools can be applied in the assessment phase to determine the biophysical and socio-economic conditions of the land system and the power-influence dynamics among actors. These tools can also help gather information about land tenure agreements and about relevant actors for use in the planning and visioning phases (see Box 2.1). They can help to understand actions that are feasible and reasons behind the success (or failure) of past interventions, and this information can be used in the implementation phase. Additionally, these tools enable sourcing feedback from local stakeholders in the monitoring phase, assessing whether planned actions have initiated the right processes and if development is occurring according to plan.
Suitability for LDN integration
Rapid-appraisal tools enable gathering and incorporating local knowledge on land degradation status and on land development. While they cannot provide quantitative information on the three global LDN indicators directly, these tools can help validate and adjust satellite-derived trends in the LDN indicators via local knowledge and ground truth data (García et al., 2019). Observations by local landholders and communities can provide information about pressures affecting land degradation as well as about actions that have proven successful in avoiding degradation or achieving restoration.

5.2.6 Process-oriented tools
Process-oriented tools are another group of participatory tools. However, instead of simply collecting information as does the rapid-appraisal group of tools, they are used to facilitate negotiation, interaction, and decision-making for the implementation of policy, planning, and management activities to reach desired outcomes (McConney et al., 2008). They empower local people by allowing them to categorise and select suitable activities based on the local resources and needs, often drawn from a “menu” of potential activities developed collaboratively or by an expert (FAO, 1998). These tools facilitate the creation of action plans to fit local conditions and help develop organisational structures that support their implementation and empower local ownership of the processes.

Relevance to phases in the ILUP-ILM cycle
Tools in this group support countries in the implementation phase of the ILUP-ILM cycle by helping negotiate feasible actions to achieve the desired outcomes as well as to plan potential compensations. These tools are particularly useful for mainstreaming and negotiating topics that often remain at the periphery of planning (e.g., land rights and arrangements related to gender, indigenous people, and communities). They can also facilitate knowledge sharing and support local ownership of the outcomes.

Suitability for LDN integration
Process-oriented tools can support the integration of LDN in the ILUP-ILM cycle by facilitating stakeholder negotiations on demands, preferences, and different scenarios of future development (e.g., LADA-Local). Groups representing the variety and composition of stakeholders (e.g., a diversity of gender, economic, cultural, and political groups) should participate in these negotiations, with a special focus on vulnerable communities and landowners or users of vulnerable ecosystems.

These tools can also facilitate knowledge sharing between the different groups involved in planning, fostering local ownership of the results (e.g., RDDST in Box 2.1). Mechanisms such as group discussions are used to negotiate the selection of different objectives and to derive an outcome that is accepted by all (e.g., Participatory scenario analysis). When integrating LDN, these discussions can concern the planning of restoration areas, the
compensation for income lost due to land degradation, or the implementation of restoration projects.

5.2.7 Summary of tools groups to support LDN integration in ILUP-ILM

Figure 5.2 presents a graphic synthesis of how various tool groups can be used to integrate different modules of the LDN framework to particular phases of ILUP-ILM planning cycles. The integration of LDN into the assessment phase of an ILUP-ILM cycle includes determining land degradation status and evaluating the socio-economic environment. For this, indicator-assessment and rapid-appraisal tools are suitable. In the visioning phase, future projections of land degradation and possibilities for restoration are explored using the multi-criteria analysis and forward-looking tool groups. Specific locations and suitable actions for avoiding land degradation and/or undertaking land restoration or land rehabilitation can be considered in the planning phase with support from process-oriented, optimisation, and forward-looking tools. The implementation phase carries out actions negotiated with stakeholders for avoiding, reducing or reversing land degradation. Process-oriented, optimisation, and multi-criteria analysis tools can support this phase. Lastly, in the monitoring phase, indicator-assessment and rapid-appraisal tools can provide evidence about whether development follows the desired trajectories or if actions should be adjusted following adaptive management that characterises ILM.
There is no one-size-fits-all tool among the tool groups. However, some tools combine characteristics of different tool groups and may address different aspects of the ILUP-ILM process. LUP4LDN (Box 5.1) is a promising example of one such tool.

**BOX 5.1. Land Use Planning for Land Degradation Neutrality (LUP4LDN)**

In 2020, the UNCCD’s GEO-LDN initiative launched an international technology innovation competition to develop an open-source tool that will assist land use planning in the context of LDN and support more transparent and well-informed land use decision making. The winning team was led by SCiO, in collaboration with experts in agricultural and sustainable land management (SLM), land preservation and conservation, and capacity building for SLM. The team designed the Land Use Planning for Land Degradation Neutrality (LUP4LDN) tool.

LUP4LDN integrates LDN into participatory land use planning through a user-friendly interface that allows for collaborative development and analysis of land use and land management transition scenarios with a visual representation of impacts and trade-offs. It supports planners “doing the right things in the right
places in the right way” by helping them focus on where land restoration efforts should take place and what SLM interventions they should choose. It allows for a fully participatory process, where key decisions are made by multi-stakeholder discussions (e.g., in a stakeholder workshop, where LUP4LDN can support discussions through responsive charts and maps). Additionally, stakeholders can be invited to participate in the project, whereby LUP4LDN facilitates remote interaction, exchanges of ideas, collaboration, and innovation for LDN.

LUP4LDN addresses the full set of LDN entry points in the ILUP-ILM cycle. Spatially-explicit maps and summary statistics of current and past land degradation can be acquired (Figure B5.1, left). Future land degradation can be anticipated through stakeholder suitability evaluation and expert assessment. The users then select different SLM innovations, as well as the area where they will be applied, to create scenarios of improved land management (Figure B5.1, right). The tool translates user scenarios into LDN scenarios, presenting the impacts of the selected SLM innovations on the three global LDN indicators and visualising trade-offs.

LUP4LDN includes WOCAT’s SLM framework and the Global SLM database to anticipate new land degradation in an innovative and sound way. It also integrates the robust functionalities of well-established tools, such as Trends.Earth and GeOC, and their interoperability. The targeted user groups are policymakers and advisors, (sub)national organisations active in land use planning, land users, and research agencies. It is applicable across the globe to any user-defined geographical or administrative unit.

Other finalists in the competition included the LDN Analytics tool, and the Multi-layered Land-Dynamics Tool (ML-LDT).

FIGURE B5.1. A screenshot of the LUP4LDN interface, presenting maps and summary statistics of current and past land degradation areas (left) and a screenshot of planning SLM innovations and land use transitions with LUP4LDN (right).

Source: https://www.geo-ldn.org/winner
The different characteristics of tools and tool groups determine their suitability—or shortcomings—for their application to specific contexts. Box 5.2 illustrates the challenges and shortcomings that might confront land use planners when using a specific tool group. Some of these challenges can be overcome through the use of a combination of tools or tool groups, as shown in the examples presented in Chapters 3 and 4. Shortcomings and challenges of single tools are included in the overview (Appendix D) and explained briefly in Appendix E. Interoperability between tools might add to the challenges and can worsen with the number of tools used for LDN integration. The tool examples given in Appendix E generally produce output files in commonly used data formats, such as GeoTIFF or data tables. However, harmonisation between spatial resolution and/or definitions might still be necessary and can result in uncertainty and inaccuracy.

Box 5.2: Applicability, challenges, and constraints of ILUP-ILM tool groups

*Indicator-assessment tools*
For indicator-assessment tools, the type, detail, and resolution of input data determine the scale of application. Spatial data, especially when derived through satellite remote sensing, allow for coarser-scale applications at regional to national levels (e.g., Cleland *et al.*, 2017). Data from field measurements or surveys are suitable for large-scale, local-level applications. At local scales, combining indicator-assessment tools with tools of the rapid-appraisal group can be helpful (Wehrmann *et al.*, 2011). The biggest challenges typically faced when using indicator-assessment tools are a shortage of (high resolution) input data, sufficient technical facilities, and human capital (know-how).

*Forward-looking tools*
Forward-looking tools, particularly land-use models, often require expert knowledge for use and interpretation. The scale of application of these tools depends on the complexity of the biophysical and socio-economic system under consideration, the level of detail desired (or required), and the resolution of available input data. Forward-looking tools are often constrained by input data that may be lacking or insufficient. This is especially the case for integrated land use models for which the availability of economic data at different scales can restrict the scale of application and analysis.

*Multi-criteria analysis tools*
Multi-criteria analysis tools are applicable at scales from local to global, depending on the complexity in terms of the number and types of actors, as well as the number of conflicting objectives. A thorough review of the involved actors should always precede the application of multi-criteria analysis tools to ensure a comprehensive inclusion of objectives and perspectives. These tools can be combined with forward-looking or optimisation tools, with the multi-criteria analysis tools providing scenarios or feedback loops. A combination with process-oriented tools can help to structure preliminary stakeholder workshops.

*Optimisation tools*
Application of optimisation tools requires technical know-how and computational facilities. These requirements increase with increasing complexity and resolution. The quality of the results is determined by the algorithm selected and depends on the clarity of problem formulation. These tools can be combined with process-oriented tools to create different spatial scenarios, which can be compared during multi-stakeholder workshops.

*Rapid-appraisal tools*
Rapid-appraisal tools are preferably applied over small areas (local level). However, they can also support larger landscape assessments if used at random locations to validate the results (particularly if used in combination with indicator-assessment tools). Their application might be challenged by a reluctance of stakeholders to participate, by misunderstandings, and miscommunication between locals and external experts, and by biased results due to strict survey framing by the facilitator (Stirling, 2006).

Process-oriented tools
Process-oriented tools are mostly designed for application at a local scale. Successful applications can be influenced by the selection of participants and by the facilitator’s skills. Opinions of different economic, political, and cultural groups, as well as balanced gender and age representation, are determinants of a fair outcome. Challenges are related to incentivising participation, facilitating equal negotiation, navigating power differences, and ensuring that all opinions are considered. Being familiar with the local conditions and with power structures is important prior to the application of these tools.

5.3 Integration of LDN into ILUP-ILM processes: User guidance on selection and application of tools

5.3.1. Considerations underpinning the user guidance
Selecting the tool most suitable for LDN integration within a particular phase of an ILUP-ILM process requires considering the characteristics of the tool groups and the nine key typological elements of a country’s national planning system (see Chapter 3). Tools can either address specific aspects of LDN and support their integration in planning systems, or they can be selected to best support current ILUP-ILM processes. While the previous sections have highlighted the fit of tools within a specific phase of the ILUP-ILM cycle, this section will—within the main stages of LDN integration—indicate how specific characteristics of a planning process may inform the choice of tools.

Figure 5.3 matches five tool characteristics that are most relevant to the nine key elements of national planning systems. These characteristics (or functionalities) that determine a tool’s applicability are as follows: (1) the direction of governance (i.e., does the tool support bottom-up or top-down planning processes?); (2) the scale of decision making (i.e., at what scale can the tool operate?); (3) the level of stakeholder involvement in planning (i.e., can the tool include stakeholder preferences and/or local knowledge?); (4) the consideration of different tenure types (i.e., does the tool account for formal and informal tenure?); and (5) the level of complexity (i.e., can the tool accommodate complex socio-economic, and biophysical systems and interactions?).
FIGURE 5.3. Tool characteristics that are most relevant to the nine key elements of national planning systems (as described in Chapter 3). With the help of this matching scheme, land use planners can assess which tool characteristics fit their land planning systems.

