THE ECONOMICS OF LAND DEGRADATION

ELD Initiative: **User Guide**

A 6+1 step approach to assess the economics of land management

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Economics of
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User Guide

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Acronyms and abbreviations

CBA	Cost-benefit analysis
ELD	Economics of Land Degradation (Initiative)
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographical Information System
HICU	Homogenous Image Classification Unit
LEDESS	Landscape Ecological Decision and Evaluation Support System
MCDA	Multi-Criteria Decision Analysis
USD	United States Dollar
USPED	Unit Stream Power Erosion Deposition
WOCAT	World Overview of Conservation Approaches and Techniques

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The ELD Initiative

Land degradation and desertification reduce the provision of ecosystem services by lands and soils. This constrains development, reduces water, food, and energy security, and triggers resource conflicts. Although biophysical processes and economic impacts are increasingly understood, efforts to combat degradation have been failing thus far to prevent further losses of land productivity, a cost estimated at 42 billion USD/year (Dregne & Chou, 1992; Requier-Desjardins, 2007). The on-going global reduction of land will also be felt at regional and local scales, hindering further economic development, and further aggravating the poverty and vulnerability of the rural poor, who number 35 per cent of the world's population and additionally rely most heavily on land for their survival, sustenance, and livelihoods (Millennium Ecosystems Assessment, 2005; Barbier & Hochard, 2014).

Driven by this issue and the need to address it, the Economics of Land Degradation (ELD) Initiative highlights the economic dimension of soil and land degradation in order to provide methods for valuing land accurately and thus enable its efficient and sustainable use. It promotes transdisciplinary approaches drawing from a range of scientific insights for informed decision-making and planning, and strives to highlight the economic potential of natural resource use to foster action and support investments in their sustainable use. Based on the capital asset framework, ecosystem service framework and 'Total Economic Value' framework, the methodological approach promoted by the Initiative can be applied at different scales and scopes, with the aim to achieve a more holistic assessment of the value of different land use options (Noel and Soussan, 2010; ELD Initiative, 2013) for all stakeholders. Evidence of the economic benefits of sustainable land management options have been compiled and summarised, and assessment results are being provided to three critical target groups: the private sector, scientific community, and policy-/decision-makers.

To enable the use of economic assessments of land management through cost-benefit analyses, principles of economic valuation were provided by the Initiative to support quick on-site assessments (see the ELD Initiative's Scientific Interim Report, 2013). Additionally, the ELD Initiative's Practitioner's Guide (2014) provides case studies from ELD MOOC 2014 participants, which can be referenced as practical examples by the three target groups of the Initiative. As part of these outputs, this document serves as an instructional and guiding text for stakeholders interested in performing cost-benefit analyses for sustainable land management options using the ELD Initiative supported approach, and includes examples from the Initiative and its partners to demonstrate how each part of the process functions practically.

The 6+1 step approach

The 6+1 step approach is the analysis method that has been adopted by the ELD Initiative to guide users through the process of establishing scientifically sound cost-benefit analyses to inform decision-making processes. *Table 1* shows a summary of each step and which aspect of the process it targets. Each step will then be discussed in detail, with practical examples from the work of the ELD Initiative to date, and guidelines on how to execute it.

TABLE 1

The 6+1 step approach of the ELD Initiative
(adapted and expanded from the methodolgy by Noel & Soussan (2010), the ELD Initiative Scientific Interim Report (2013), and Chapter 2 of the ELD Initiative Report 'The Value of Land' (in print, 2015))

1. Inception	Identification of the scope, location, spatial scale, and strategic focus of the study, based on stakeholder consultation. Preparation of background materials on the socio-economic and environmental context of the assessment.
	Methods for: *stakeholder participation (consultation, engagement); systematic review and synthesis of academic and grey literature; selection of relevant existing case studies; extrapolation of existing case studies for global comparison; collection of background socio-economic and environmental data; policy analysis.*
2. Geographical characteristics	Establishment of the geographic and ecological boundaries of the study area identified in Step 1, following an assessment of quantity, spatial distribution, and ecological characteristics of land cover types that are categorised into agro-ecological zones and analysed through a Geographical Information System (GIS).
	Methods for: *stakeholder participation (consultation, engagement); definition and mapping of land covers and agro-ecological zones from the sciences (physical geography, ecology, soil sciences, landscape sciences, etc.).*
3. Types of ecosystem services	For each land cover category identified in Step 2, identification and analysis of stocks and flows of ecosystem services for classification along the four categories of the ecosystem service framework (provisioning, regulating, cultural, and supporting services).
	Methods for: *stakeholder participation (consultation, engagement); identifying different ecosystem stocks and flows (from ecology); categorising ecosystem services into the four categories of the ecosystem service framework.*

4. Roles of ecosystem services and economic valuation	Establishment of the link between the role of ecosystem services in the livelihoods of communities living in each land cover area and in overall economic development in the study zone. Estimation of the total economic value for each ecosystem service. **Methods for:** *stakeholder participation (consultation, engagement); identification of available economic data from relevant case studies; data collection and surveys; multi-criteria analyses to identify important ecosystem services; valuation methods for estimation of "missing" economic values (no market price); extrapolation of case studies for global comparison.*
5. Patterns and pressures	Identification of land degradation patterns and drivers, pressures on sustainable management of land resources and drivers of adoption of sustainable land management (including determining the role of property rights and legal systems), and their spatial distribution to inform the establishment of global scenarios. Revision of previous steps if needed, to ensure the assessment is as comprehensive as possible. **Methods for:** *stakeholder participation