For example, top-down national planning systems with low stakeholder involvement usually require tools applicable at large scales, use spatial and census data as inputs, and identify relationships or interactions based on statistical assessments or expert judgment. Therefore, these planning systems require a suite of tools consisting of, for example, indicator assessment tools in combination with forward-looking and multi-criteria analysis tools. On the other hand, bottom-up and participatory land planning systems in which decision-making occurs more often at regional level are better served by a suite of rapid-appraisal and process-oriented tools combined with forward-looking and optimisation tools that allow for stakeholder involvement.

The following section introduces tools that fit with the nine key elements of national planning systems identified in Chapter 3. For each phase of the ILUP-ILM planning cycle, only those tool characteristics that directly guide their selection are included to simplify the decision matrices. In some cases, specific tools from a larger tool group are suggested when they offer a better fit than others to the specific elements of national planning systems. Some cases are indicative of exemplary combinations of tools to support the integration of LDN in a national planning system. This is because individual tools may only
address specific characteristics while tool combinations provide more integrated and insightful results (e.g., see Appendix F).

5.3.2 Land degradation assessment in the baseline year and monitoring

Indicator-assessment and rapid-appraisal tools can be applied for assessing land degradation in the baseline year selected for LDN integration and for monitoring change in land-based natural capital (Figure 5.4). For all planning systems where land planning and decision making is conducted at national scales, indicator-assessment tools that rely (at least partly) on spatial data are the most suitable because they can assess large geographic or administrative areas. For example, for national, top-down planning systems with low stakeholder involvement, tools such as Trends.Earth or the desertification vulnerability index are suitable as they apply to large areas and are underpinned by general relationships between indicators. On the other hand, on-the-ground assessments by experts are suitable for top-down land planning systems with decision making at regional scales and with low stakeholder involvement. Also, crowd-sourcing and citizen science can be employed for these assessments to facilitate greater involvement of local land users.

Rapid-appraisal tools are generally the most suitable for national planning systems with decision making at regional scales and that seek stakeholder involvement. For example, gender-balanced focus group discussions of land degradation trends or the LADA questionnaire are suitable for national planning systems with regional-scale, bottom-up decision making with high stakeholder involvement, as they commonly capture local characteristics with great detail and can include various types of local knowledge. To

FIGURE 5.4. A decision matrix for selecting a suitable tool for assessing land degradation in the baseline year and for monitoring change. Tools named are examples and representative of tool groups with similar characteristics. They are colour coded according to their tool group (see Figure 5.1).
address national scale planning with bottom-up decision making and high stakeholder involvement, spatial indicator-assessment tools, such as Trends.Earth, can be combined with rapid-appraisal tools, such as transect walks at random locations, to validate and adjust the results of larger scale spatial assessments.

5.3.3 Tools for integrating LDN in the visioning and planning phase of ILUP-ILM

Tools suitable for integrating LDN in the visioning and planning phase of ILUP-ILM can be drawn from the forward-looking or optimisation tool groups and can potentially be applied in combination with tools from the process-oriented or multi-criteria analysis tool groups (Figure 5.5). Forward-looking tools are, therefore, most suitable for top-down planning systems with low levels of complexity and low stakeholder involvement. These are able to address larger scales but usually rely on generalisations. They can be combined with process-oriented tools, such as participatory scenario analysis or multi-criteria analysis tools, to accommodate increased complexity and to facilitate stakeholder involvement. Models such as CLUMondo (see Box 3.1 and Box 5.3) that can simulate the counterbalancing mechanism are suitable for integrating LDN into this phase of ILUP-ILM.

Box 5.3: LDN integration in the CLUMondo land use model

The Conversion of Land Use on Mondial Scale (CLUMondo) model was modified to simulate the no-net-loss of land-based natural capital and to consider LDN principles in Turkey. The project had to resolve the impact on the future land system of achieving LDN while fulfilling demands for food, timber, and shelter.

The CLUMondo model allocated land system changes based on four components (Figure B5.3): (1) demand scenarios for land-based commodities, (2) supply of these commodities per land system, (3) conversion rules due to policies, neighbourhood effects, or restrictions, and (4) land suitability based on biophysical and socio-economic variables. To develop an LDN scenario, no-net-loss of land-based natural capital was included as one of the demands. A land system conversion matrix was added as a functionality of the model, which allowed accounting for the binary, area-based approach of calculating net change in land-based capital. Spatial data was used to establish whether a land system conversion was considered either a loss, gain, or stable change in natural capital. By overlaying the land system map of the initial year with spatial datasets of the three LDN global indicators, average values for each indicator and land system were determined. Values of the initial land system were then compared with the values of the converted land system and losses and gains in natural capital assigned according to the ‘one-out, all-out’ principle of LDN (see Glossary; Orr et al., 2017). This meant a land system conversion was assigned as a loss in natural capital if the average value of one of the three indicators was lower in the converted land system than in the initial one. The ‘like-for-like’ principle of LDN was partly implemented by requiring neutrality in biogeographical regions (equated to ‘land types’). See Schulze et al. (2021) for a more thorough explanation and justification of the method.
Optimisation tools are suitable for use in both bottom-up or top-down planning systems, depending on the chosen tool and set-up. For top-down land planning systems with an associated high degree of planning complexity (i.e., with a wide intersectoral focus and scope) and with high-level stakeholder participation, evolutionary algorithms are suitable optimisation tools that can address complex decision problems involving multiple stakeholders and objectives. These tools can be combined with multi-criteria analysis tools in national-scale decision-making systems to facilitate stakeholder negotiations and to include a better representation of objectives and criteria. For bottom-up planning systems with decision making at regional scales, high stakeholder involvement, and a more complex scope of land use planning, optimisation tools can be combined with process-oriented tools to include local land users and potentially create best- or worst-case scenarios for optimising land use planning accordingly.
5.3.4 Stakeholder negotiation and LDN integration

Tools within the multi-criteria analysis, optimisation, and process-oriented tool groups are useful for stakeholder negotiations and participatory approaches for integrating LDN within ILUP-ILM processes (Figure 5.6). Process-oriented tools are suitable for land planning systems with bottom-up decision making at regional scales and with low levels of land use planning complexity (i.e., narrow, sectoral focus and scope). For planning systems with high levels of land use planning and management complexity (e.g., with competing socio-economic and environmental objectives), these tools can be combined with multi-criteria analysis tools, which allow weighing and ranking the outcomes of process-oriented tools with other competing objectives.

Multi-criteria analysis tools are suitable in almost all land planning systems. In bottom-up planning systems with a variety of land tenure types, these tools should be combined with tools that consider all tenure types, such as the Social Tenure Domain Model (STDM). For top-down decision-making at a national scale, optimisation tools may be deemed more
suitable than multi-criteria analysis tools, as they can better address large-scale, generalised, and abstract decision-making.

Choosing the right data (e.g., gender and age disaggregated data, if possible and pertinent) is important for decision makers integrating LDN in planning systems. Also important are tools that allow for all involved actors to be included and that use fair and equal methods during the process (e.g., in rapid appraisal and process-oriented tools).

3. Stakeholder negotiations for LDN implementation

<table>
<thead>
<tr>
<th>Decision making scale</th>
<th>Complexity of LUP scope and focus</th>
<th>Decision making direction</th>
<th>Different land tenure types</th>
<th>Suitable tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional</td>
<td>High</td>
<td>Bottom-up</td>
<td>Yes</td>
<td>Multi-criteria-analysis + Process-oriented tools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Top-down</td>
<td>No</td>
<td>Multi-criteria-analysis + Process-oriented tools</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Bottom-up</td>
<td>Yes</td>
<td>Multi-criteria-analysis + STDM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Top-down</td>
<td>No</td>
<td>Multi-criteria-analysis tools</td>
</tr>
<tr>
<td>National</td>
<td>High</td>
<td>Bottom-up</td>
<td>Yes</td>
<td>Multi-criteria-analysis + STDM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Top-down</td>
<td>No</td>
<td>Multi-criteria-analysis tools</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Bottom-up</td>
<td>Yes</td>
<td>Multi-criteria-analysis tools</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Top-down</td>
<td>No</td>
<td>Optimization tools</td>
</tr>
</tbody>
</table>

FIGURE 5.6. A decision matrix for selecting a suitable tool for stakeholder negotiations and LDN integration. Tools named are examples and representative of tool groups with similar characteristics. They are colour coded according to their tool group (see Figure 5.1).

Integrating LDN in ILUP-ILM processes offers a pathway for engaging society and minority voices and for considering gender equity and equality. It is essential that significant numbers of women, including local or national women’s organizations, engage in meaningful ways in all stakeholder processes. The integration of LDN into ILUP-ILM processes can explicitly help to navigate social, ecological, and other trade-offs among stakeholders (at societal and actor levels).

Noteworthy is that ILUP-ILM is underpinned by tools that can incorporate gender equity and equality, though there is no warranty that these goals can always be achieved. In
short, both LDN and ILUP-ILM processes share principles of inclusion, equity, and public participation and present opportunities to address equity, equality, and fairness. However, achieving any of these depends on a sound and inclusive implementation of the processes.

5.3.4 Final remarks on tool selection and application for integrating LDN into ILUP-ILM processes

Effective and efficient integration of interventions to achieve LDN within the national planning systems that incorporate ILUP-ILM goes beyond technological solutions. Tools and approaches for land use planning and landscape management are not the solutions, per se. The processes of ILUP-ILM and the diverse human capacity of institutions for selecting multiple tools and models within their socio-political, economic, and ecological contexts drives the quality of implementation. It is not just a matter of choosing the right tool and accessing the best information. Tools and approaches can support processes and should therefore account for the dynamic context of socio-economic development and climate change to better inform and link science and policy.

Attention needs to be given to how best to integrate LDN interventions into existing national or sub-national planning systems for which the use of tools is just a step. Also important is a consideration of the social, political, and cultural contexts in which policymakers’ interpretations are made and are affected by the goals and values embodied in political and economic systems. These contexts include discussions about land degradation, desertification and green growth, the unsustainability of economic policies, infrastructure planning, consumption patterns, and global financial markets.

Policymakers and other stakeholders tasked with the integration of LDN into planning systems and ILUP-ILM processes need to be aware and appreciative of these tools. Furthermore, capacity built within countries for the assessment and use of ILUP and ILM tools is needed along with scientific institutions with the capacity to support ILUP and ILM processes for achieving LDN.
References


https://www.unccd.int/sites/default/files/documents/27072016_The%20ripple%20effect_ENG.pdf


https://www.unccd.int/sites/default/files/relevant-links/2019-09/190906%20UNCCD%20drought%20resilience%20technical%20guideline%20EN.pdf


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Appendix A: Full list of criteria and requirements for LDN implementation

<table>
<thead>
<tr>
<th>Planning phase</th>
<th>LDN Module</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment phase</td>
<td>Module B</td>
<td><strong>Land degradation in the baseline year</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ At least 3 indicators (NPP, SOC, and land cover) are considered for land degradation assessment, potentially in addition to national/regional specific indicators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Indicator values are averaged over 10-15 years before baseline year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Assessment is validated with local knowledge</td>
</tr>
<tr>
<td>Visioning phase</td>
<td>Module A</td>
<td><strong>Recognise ecological functions, increase resilience</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Biophysical and socioeconomic drivers for land degradation are determined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Natural and anthropogenic pressures are identified</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Restoration potential is analysed</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Reinforce responsible and inclusive governance:</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Land tenure rights are identified and accounted for</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Different land-holding/tenure types are considered, including small- or large-scale holders, and none is given preference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Gender and age disaggregated data is used in analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Representatives of different gender, age, and indigenous groups are consulted to include dynamic tenure arrangements, informal governance, and statutory and customary laws</td>
</tr>
<tr>
<td>Planning phase</td>
<td>Module C</td>
<td><strong>Simulating no-net-loss</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Area of anticipated future land losses can be counted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Area of proposed future restoration can be counted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ No-net-loss can be simulated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ No-net-loss simulation is based on at least 3 global indicators</td>
</tr>
<tr>
<td>Implementation phase</td>
<td>Module D</td>
<td><strong>Stakeholder engagement and negotiation</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Stakeholders are identified and characterised</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Multi-stakeholder platforms are used to link scientific assessment with local knowledge and for cross-sector coordination</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Attention is given to including different economic, political, and cultural groups, to women and men participating equally, and to representation by young and indigenous people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Alternative ways of communication and collection of information are relied upon to include illiterate people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Knowledge sharing between technocrats and land users is facilitated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Local ownership of results is ensured</td>
</tr>
<tr>
<td>Monitoring phase</td>
<td>Module E</td>
<td><strong>Monitoring</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Values of at least 3 global indicators are monitored</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Results of indicator monitoring are integrated using the ‘one-out, all-out’ principle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ Results are validated and interpreted with local knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>□ ‘False positives’ can be reported</td>
</tr>
</tbody>
</table>
Appendix B: Current cross-cutting thematic issues that policy makers can address through ILUP-ILM

Land use and landscape management decisions in support of LDN targets are not made in isolation. Rather, they happen against the backdrop of other current challenges with social, environmental, and economic implications, which likewise require integrated approaches.

Five major cross-cutting thematic issues for which land health is central are the subjects of requests from Country Parties for better insights into how these issues can be addressed with ILUP-ILM. These issues are (1) building back better in the COVID-19 era, (2) sand and dust storm source mitigation, (3) the food, energy, and nature trilemma, (4) strengthening urban-rural socio-ecological systems, and (5) increasing drought resilience. In reality, each theme represents a complex socio-ecological issue in itself and, at the same time, is interrelated with other themes. Thus, by tackling one issue, other issues are often simultaneously addressed.

Building back better in the COVID-19 era

The Covid-19 pandemic is not only a health crisis but a social and environmental crisis as well. Its impact has put the spotlight on the intricate interconnections between animal health, human health, and ecosystem health. It is well known that land use and land use change play a key role in the emergence and spread of zoonotic diseases. An estimated 30% of emerging infectious disease events, for example, have been attributable to land use change, agricultural expansion, and urbanization since 1960 (IBPES, 2020). Land use and land use change are also important to building resilience to disease shocks and mitigating their socio-economic impacts (UNCCD, 2020; Anseeuw and Baldinelli, 2020).

Encroachment of agricultural activities and developed land into natural habitats expands the wildlife-human interface and increases the risks of disease transmission from wildlife to domestic animals and humans. Land degradation, by rendering formerly productive land unproductive, creates the need to clear new lands to ensure food security. Taking new lands under the plough not only increases habitat fragmentation and promotes interaction among pathogens, wildlife, and humans, but it also decimates biodiversity and carbon sequestration potential. Mitigating global health challenges, therefore, requires collaboration across all domains to navigate trade-offs between disease risk, loss of livelihoods, and food security, and ecosystem health.

Until now, the approach of dealing with zoonotic infectious diseases has been one of reacting to them rather than preventing them. Pursuing LDN plays a central role in building back better in the COVID-19 era and beyond, with a more prevention-oriented approach. LDN simultaneously (1) reduces the need for expanding human activities into natural habitat by restoring degraded land and avoiding degradation in the first place, and (2) helps build resilience to the
socioeconomic impacts of disease by creating local economic opportunities, decreasing dependence on costly food imports, and fostering equitable access to land. The ILUP-ILM continuum is the vehicle by which LDN can be delivered in conjunction with climate and biodiversity goals.

Sand and dust storm source mitigation
Sand and dust storms not only play an important role in global biogeochemical processes, but also present threats to environmental and economic sustainability by causing damage to crops, soils, infrastructure, livestock, and human health (Middleton and Kang, 2017). Land use changes and climate change have increased the frequency and intensity of sand and dust storms (UNEP, WMO, UNCCD, 2016), prompting the establishment of a UN Coalition on Combatting Sand and Dust Storms to prepare a global response to this multi-faceted and transboundary issue (Decision 31/COP.13). Although the majority of sand and dust storm sources are natural, dust emissions have increased by 25-50% since 1900 due to human activity. Agriculture, water diversion and deforestation are estimated to generate a quarter of global dust (Shepherd, 2017).

Source mitigation of sand and dust storms requires strategies aimed at reducing wind speed, sand, and dust mobilization across different landscape components, including croplands, rangelands, dune fields, and mining operations. These strategies of reducing sources of anthropogenic dust and sand at a landscape scale simultaneously contribute to LDN, climate change adaptation and mitigation, and the conservation of biological diversity. In addition to land use and management-based strategies, sustainable water management strategies are necessary for preventing the excessive diversion of water from dryland rivers that has resulted in dried up lake beds as major dust sources, such as the Aral Sea and Lake Chad. ILUP and ILM are critical for implementing a cohesive sand and dust storm mitigation approach (Middleton and Kang, 2017). Lessons learned from the Great Green Wall initiatives in both China (Box 4.5) and West Africa suggest that greatest success can be achieved by combining a regional-scale approach with a focus on adaptation of interventions to local conditions, such as in the choice of indigenous tree species that are familiar to and appreciated by local residents (Shepherd, 2017).

The food, energy, and nature trilemma
A trilemma describes a situation in which three goals relate to each other in such a way that reaching any two of them precludes achieving the third (Vik, 2020). Among many land uses competing for the same limited resources, food production, energy production, and nature (biodiversity conservation and climate change mitigation) are three that occupy large areas and are responsible for many of the dynamics affecting global land cover change. While the cultivation of biofuels has been motivated by the need to curb carbon dioxide emissions resulting
from fossil fuels, sometimes clearing land of its native vegetation to make space for biofuel crops has turned out to be most profitable in the short term, counteracting the goal of nature conservation and often releasing greenhouse gases into the atmosphere in the process of burning or decomposing biomass. In other cases, biofuel crops have left native ecosystems intact but displaced food crops, leading to clearing of land for food production elsewhere to make up for the lost food production (Tilman et al., 2009). On the other hand, prioritizing nature conservation has often made it simultaneously difficult to meet food and energy needs.

Acknowledging the interdependent relationships between food, energy, and nature are best addressed using a nexus approach that helps exploit synergies and navigate trade-offs (Box 3.1). The ILUP-ILM continuum is the most appropriate vehicle for implementing such an approach, as it is by definition integrative and encompasses the landscape as a whole. Holistic planning and management help achieve the most beneficial configuration of land use in a landscape to meet the demands of both food and energy, while also contributing to LDN: For example, crop residues and sustainable harvest of wood and other forest residues provide an energy resource without the need for entirely clearing native ecosystems. Cultivating bioenergy crops, which often have very low nutritional demands, can be used as restoration crops on degraded lands, producing energy without compromising food crops and, at the same time, contributing to LDN (Rahman and Baral, 2020).

Strengthening urban-rural socio-ecological systems

Regional development is a geographically uneven process, leading to spatial disparities. Globalization has disproportionately benefitted urban in comparison with rural areas (Hatcher, 2017). The pull factor of economic opportunities, together with push factors of land degradation and climate change disproportionally affecting livelihoods in rural areas, has encouraged rural-urban migration, which in turn exacerbates spatial disparities. At the same time, the divide between traditionally urban and traditionally rural practices is diminishing: rural households increasingly rely on non-farming employment and urban agriculture can play an important role in the food security of urban households. Much growth, development, and land use transformation happen in the peri-urban space, where urban and rural features co-exist (Egal and Foster, 2020).

The interlinkages and co-dependencies between urban and rural areas call for integrated approaches to planning and development that identify rural-urban synergies rather than treat rural and urban areas as distinct and isolated from one another (Sietchiping et al., 2019). A major shared challenge—and opportunity—for rural and urban areas is providing food security while safeguarding environmental resources (Box 4.4). In the context of planned and unplanned urban growth and loss of productive land, the LDN framework offers a mechanism to counterbalance expected losses of productive land with the restoration of already degraded areas. In particular,
the peri-urban space, where the built-up area has not yet reached a high density, could benefit from restoration in the form of afforestation, revegetation, public parks, and urban agriculture. ILUP that emphasizes rural-urban linkages, strengthens peri-urban areas, and fosters small and medium-sized towns can lead to a more balanced development between rural and urban areas, while at the same time promoting LDN (Piesik, 2019).

Increasing drought resilience

Drought is a complex, creeping natural hazard with significant socio-economic and environmental impacts. Droughts account for more human and livestock deaths and displaces more people than any other natural disaster. While droughts can occur in every climate zone, drylands are particularly susceptible to severe impacts. Climate change is likely to increase the frequency and severity of droughts and water shortages in most dry subtropical regions of the world (IPCC, 2014).

Traditionally, droughts have been addressed through a reactive crisis management response that primarily deals with the symptoms of an already unfolding disaster. Acknowledging the inefficiency of this traditional approach in avoiding large-scale loss and damages, a paradigm shift has taken place towards promoting a proactive approach that focuses on building drought resilience across an entire socio-ecological system. This proactive preparedness approach rests on principles and operating guidelines that were developed through a series of high-level meetings since 2013 and eventually resulted in the Drought Resilience, Adaptation and Management Policy (DRAMP) framework (Crossman, 2018). DRAMP is an integrated framework for strengthening ecological, economic, and social systems against severe impacts of drought. It is composed of three important pillars: (1) monitoring and early warning, (2) vulnerability and risk assessment, and (3) drought risk mitigation measures.

The latter is centered on improved management of land and water resources in line with approaches promoted by the LDN framework. Suggested interventions include water harvesting, restoring pastures, recovering the water holding capacity of soils through tree planting, enhancing irrigation schemes, diversifying rural livelihoods, shifting to drought tolerant crops, crop insurance, managing livestock production within the landscape, among others. Rather than locally isolated, these interventions have to be coordinated and implemented at landscape scales for maximum impact, aligning with the scale of implementation of the neutrality mechanism. Because drought impacts and resilience interventions affect multiple sectors—e.g., land, water, energy, environment, and agriculture—ILUP and ILM provide the most suitable vehicle for anchoring a proactive drought preparedness approach (UNCCD, 2016a) (Box 4.1, Box 4.3).
Appendix C: Detailed description of tool examples mentioned in the text regarding their properties and suitability for the integration of LDN

**Indicator-assessment tool examples**

The **Trends.Earth** tool (available at: [http://trends.earth](http://trends.earth)) combines available data sources, algorithms and GIS tools in one user-friendly package, thereby creating a consistent workflow that improves comparability between regions and makes the assessment of land degradation easier and more readily available. By default, the assessment is based on freely available global raster data on the three LDN indicators, which users can update with custom regional datasets. Local knowledge can be integrated by adjusting the input matrix for land cover conversion or by uploading modified input raster layers for any of three indicators. Trends of indicator values before the baseline year can be assessed based on historic data available for at least the past 20 years. Additional national- or region-specific indicators cannot currently be included, as only a maximum of three indicators can be considered. Since the option to load custom data is already implemented, a modification of the tool could include more than three indicators. The tool can support monitoring of land degradation through repetition of assessment, if future satellite data will allow comparison. Theoretically, the tool is applicable on all scales, from global to local. However, for small scale applications, it is advisable to use region specific data with higher resolution to achieve higher accuracy. The tool is open-source and works in an open-access GIS environment (i.e., QGIS and Google Earth Engine). It requires some knowledge on spatial data and mapping, but usage is supported by a step-by-step guide (Yengoh et al., 2018). Next to land degradation status assessment and monitoring, the outputs of this tool can furthermore be used to estimate drivers and pressure factors of degradation, by overlaying negative trends in the indicators with spatial time series data on potential drivers (e.g., land use, population, or deforestation rates). Alternatively, negative trends can be evaluated by local experts through combination with rapid-rural-appraisal tools.

**Visual soil or vegetation guides** (see, for example, Ball et al., 2017; Shepherd et al., 2008) can support expert judgement for a quick assessment on the condition on land, but experience is needed to get reliable results. This tool produces visually estimated rather than measured quantitative indicators. It can support identifying degradation trends and areas affected by soil erosion. Including data from 10-15 years before the baseline year, as recommended by the LDN framework, is not feasible. As assessment can be subjective, current and future assessments should be conducted by the same expert or expert team to ensure comparability of assessment. The tool is applicable at local scales, but its quick application supports assessments of larger areas compared to measurements in the field.

The **siting tool** combines spatial assessment with field measurements. In this tool, a desk study of a range of indicators helps to identify the optimal location of sampling sites or the location of sensitive areas (ESRD, 2012). To be suitable for LDN, the desk study can use spatial data on the global indicators to determine, for example, areas that show larger changes over the last years (‘hotspots of change’), which would be visited to validate the spatial assessment and to identify the underlying drivers and pressure factors for degradation. The tool can assess the development of the indicators over time, but average values would solely rely on the spatial assessment and cannot be validated by site visits. Similarly, the tool is unsuitable for monitoring, as the sites for visitation would change over time (as only priority areas should be visited). The tool can be applied on larger scales, due to the use of spatial data, but the landscapes to be assessed should be stratified by land types or by agro-ecological zones prior to assessment to ensure that site visits are representative within the larger area.
The **WOCAT-LADA-DESIRE mapping tool** combines spatial mapping of land use systems and land degradation with assessment by national specialists on the underlying biophysical and socio-economic drivers using a questionnaire (Liniger et al., 2008). The land degradation indicators are thereby assessed based on metrics, such as yields for productivity. Additional analysis is needed for the soil organic carbon indicator, as here metrics are less informative (Liniger, Harari, et al., 2019). The tool is especially useful for determining drivers, pressure factors, and suitable actions to avoid or counterbalance degradation.

The environmental sensitivity index estimates the extent of a nation’s environment that is vulnerable to damage and degradation (Kaly et al., 1999). The index is divided into separate sub-indices, including a **desertification vulnerability index**. As a calculation of the index is rather simple, it can be easily transferred into a GIS environment (see, for example, Santini et al., 2010). In the scientific literature, spatial-explicit desertification vulnerability has been determined for several countries and globally (see, for example, Huang et al., 2020). Spatial data, for example on climate and soil conditions, is combined with census data for socio-economic variables and partly expert judgement. In the literature, the original simple ranking and averaging of indicators is often advanced by statistical models that distinguish the impacts of different indicators (see, for example, Gül and Erşahin, 2019; Wu et al., 2019). The index can be used to identify drivers and pressure factors for degradation, as well as for assessments of the socio-economic environment. Disaggregation of gender and age in population data has so far not been implemented, but it should be wherever feasible and suitable. As the index relies partly on expert judgement, relationships between different variables become more general and accuracy decreases with increasing scale. Therefore, this index is better suited for local to national scale applications, although it can be based on global datasets and larger scale calculations are technically possible.

The **Social Tenure Domain Model** aims to include the whole continuum of different land tenure types, building on satellite and spatial data on formal land titling combined with on-the-ground land surveys (Lemmen, 2018). For LDN, it can be used for preliminary assessments of land tenure, which can guide stakeholder identification and can be relevant when planning concrete actions and the location of restoration areas.

**Forward-looking tool examples**

Generally, **USLE or RUSLE** (Revised Universal Soil Loss Equation) are the most commonly applied erosion models, as they require somewhat limited data input and are not region-specific. However, more data intensive and less universal models, such as **PESERA** (Pan European Soil Erosion Risk Assessment), may provide more accurate spatial and temporal erosion simulations.

The **CLUMondo model** allocates future land use based on demand and supply scenarios, local suitability preference, and constraints (Van Asselen and Verburg, 2013). It is the only land use model that has been used to simulate land use patterns as a result of the no-net-loss mechanism, based on the three global indicators (Schulze, Malek and Verburg, 2021). Average values of SOC, NPP, and land cover are thereby assigned to different land systems. While land use change has a substantial impact on the indicators (see for example Deng et al., 2016), ignoring local characteristics, such as terrain or soil types that can drive degradation, results in simplified projections of future land degradation. Counterbalancing ‘like-for-like’ is partly implemented within biogeographical regions, instead of land type. The model currently lacks the computational power to include more than three regions, which should be updated in the future. The model is open access and has been applied at global (e.g., Wolff et al., 2020) to local scales (e.g., Zhu et al., 2020).
The LAND System Cellular Automata model for Potential Effects (LANDSCAPE) is based on a hierarchical allocation strategy and resistances of land use. It distinguishes between active land uses, which are a direct result from human demands, and passive land uses, which are driven by changes in active land uses (Ke et al., 2017). Different land use types have different measures of ‘aggressiveness’ which determine at which stage in the hierarchy they are allocated in their most suitable locations (e.g., urban is often the most ‘aggressive’ and would be allocated first in the most suitable location, disregarding suitability of other land uses in the same location). The main advantage of the model is its capability to simulate cascading processes of land-use change in which one process initiates another. It has been used for optimizing land use to balance cropland protection policies, whereby losses of ecological land were reduced (Wang et al., 2021). A similar approach can be applied for the implementation of LDN, by comparing different strategies to achieve LDN and identifying the most suitable future pathway.

The CGELUC model is based on the Computable General Equilibrium framework and analyses how the structure of regional land use is influenced by socioeconomic factors, such as the industrial structure, trade environment, economic policies, and institutional arrangements in an equilibrium economic system (Deng, 2011). The model can be used to simulate principles of structural changes in regional land use, due to constraints and influences at the policy level and including consumer and government behavior. This can support an understanding of relationships between economic variables and changes in the area of cultivated, economic forest, and pasture lands. The model is applicable to all scales. The parameters of a Social Accounting Matrix need to be prepared before model operation.

Multi-criteria analysis tool examples
The Analytical Hierarchy Process tool is the most commonly applied tool for multi-criteria analysis, especially for decisions on natural resource management with stakeholder involvement (Velasquez and Hester, 2013; Cegan et al., 2017). With the help of pairwise comparisons, the tool supports the identification of the best alternative and of the relative importance of the different criteria, which are assumed to be not known to the decision maker (Greene et al., 2011). Criteria and sub-criteria can thereby be incommensurable and multi-dimensional (Wagner and de Vries, 2019). The tool has been used, for example, to identify the most suitable land management options to satisfy stakeholder objectives (Ananda and Herath, 2003) and to identify goals of different stakeholders and define incentives for compliance to protected areas (Guaita Martínez et al., 2019). In a spatial context, the tool has been applied in land suitability and capability assessments by determining the weight of different criteria, such as soil conditions, topography, land use classes, and protected area locations (Yalew et al., 2016). Additionally, it has been used within a modeling framework to determine the weight of land degradation factors (Wang et al., 2006), also in combination with RUSLE (Ewunetu, Simane and Teferi, 2021). By adopting these spatial methods, the tool can support the implementation of LDN by analyzing land degradation risk and restoration potential. Additionally, it can be used in combination with forward-looking tools to compare different future alternatives and choose the most desirable pathway and the appropriate policy implementations (Palafox-Alcantar, Hunt and Rogers, 2020). Due to the pair-wise comparison, the tool is somewhat time consuming compared to other multi-criteria analysis tools and is therefore best suited for local scale or expert-based desk analysis. Situations that involve more complexity, for example due to many different stakeholders and (sub-)criteria or a larger scale, are better suited for other multi-criteria analysis tools.

Multi-Attribute Utility Theory and its variants comprise another commonly used multi-criteria analysis tool set that is more applicable to decision problems with many criteria and/or stakeholders and that takes
uncertainty into account (Konidari and Mavrakis, 2006; Velasquez and Hester, 2013; Cegan et al., 2017). With this tool set, a score for each alternative is derived through weighing and summing normalized criteria values (Greene et al., 2011). It is data-intensive, and weights for each criteria are assigned by the decision maker, making the application somewhat subjective (Velasquez and Hester, 2013). To decrease subjectivity, the tools can be combined with the analytical hierarchy process to preliminarily determine weights of different criteria, as has been done for analyzing synergies and trade-offs of climate policies (Konidari and Mavrakis, 2006). Similarly, the tools could be used to seek for synergies with already existing policies, when implementing LDN. Furthermore, the tools have been combined with spatial analysis to determine pollution vulnerability, combining expert and local assessment (Zabeo et al., 2011). A similar approach could be applied in the LDN status assessment.

Outranking tools (which groups PROMETHEE and ELECTRE) also use pairwise comparison, but of alternatives (Uhde et al., 2015). The number of alternatives or actions is thereby known and discrete (Greene et al., 2011). Criteria importance is defined subjectively by stakeholders and the performance of each alternative is determined by objectively measured attributes for each criterion (Buchanan and Sheppard, 1998). Stakeholders then pair-wise compare alternatives by their performance along the criteria and assign strong preference, weak preference, or indifference (Bisdorff et al., 2015). Each alternative then receives an index of concordance (i.e., the number of “as good as” relations) and discordance (i.e., the number of “worse than” relations). The best alternative is chosen based on concordance and discordance thresholds. The tool is thereby especially applicable to situations with more than one decision maker and when certain criteria are very important only to some (Munda, 2016). The tool has been applied to find suitable actions for land degradation response (Metchebon Takougang et al., 2015) and de-desertification (Sadeghiravesh, Zehtabian and Khosravi, 2014), as well as to determine, which drivers of land degradation are most important and need to be addressed by policies (Akbari et al., 2020). When planning for LDN, the tool can be used to identify suitable actions for avoiding land degradation or planning for restoration. A multi-stakeholder workshop can thereby determine the available actions potentially in combination with a preliminary assessment of drivers and pressure factors. Performance can be measured through analyzing historical trends or forecasting future trajectories of LDN’s land degradation indicators and/or erosion models.

Optimization tool examples
For top-down land planning systems with low complexity, simple hierarchical tools can be applied, whereby a suitability analysis first evaluates where land uses can occur and where land uses conflict (i.e., locations that are suitable for more than one land use type) and then a priority ranked allocation determines where the land use with the highest priority is allocated first in areas of conflict until the land demand is met (Chen et al., 2015). For LDN, these tools could be used to determine the most suitable areas for restoration, while avoiding conflict with other uses.

The goal programming tool aims to find a solution in a satisfactory distance to a predefined optimal solution, and, if applicable, to a pessimal (worst) case (Guaita Martinez et al., 2019). The decision-maker defines at which distance to the optimal (and potentially pessimal) solution the compromise alternative is deemed satisfactory, which can differ by criteria if weights are assigned (weighted goal programming; Colapinto, Jayaraman and Marsiglio, 2017). It is often applied for finding the best allocation of resources, including land, in situations with conflicting demands and preferences. The tool has been used for determining the optimal distribution of land uses and management practices to minimize soil erosion and address social, economic, and environmental interests (Cisneros et al., 2011), which can be similarly
applied in the implementation of LDN for finding the most suitable locations and practices for avoiding and counterbalancing degradation. Additionally, it has been used for determining optimal allocation of employment and monetary resources to achieve sustainable development goals in India and Canada (Gupta, Fügenschuh and Ali, 2018; Nechi, Aouni and Mrabet, 2020) which could be adjusted by including land resources and focusing on LDN specifically. For implementation of LDN, the optimal outcome includes avoidance of new degradation as much as possible, restoring unavoidable degradation, and meeting local stakeholder preferences and needs. The latter should be compiled in a stakeholder workshop, which would also serve to negotiate best- and worst-case scenarios, as well as suitable criteria and their optimal/pessimal values. The land degradation avoidance and neutrality criteria can be based on the current state of the land degradation indicators using trend analysis or forecasting models to understand what impact different actions might have.

**Evolutionary algorithms** (including genetic algorithms) start with an initial set of solutions or land use plans from which a next generation of solution evolves through selection, crossover, and mutation (Kaim, Cord and Volk, 2018). An evaluation criterion or a maximum number of generations determines when the process stops (Yao et al., 2019). The tools are best suited to situations in which no single optimal solution exists, making them thereby especially suitable to more complex land use allocation problems and when the aim is to improve existing solutions/land use plans, for example by implementing LDN.

The **Restoration Opportunities Optimization Tool** (Beatty et al., 2018) is a user-friendly, open-access optimization tool that can be used for planning restoration projects to achieve benefits for several ecosystem services, while including objectives of beneficiaries and land use change constraints. For LDN implementation, it can be used to identify potential restoration areas and analyze their impact. Spatial data on the land degradation indicators (potentially combined to fulfill the ‘one-out, all-out’ requirement) could be included as ecosystem service maps and one of the targets could be to counterbalance anticipated degradation. Preferably, the tool would be updated to include no-net-loss by calculating future land degradation itself and updating the restoration area target.

**Rapid-appraisal tool examples**

The **Questionnaire on Sustainable Land Management Technologies** is a surveying tool and database to gather information on available land management technologies and how to implement them (Liniger Schwilch, et al., 2019). Interviews are conducted with land users on existing technologies to assess their applicability, socio-economic, ecological, and sociocultural impact, as well as inputs and costs. Furthermore, information is gathered on the natural and human environment. The results are collected in a database that can be used by land planners to adapt suitable technologies.

**Transect walks** is a similar tool whereby experts together with local representatives walk along a certain area (Wehrmann et al., 2011). Information on the landscape and land profile that are observed during the walk are documented on a map. The tool can be used to map areas of unfertile soil and land degradation with the help of local knowledge. Local knowledge can furthermore help to identify drivers of land degradation.

During **locality mapping**, stakeholders, either individually or in a group, draw a map of the discussed geographic unit, containing the boundaries and important features, such as roads, rivers, towns and property boundaries (Wehrmann et al., 2011). Post-its, local materials, and three-dimensional objects can be used to add information, depending on the aim of the mapping. The resulting maps are compared and through discussion and negotiation, the final map will be adjusted until all participants are satisfied with
the result. **Context and community mapping** is similar to locality mapping but starts with expert mapping of land cover, including key land uses, based on interpretation of aerial imagery of the focal area and its surrounding. During community mapping sessions, local farmers are then asked to mark points of interest on the satellite images and land cover/use maps, including land holdings or socially and culturally important areas and areas of conflict (Milder et al., 2013). The **Fit-For-Purpose Land Administration framework** uses a similar methodology (Enemark, McLaren and Lemmen, 2016). These participatory mapping tools can be used to outline land tenure rights and culturally important locations.

**Focus groups** are another tool to compile local knowledge on land degradation status and drivers. They can be supported by visual representation of trends of land degradation indicators, e.g. using a timeline or matrix (Wehrmann et al., 2011).

The **Land potential knowledge system (LandPKS)** is a web-based decision support tool that evaluates land through a combination of geospatial data on soil, terrain, and climate with local knowledge through crowdsourcing (Herrick et al., 2013). Users can take soil pictures and upload them to a cloud storage, which allows for cross comparison and on-site analysis.

**Process-oriented tool examples**

The **LADA Local Assessment tool** combines transect walks with focus group discussions, livelihood interviews, and biophysical assessments to negotiate with local stakeholders responses to land degradation and plans for sustainable development (Bunning, McDonagh and Rioux, 2016)

The **Resilience Diagnostic and Decision Support Tool**, part of the Stakeholder Approach to Risk Informed and Evidence Based Decision Making, compiles spatial and census data on social, economic, and biophysical parameters. The tool uses a dashboard to visualize and facilitate stakeholder-scientists communication and inclusive negotiation.

**Participatory scenario analysis** (Boedhijartono, 2012) is a visualization technique in which different potential scenarios, such as worst and best cases, are explored and negotiated in a group setting. This involves identification of the current situation, driving forces for change, assessing implications of different scenarios and to negotiate a common ground between different groups of people. Another version is smart-mapping in which alternative scenarios are created using images on a computer. By updating the maps, changes can be monitored over time.

**References**


Liniger, H., Schwilch, G. et al. (2019). Questionnaire on Sustainable Land Management (SLM) Technologies. Bern, Switzerland.


Appendix D: Overview of tool examples reviewed as part of this report

x means the tool supports the implementation of LDN at the respective entry point, while (x) means the tool offers partial support.

*Scale: All = No scale restriction, G = Global, R = Regional, N = National, L = Local

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## Characteristics for planning systems

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<th>Bottom-up or top-down</th>
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<td>Tool group Name</td>
<td>Characteristics for planning systems</td>
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<td>Scale*</td>
<td>Stakeholder involvement</td>
<td>Bottom-up or top-down</td>
<td>Different tenure types</td>
<td>Captures complex systems</td>
<td>Drivers and pressure factors</td>
<td>Land degradation status</td>
<td>Land degradation projection</td>
<td>No-net-loss mechanism</td>
<td>Socio-economic environment</td>
<td>Stakeholder negotiations</td>
<td>Suitability/impact of actions</td>
<td>Knowledge exchange</td>
<td>Monitoring</td>
<td>Open access</td>
<td>Open source</td>
<td>Input data provided</td>
<td>Computer facilities necessary</td>
<td>Spatial data required</td>
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Appendix E: Review of tool examples, including a short description, their applicability to LDN, shortcomings and/or potential challenges for their use, and examples of local applications

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<tr>
<th>Name</th>
<th>Description</th>
<th>Applicability to LDN</th>
<th>Shortcomings and potential challenges</th>
<th>Application examples</th>
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<tbody>
<tr>
<td>Trends.Earth</td>
<td>Software tool embedded in QGIS &lt;br&gt; Developed to track the SDG 15.3.1 indicator and monitor the effectiveness of individual SLM projects to avoid or reduce degradation &lt;br&gt; Uses as default global data on 3 LDN indicators &lt;br&gt; Possible to update with higher resolution national/regional data and change direction</td>
<td>Assesses land degradation status based on the 3 global indicators and by averaging values from 10-15 years prior to the baseline &lt;br&gt; Determines locations with declining or inclining trends and identify drivers behind decline/incline</td>
<td>Not possible to include additional local indicators &lt;br&gt; Computer facilities needed &lt;br&gt; Small scale applications potentially require higher resolution maps of the area &lt;br&gt; QGIS skills needed</td>
<td>Argentina&lt;sup&gt;2&lt;/sup&gt; &lt;br&gt; Madagascar&lt;sup&gt;3&lt;/sup&gt; &lt;br&gt; Namibia&lt;sup&gt;4&lt;/sup&gt; &lt;br&gt; South Africa&lt;sup&gt;5&lt;/sup&gt; &lt;br&gt; Global&lt;sup&gt;6&lt;/sup&gt;</td>
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<tr>
<td>WOCAT-LADA-DESIRE mapping tool&lt;sup&gt;7,8&lt;/sup&gt;</td>
<td>Guidelines and questionnaire to combine spatial mapping of land use and degradation with expert assessments &lt;br&gt; Provides guidance of land use mapping in a GIS environment</td>
<td>Facilitates assessment of land degradation status and drivers by local specialists through a questionnaire &lt;br&gt; Possible to assess change in LDN indicators based on metrics, such as yield for productivity</td>
<td>For SOC, used metrics might be less informative&lt;sup&gt;3&lt;/sup&gt; &lt;br&gt; Computer facilities required &lt;br&gt; GIS skills required &lt;br&gt; Spatial data or satellite images needed &lt;br&gt; Local knowledge/experts needed</td>
<td>Argentina&lt;sup&gt;3&lt;/sup&gt;</td>
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<td>Social Tenure Domain Model&lt;sup&gt;9,10&lt;/sup&gt;</td>
<td>Software tool embedded in QGIS, part of the Fit-For-Purpose land administration framework&lt;sup&gt;11&lt;/sup&gt; &lt;br&gt; Supports inventorying land tenure types of all kinds, covering the whole continuum (i.e., informal to formal land rights) &lt;br&gt; Combines satellite and spatial data on formal land titling with on-the-ground surveys &lt;br&gt; During on-ground-data collection, local tenure holders draw land tenure on high resolution satellite images (either on paper or with digital pen) &lt;br&gt; Digitization of images by scanning and vectorising &lt;br&gt; Creation of entry in database for each land tenure holder, which is connected to spatial features</td>
<td>Identifies stakeholders and land owners/users &lt;br&gt; Supports LDN implementation by planning together with land tenure holders and selecting suitable measures for achieving LDN while considering local needs and practices</td>
<td>Computer facilities required &lt;br&gt; QGIS and some PostGIS, PostgreSQL skills needed &lt;br&gt; Up-to-date high resolution satellite imagery needed &lt;br&gt; Capacity building beforehand needed &lt;br&gt; Applicable only to local scales</td>
<td>Colombia, Congo DR, Iraq, Malawi, Namibia, Nepal, Philippines, Saint Lucia, Saint Vincent, Zambia&lt;sup&gt;12&lt;/sup&gt; &lt;br&gt; Kenya&lt;sup&gt;10,12&lt;/sup&gt; &lt;br&gt; Uganda&lt;sup&gt;12,13&lt;/sup&gt;</td>
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<td>Desertification Vulnerability Index&lt;sup&gt;14&lt;/sup&gt;</td>
<td>• Part of Environmental Sensitivity Index • Calculates risk of desertification either for total area or spatially explicit based on spatial data • Includes environmental (e.g., climate, soil, land use) &amp; socio-economic data • Biophysical and socioeconomic sub-indices</td>
<td>• Indicates areas at risk for degradation, where careful monitoring and actions are needed to avoid or reduce degradation • Indicates which drivers and pressure factors cause degradation – including natural and anthropogenic</td>
<td>• Does not include the 3 LDN indicators • Computer facilities required • Spatial and/or census input data needed • GIS skills required for spatially explicit analysis • Often requires expert assumptions</td>
<td>China: SASDI&lt;sup&gt;15&lt;/sup&gt; India&lt;sup&gt;16&lt;/sup&gt; Italy&lt;sup&gt;17,18&lt;/sup&gt; Turkey: DIS4ME&lt;sup&gt;19&lt;/sup&gt; Global&lt;sup&gt;20&lt;/sup&gt;</td>
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<td>Composite Land Degradation Index&lt;sup&gt;21&lt;/sup&gt;</td>
<td>• Method to determine land degradation type, extent and degree, as well as drivers • Combines existing (spatial) data with field observations &amp; checks • Delineates field zones with similar physical characteristics, type of land use and degradation type • Can include spatial data on the 3 LDN indicators • Final index is sum of degree and extent ranking for each field zone polygon</td>
<td>• Assesses land degradation status with the possibility to include the 3 global indicators, plus national/region specific indicators • Differentiates between types of degradation, which can ease finding suitable actions • Identifies drivers for degradation</td>
<td>• Computer facilities required • GIS skills required • Spatial and/or census input data needed • Field measurement skills and local knowledge required • If stakeholder workshop is included, facilitator training needed • Time consuming</td>
<td>Botswana&lt;sup&gt;22&lt;/sup&gt; Lebanon&lt;sup&gt;23&lt;/sup&gt; Togo&lt;sup&gt;21&lt;/sup&gt;</td>
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<td>Visual soil or vegetation assessment guides&lt;sup&gt;24-26&lt;/sup&gt;</td>
<td>• Guide for judging soil and land conditions based on visual features • Includes visual assessment of soil texture, structure, color, porosity, number and color of soil mottles, earthworms and potential rooting depth • Also includes observations on the degree of surface ponding, soil crusting and soil erosion • Available for different land uses</td>
<td>• Assesses rapidly on ground soil and land conditions • Possible to find drivers for land degradation from observing the vicinity</td>
<td>• Experience with assessment and soils of the region needed • Visually assessed, rather than measured indicators can result in some inaccuracies • Results best comparable when prepared by the same assessor • Time consuming, but less time required compared to measuring indicators</td>
<td>Australia&lt;sup&gt;27,28&lt;/sup&gt; Canada, China, Germany&lt;sup&gt;29&lt;/sup&gt; England, Wales&lt;sup&gt;30&lt;/sup&gt;</td>
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<td>Siting&lt;sup&gt;31&lt;/sup&gt;</td>
<td>• Planning method to identify highly valued landscape features and hotspots • Combines spatial assessment with field measurements • Preliminary desk study can help to identify hotspots of change in indicators and/or optimal sampling locations</td>
<td>• Combines spatial and on-ground analysis to accelerate and fine-tune assessments of land degradation • Drivers can be identified by observing the vicinity of degradation hotspots</td>
<td>• Computer facilities required • GIS and field measurement skills required • High resolution spatial data required • Preliminary stratification of land types required to understand representativeness of site visitation</td>
<td>Australia&lt;sup&gt;31&lt;/sup&gt; Indonesia&lt;sup&gt;32&lt;/sup&gt;</td>
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<td>Assessment of the Economics of Land Degradation</td>
<td>• Framework to estimate costs of action and inaction against land degradation considering local and global costs</td>
<td>• Identifies land degradation hotspot based on NPP and/or household surveys</td>
<td>• Computer facilities needed • Remote sensing/GIS skills needed • Spatial data needed</td>
<td>Sub-Saharan Africa, Central Asia, Argentina, Bhutan,</td>
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<td>Name and Improvement(^{33,34})</td>
<td>Description</td>
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<td>Shortcomings and potential challenges</td>
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| **Erosion models**\(^{35}\), (e.g., USLE, RUSLE, PESERA) | • Method to calculate/project soil loss from (water) erosion  
• Based on spatial data on topography, climate, soil condition, land cover and land management  
• Calculates current level of soil loss or projects future soil loss following climate and land use scenarios | • Projects future degradation based on land use scenarios and determine required restoration extent for counterbalancing  
• Highlights sensitive areas that need intervention to avoid/reduce degradation | • Exact relationship between erosion (soil loss) and change in land degradation indicators not fully known  
• Computer facilities required  
• Spatial data required  
• GIS skills needed  
• Potentially land use scenarios required | Iran: RUSLE\(^{36}\)  
Malaysia: USLE\(^{37}\)  
Turkey: PESERA\(^{38}\)  
Global: USLE\(^{39}\) |
| **Conversion of Land Use on Mondial Scale (CLUMondo) model**\(^{40}\) | • Spatially explicit (geographical) land system model  
• Allocates future land system patterns to fulfill future demand scenarios based on supply, local suitability (based on biophysical and socioeconomic variables), and conversion rules, for example as a result of policies  
• Global degradation indicators can be incorporated as average ‘supply’ values per land system change  
• Possible to simulate no-net-loss scenarios | • Can simulate land system change as a result of achieving LDN  
• Can project suitable possibilities for counterbalancing degradation  
• Can give an estimation of future trajectories of land degradation indicators | • Only approximation of land degradation indicators as average value per land system type is used, ignoring local characteristics, like terrain or soil types  
• Land types for counterbalancing ‘like-for-like’ currently restricted to 3  
• Computer facilities required  
• Spatial data required  
• Partly expert assumptions needed | China\(^{41}\)  
Ghana\(^{42}\)  
Laos\(^{43}\)  
Mediterranean\(^{44}\)  
Thailand\(^{45}\)  
Turkey: LDN simulation\(^{46}\)  
Global\(^{47}\) |
| **LAND System Cellular Automata model for Potential Effects (LANDSCAPE)**\(^{48}\) | • Based on a hierarchical allocation strategy and resistances of land use types  
• Distinguishes between active (direct result from human demands) and passive (driven by active land use change) land uses  
• Different ‘aggressiveness’ of land uses determines stage in hierarchy in which they are allocated  
• Capable to simulate cascading processes of land-use change (one initiates another) | • Simulates and compares different strategies and suggestions of achieving LDN  
• Optimizes land-use configurations to achieve LDN, alongside other goals  
• Projection and simulations of land use change can reveal its impacts on land degradation | • Computer facilities required  
• Spatial data needed  
• Partly expert assumptions needed  
• Not open access | China\(^{49}\) (Hubei\(^{50,51}\), Wuhan\(^{52-54}\)) |
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| Computable General Equilibrium of Land Use Change (CGELUC) model     | • Econometric model based on the Computable General Equilibrium framework  
• Analyses how socioeconomic factors influence the structure of regional land use  
• Includes industrial structure, trade environment, economic policies and institutional arrangements in an equilibrium economic system | • Simulates the impact of policies on land use, economic variables and consumer and government behavior and their potential to support achieving LDN  
• Helps to understand the relationships between economic variables and land cover/use change, which can indicate feasibility and benefits of measures against degradation | • Social Accounting Matrix need to be prepared beforehand  
• Computer facilities required  
• Spatial data required  
• Partly expert assumptions needed  
• Not open access                                                                                             | China<sup>55</sup>                                                              |
| Model of Agricultural Production and its Impact on the Environment (MAgPIE) | • Land use allocation model, connected to a grid-based dynamic vegetation model (LPJmL) and consisting of 38 modules  
• Simulates spatially explicit land-use and water-use patterns, with a focus on agricultural production  
• Uses as inputs crop yields, land and water constrains from LPJmL, as well as economic variables such as demands, prices and cost structures, and technological development  
• Simulates scenarios for land use patterns, yields, and costs of agricultural production, as well as economical and biogeochemical outputs  
• Minimizes total cost of food and bioenergy demand fulfilment | • Estimates land degradation extent for different scenarios from NPP and carbon content outputs  
• Informs on the economical and land use consequences of different LDN strategies  
• Finds the best strategy for achieving LDN  
• Evaluates the impact of achieving LDN for other commitments (e.g., GHG emissions, biodiversity) | • Rather coarse resolution (0.5⁰ x 0.5⁰)  
• Only global applications  
• Number of land types limited  
• Computer facilities required                                                                                       | Global<sup>59</sup>                                                             |
| Integrated Assessment Models (IAM) (e.g., AIM, GCAM, MESSAGE-GLOBIOM, IMAGE) | • Single modelling framework explores the interplay between human and natural systems by simulating socioeconomic and biophysical processes and dynamics<sup>60,61</sup>  
• Usually consists of several modules, covering among others socioeconomic development, energy use, land use, emissions, policies, trade, … | • Develop different future scenarios, e.g., of different policies, consumer behaviors and analyze their impact on land degradation and restoration  
• Scenarios can also be used as input for geographical (i.e., spatially explicit) land use models | • Only few are open access and/or open source (e.g., GCAM)  
• Often very complex and require powerful computational resources  
• Often not spatially explicit or rather coarse resolution  
• Mostly global or world region applications                                                                                   | Cambodia, Laos, Viet Nam: GLOBIOM<sup>62</sup>  
Global<sup>63</sup>  
Global: IMAGE<sup>54</sup>                                                                                          |
| Land use planning for LDN (LUP4LDN)                                 | • Web-based tool that visualizes and allows for assessment of current land degradation based on the 3 global land degradation indicators, as well as historical and future trends and risk of future degradation | • Assesses land degradation status  
• Helps in planning for neutrality by creating different scenarios | • Computer facilities required                                                                                                         | (still in development)                                           |
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<tr>
<td><strong>Analytical Hierarchy Process (AHP) and its variants</strong></td>
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<td>• Areas of intervention can be defined and different scenarios can be evaluated concerning achieving LDN</td>
<td>• Chooses suitable actions to avoid, reduce, and counterbalance degradation</td>
<td>• Rather time-consuming, compared to other multi-criteria methods and tools</td>
<td>Australia71  China72  Ethiopia73,74  Iran75  Indonesia76  India77  Germany78</td>
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<td>• Supports selection of appropriate SLM techniques by connection to WOCAT Global SLM database and analysis of how chosen actions impact socioeconomic and biophysical variables</td>
<td>• Encourages stakeholder negotiation by inviting others to contribute to scenarios and analysis</td>
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<td><strong>Multi-Attribute Utility Theory (MAUT) and its variants</strong></td>
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<td>• Most commonly applied multi-criteria analysis for decisions on natural resource management with stakeholder involvement66,67</td>
<td>• Analyzes land degradation risk and restoration potential</td>
<td>• Data intensive</td>
<td>Australia80  Canada81  Netherlands82  Poland83</td>
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<td>• Uses pairwise comparison to identify best alternatives and the weight of criteria68</td>
<td>• In combination with forward-looking tools, compares future alternatives and find most desirable pathway based on stakeholder preferences and LDN70</td>
<td>• Rather subjective, if weights are assigned by decision maker67</td>
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<td>• Able to address incommensurable and multi-dimensional criteria &amp; sub-criteria69</td>
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<td>• Local knowledge required to weigh criteria</td>
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<td><strong>Outranking (PROMETHEE &amp; ELECTRE)</strong></td>
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<td></td>
<td>• Pairwise comparison of alternatives84</td>
<td>• Determines which drivers of land degradation are most important and need to be addressed by policies</td>
<td>• More complex than the AHP and MAUT</td>
<td>Burkina Faso: ELECTRE88  Iran: ELECTRE89  Iran: PROMETHEE90  Serbia: PROMETHEE91</td>
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<td></td>
<td>• Number of alternatives is known &amp; discrete68</td>
<td>• Identifies suitable actions for avoiding or reducing land degradation and planning for restoration</td>
<td>• Data and measurements of attributes/criteria required</td>
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<td>• Criteria importance defined subjectively by stakeholders65</td>
<td>• Can be combined with preliminary stakeholder workshop and/or assessment of drivers and pressure factors to determine suitable actions</td>
<td>• Requires local contribution</td>
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<td></td>
<td>• Performance of each alternative towards criteria is determined objectively by measuring attributes for each criteria65</td>
<td>• Performance of LDN indicators could be measured through analyzing historical trends, forecasting or erosion models</td>
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<td>• Pair-wise comparison of alternatives by stakeholders assigns strong or weak preference or indifference86</td>
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<td></td>
<td>• Each alternatives receives an index of concordance (number of “as good as” relations) and discrepancy (number of “worse than” relations)</td>
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<td>Name</td>
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| **OPTamos**                 | - Web-based tool to support Multi Criteria Evaluation with stakeholder participation  
  - Options, criteria and goal are given by the user  
  - Options are pairwise compared and weighted regarding each criterion  
  - Criteria are pairwise compared and weighted according to their importance regarding the goal  
  - An inconsistency ratio is given to ensure provided information is logical  
  - The option for sensitivity analysis is provided | - Assesses the socio-economic environment in terms of stakeholder preferences  
  - Evaluates suitability and impact of actions | - Requires local contribution  
  - Somewhat subjective weighting of options and criteria | Mexico93 |
| **se.plan (part of SEPAL)** | - Mapping tool for providing spatially explicit information on forest restoration suitability and impacts  
  - Costs of restoration are weighted against its benefits  
  - Users can rank restoration benefits and declare constraints  
  - Trade-offs can be identified and areas where action is required can be outlined | - Evaluates costs and benefits of (forest) restoration | - Currently focused on forest restoration, could potentially be expanded to other restoration types (e.g., soil) | |
| **Hierarchical allocation** | - Allocates land uses based on priorities and suitability analysis  
  - Applicable to low complexity problems with clear priority hierarchy | - Determines suitability for restoration, while avoiding conflict with other uses | - Priority hierarchy might be rather subjective  
  - Computer facilities required  
  - (Higher resolution) spatial data required  
  - GIS skills required  
  - Expert & local knowledge needed | China94 |
| **Goal programming**        | - Finds solution as a satisfactory distance to a predefined optimal solution and if applicable to pessimal (worst) case  
  - Threshold for satisfactory distance is set by decision maker, potentially for each criteria separately | - Finds the most suitable locations and practices for avoiding and counterbalancing degradation  
  - Optimizes allocation of resources (e.g., monetary, employment or land) to achieve LDN  
  - Combines with preliminary stakeholder workshop to negotiate | - Threshold setting might be rather subjective and might have large impact on result  
  - Computer facilities required  
  - Spatial data required  
  - GIS skills required  
  - Expert & local knowledge needed | Argentina97  
  - Canada98  
  - Iran100  
  - Netherlands101  
  - Panama102  
  - Portugal103 |
<table>
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<tr>
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<tr>
<td><strong>Evolutionary algorithms</strong> (including genetic algorithms)</td>
<td>• Applicable for finding the best allocation of resources, including land, in situations with conflicting demands and preferences</td>
<td>• Optimizes land use allocation in more complex situations</td>
<td>• Computer facilities required</td>
<td>China (^{106}) Iran (^{107}) Portugal (^{108})</td>
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<td>• Starts with an initial set of solutions or land use plans from which a next generation of solution evolves through selection, crossover and mutation (^{104})</td>
<td>• Improves existing solutions/land use plans and the implement of LDN</td>
<td>• Spatial data required</td>
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<td>• Stops when evaluation criterion or a maximum number of generations is reached (^{105})</td>
<td>• Applicable to problems with no (single) optimal solution</td>
<td>• GIS skills required</td>
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<td>• Applicable to LDN preferences &amp; needs, best/worst case and suitable criteria</td>
<td>• Expert knowledge needed</td>
<td>• Computer facilities required</td>
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<tr>
<td><strong>Restoration Opportunities Optimization Tool</strong> (^{109})</td>
<td>• Tool for planning restoration projects to achieve benefits for several ecosystem services, while including objectives of beneficiaries and land use change constraints</td>
<td>• Identifies potential restoration areas and analyzes their impact on ecosystem services and for beneficiaries</td>
<td>• Computer facilities required</td>
<td>Brazil, Malawi, Myanmar, Colombia, Costa Rica (^{109})</td>
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<td>• Through linear programming optimization best locations for restoration are identified</td>
<td>• Spatial data on land degradation indicators could be included as ecosystem service maps to facilitate assigning restoration areas in-line with LDN, possibly combined to account for one-out, all-out</td>
<td>• Spatial data required</td>
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<td></td>
<td>• Multiple objectives can be specified by combining maps of demands for ecosystem services with expected changes in biophysical values</td>
<td>• Input polygons could delineate like-for-like regions</td>
<td>• Local knowledge needed</td>
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<td>• Many optimizations with changing weights for objectives are performed, which are synthesized in agreement maps that highlight areas with high intervention priority</td>
<td>• Tool could potentially be used to identify areas of high degradation risk in the opposite way of restoration</td>
<td>• Tool could potentially be used to identify areas of high degradation risk in the opposite way of restoration</td>
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<td><strong>MARXAN</strong> (^{110})</td>
<td>• Software tool for conservation planning and solving spatial prioritization issues</td>
<td>• Can be adapted to determine optimal restoration areas</td>
<td>• Created for conservation planning, would need to be adapted to be suitable to LDN</td>
<td></td>
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<td>• Selects areas that meet predefined targets at minimal costs</td>
<td>• Can also help to determine biodiversity-sensitive areas</td>
<td>• Computer facilities required</td>
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<td>• Spatial data required</td>
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<td>• Expert knowledge required</td>
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**RAPID-APPRaisal TOOLS**

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<tr>
<td><strong>WOCAT Questionnaire on SLM Technologies</strong> (^{111})</td>
<td>• Surveying tool to gather information on and feasibility of available sustainable land management (SLM) technologies</td>
<td>• Collects sustainable practices of land management, including the context where they have been proven suitable</td>
<td>• Requires trained and accepted interviewer</td>
<td>SLM Practices collected from 133 countries (^{112})</td>
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<td>• Contains questionnaire that can be used to interview land users on which technologies</td>
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<td>• Time-consuming in areas of large diversity in terms of land</td>
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| Transect walks<sup>26,113</sup> | ● Group exercises in which experts together with locals, planners and municipality representatives walk down defined transects representative of a studied area  
* Observations and information on landscape and land profiles are documented on a map | ● Map areas of degraded or infertile soils  
● Identify drivers and pressure factors of land degradation  
● Collect information on socio-economic environment, such as (informal) land tenure types  
● Facilitate knowledge exchange (e.g., on land conditions) between land users and local decision makers | ● Requires trained and accepted interviewer  
● Time-consuming | Ethiopia<sup>114</sup>, Swaziland<sup>115</sup>, Tanzania<sup>116</sup> |
| Context and community mapping<sup>117,118</sup> | ● Starts with expert mapping of land cover and key land uses based on satellite imagery  
* Land users then mark points of interests on the map, including land holdings and socially or culturally important features/areas and areas of conflict | ● Helps to understand stakeholder preferences and needs that need to be considered when planning restoration areas  
● Evaluates the socio-economic environment, e.g., (informal) tenure and understanding of boundaries | ● Requires trained and accepted facilitator  
● Time consuming  
● Spatial data required | Ecuador<sup>119</sup>, Mali<sup>120</sup> |
| Focus groups<sup>26,113</sup> | ● Discuss and gather local knowledge on local conditions and/or changes  
* Can be supported by visual representation, e.g., using a timeline or matrix (also called Trend analysis) | ● Gather information on observed land degradation and potentially locally specific indicators for land degradation, as well as drivers and pressure factors  
● Help to understand socio-economic environment | ● Require trained and accepted facilitator  
● Time consuming | Ethiopia<sup>121</sup>, Romania<sup>122</sup> |
| Land potential knowledge system (LandPKS)<sup>123</sup> | ● Cloud-based decision support tool based on crowdsourcing  
* Evaluates land through a combination of geospatial data on soil, terrain, and climate in combination with local knowledge  
* Users take and upload pictures of soil and answer questions about sustainable land management options | ● Allows for knowledge exchange between single users and local governments  
● Identifies land degradation status of single locations which could be extrapolated over larger areas  
● Gathers information on suitable actions to reduce or avoid degradation | ● Accuracy and level of detail depends on the number of users  
● Computer facilities required | Ethiopia, Kenya, Tanzania<sup>123</sup> |
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| Sustainable land management (SLM) Mainstreaming Tool                  | • Questionnaire tables to support rapid assessments of  
1) Barriers to sustainable land management  
2) Existing decision-making processes  
3) Involved institutions and stakeholders  
Also facilitates the creation of a mainstreaming strategy and action plan | • Identifies suitable actions  
• Evaluates the socioeconomic environment  
• Evaluates the decision-making structure and stakeholder relationships  
• Identifies which SLM actions are suitable | • Requires trained and accepted interviewer  
• Local knowledge and participation needed  
• Time consuming  
• Local knowledge needed  
• Time consuming | Benin, Burkina Faso, Ethiopia, India, Kenya<sup>125</sup>, Malawi, Tanzania<sup>126</sup> |
| Evaluating Land Management Options (ELMO)<sup>124</sup>              | • Surveying tool to identify motivation of local land users for land management decisions  
Known or practiced sustainable land management (SLM) alternatives are discussed with the respondent, their resource requirements weighted, and positive and negative impacts ranked | • Identifies suitable actions  
• Evaluates the socioeconomic environment | • Local knowledge needed  
• Time consuming  
• Local knowledge needed | |
| LADA-Local<sup>127</sup>                                             | • Local information on biophysical and socioeconomic conditions are collected with the help of transect walks, focus group discussions, livelihood interviews and biophysical assessments  
• Discussion with and feedback from local stakeholders on the assessment results help to derive the optimal response to land degradation and plans for sustainable development  
• Quantitative and qualitative results of assessments are stored to provide baseline for future monitoring of change | • Develops commonly agreed plan on how to address land degradation and implement LDN  
• Assesses land degradation and socioeconomic environment  
• Combines and validates results from different tools  
• Facilitates knowledge exchange between local people, decision-makers and external experts | • Requires trained and accepted facilitator  
• Time consuming due to the application of several assessment tools  
• Requires trained and accepted interviewer  
• Local knowledge and participation needed  
• Time consuming | China, Mongolia<sup>127</sup> |
| Resilience Diagnostic and Decision Support Tool (RDDST)<sup>128</sup> | • Part of Stakeholder Approach to Risk Informed and Evidence Based Decision Making (SHARED)  
• Web-based tool that compiles spatial and census data on social, economic and biophysical parameters  
• Uses a dashboard interface to visualize data and results, with the aim to facilitate stakeholder-scientists communication and inclusive negotiation | • Assesses and visualizes land degradation status, change, and hotspots  
• Facilitates stakeholder negotiations & knowledge exchange  
• Can support monitoring, if data is consistently collected and uploaded  
• Computer facilities required  
• Spatial data required  
• Census data required  
• Step-by-step guidelines only partly available | • Computer facilities required  
• Spatial data required  
• Census data required  
• Step-by-step guidelines only partly available  
• Computer facilities required  
• Spatial data required  
• Census data required  
• Step-by-step guidelines only partly available  
• Computer facilities required  
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• Census data required  
• Step-by-step guidelines only partly available  
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• Spatial data required  
• Census data required  
• Step-by-step guidelines only partly available  
• Computer facilities required  
• Spatial data required  
• Census data required  
• Step-by-step guidelines only partly available | Kenya<sup>129</sup>, Ethiopia, Tanzania, Zambia: SHARED & SAI dashboard<sup>130</sup> |
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| Participatory scenario analysis\(^{131,132}\) | • Visualization technique to compare different potential future scenarios, e.g., worst and best case  
• Scenarios are explored and negotiated in a group setting  
• Involves identification of the current situation, driving forces for change, assessing implications of different scenarios and to negotiate a common ground between different groups of people  
• In smart-mapping, alternative scenarios are created with images on a computer | • Determines status, drivers, and pressure factors of land degradation based on local knowledge  
• Negotiates plans to reduce or avoid degradation  
• Facilitates knowledge exchange between local land users and stakeholders  
• Scenarios can be used as input in forward-looking tools to determine the impact on land use patterns or other variables | • Requires trained and accepted facilitator  
• Local knowledge needed | Ghana, Honduras, Tanzania\(^{133}\)  
Greece, Italy, Portugal, Spain\(^{134}\)  
Switzerland\(^{135}\) |
| Participatory mapping, e.g. locality mapping\(^{113}\) | • Stakeholders, either individually or in a group, draw a map of discussed geographic unit containing boundaries and important features, e.g., roads, rivers, towns and property boundaries  
• Additional information can be added with post-its, local materials, or 3-dimensional objects  
• Results are compared and the final result is created through negotiation and discussion by the entire group | • Evaluates socioeconomic environment, e.g., (informal & formal) land tenure holdings  
• Facilitates stakeholder negotiations and gathers stakeholder preferences | • Requires trained and accepted facilitator  
• Local knowledge needed | Laos, Mali, Peru\(^{113}\)  
India\(^{136}\) |
| Serious Gaming (includes Simulation Gaming, Game-Based Modeling, Games with a Purpose and role games)\(^{137,138}\) | • Embeds (decision) problems into gaming experience  
• Decisions by players can for example include resource allocation to different resources, land use type selection or price setting  
• Supports scenario development, understanding of household decision making, stakeholder engagement and education | • Evaluates socioeconomic environment  
• Facilitates stakeholder negotiations  
• Supports knowledge exchange | • Game set-up might be time-consuming as it requires intensive preliminary study of the region to understand the options that should be included in the game, developing an engaging, enjoyable, and challenging game setup and a clear goal definition | Germany\(^{139}\)  
Ghana\(^{140}\)  
Laos\(^{43}\)  
Senegal\(^{141}\) |
| Triangulation of participatory methods\(^{142}\) | • Overcome hesitance of engagement between different groups (i.e., farmers/village heads, local municipality partner and scientists)  
• Feedback on initial participatory method is collected and adapted if necessary  
• Increase interest, team-building between different groups and ownership of the results | • Facilitate stakeholder engagement, negotiations and knowledge exchange | • More time consuming due to adaptation of methods | China\(^{142}\) |
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| Green Negotiated Territorial Development (GreeNTD) approach and toolkit | • Approach to facilitate inclusive, fair, and equal stakeholder negotiation and engagement  
• Promotes strengthening of weaker stakeholders, and balancing competing demands and interests  
• Consists of 5 phases, similar to the ILUP/ILM phases  
• Toolkit contains 30 tools that can mostly be characterized as process-oriented, but tools with characteristics from other groups are also included | • Facilitates stakeholder identification, engagement and negotiation | • Somewhat time and resource consuming, due to large set of tools | Congo DR |
References of Appendix E


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Appendix F: Example - The ‘Decision Support Framework for SLM mainstreaming and scaling out’ project

As part of the Decision Support for Mainstreaming and Scaling out Sustainable Land Management (DS-SLM) project, WOCAT and FAO developed a methodological framework that provides guidance and descriptions of tools that can facilitate decision making for planning and implementing SLM innovations. The framework has been applied and adjusted to the needs of 15 countries. It consists of 7 modules which align with phases of the ILUP/ILM cycle. Module 1 is similar to the Visioning phase of the ILUP/ILM cycle. In this module, the strategy and action plan are defined, which includes the identification of objectives and goals, of opportunities and barriers for SLM implementation, and of stakeholders and potential partnerships. The SLM Mainstreaming Tool is suggested to support this phase.

Module 2, 3, and 4 include assessments at the national, subnational, and landscape level and the selection of priority areas. These modules thereby address characteristics of the Assessment phase of the ILUP/ILM cycle. Suggested tools for these modules include the WOCAT-LADA-DESIRE mapping tool for local-expert based mapping of land degradation, stakeholder workshops to validate and refine the derived land degradation maps at the local level, and the WOCAT Questionnaire on SLM Technologies in combination with the Global SLM database to identify suitable SLM innovations.

Module 5 includes territorial planning, which is in-line with the Planning phase of the ILUP/ILM cycle. Existing policy instruments are reviewed, SLM implementation is discussed with authorities, and partnerships with key institutions are established. Together with stakeholders, SLM strategies are then formulated.

In Module 6, SLM is implemented and scaled-out. This is similar to the Implementation phase of the ILUP/ILM cycle. In this step, demonstration sites are established, activities for promoting SLM implementation are developed, and support for SLM best practices are planned.

Lastly, Module 7 suggests the use of a knowledge management platform to support informed decision making. Such a platform could also be used in the Monitoring phase of the ILUP/ILM cycle.

Source: WOCAT, 2019
Appendix G: Integrated land use planning vs. the free market economy: environmental degradation in the “Jadar” lithium project, Serbia

The global demand for lithium has increased exponentially due to the push for the integration of renewable energy and clean energy storage in the transportation sector, a substantial part of which is being fulfilled by lithium-ion batteries. As a result, the prospecting and exploitation of lithium resources has been expanding. Jadarite is a newly recognized lithium-borate deposit named after the Jadar Basin in Loznica, Serbia, where it was discovered in 2004. It remains the only known jadarite deposit worldwide, and one of the most significant lithium deposits in the world, with declared mineral resources at 136 million tons.

The British-Australian company Rio Tinto has been exploring the jadarite deposit in Serbia for more than 16 years. Rio Tinto announced an investment of USD 1.5 billion in the mining of the jadarite. Pre-feasibility studies showed that the Jadar project has the potential to produce 58,000 tons of battery-grade lithium carbonate, 286,000 tons of boric acid and 259,000 tons of sodium sulfate out of 1.6 million tons of jadarite ore annually. The government of Serbia considers the exploitation of the jadarite deposit at the doorsteps of the world’s fastest growing electric vehicle market an opportunity for Serbia’s economic revival. However, residents of the city of Loznica and Jadar River Valley argue that the mining facilities would threaten the environment and the health and well-being of agricultural households in a region where the existing economy is based on high-quality agriculture. In the absence of clear answers about the proportions of the environmental and health damage that jadarite mining could cause, the type of technologies that will be applied, and the possibility of resettlements, residents have taken to showing resistance.

Among the 533 ha of land re-classified as “construction land” are 203.7 ha of forests and shrubs, 316.7 ha of arable land, 8.3 ha of households and gardens, and another 8.3 ha of orchards, all of which would be irretrievably destroyed by the project. It would also endanger 145 species of strictly protected plants and animals. The strong influence of the mining activities will be present on at least 1,289 ha, and with the projected enlargement of the exploitation field, this amount will probably grow to more than 2,000 ha. Subsidence on almost 850 ha is projected due to the use of ore and groundwater. The height of the planned landfill (on arable land) will exceed a height of 40 meters, and it will be located in a zone susceptible to possible flood waves from local watercourses.

The land use plan of the city of Loznica does not account for the opening of the mine and its use of more than 2,000 hectares of agricultural and forest land. While a significant economic opportunity, ore exploitation on such scale conflicts with sustainable development as pursued in the Rio Conventions and other multilateral environmental agreements that Serbia has ratified. The activities within the Jadar project would also obstruct the national voluntary LDN targets that Serbia has committed to.

Sources: Ristić et al., 2021; Tabelin et al., 2021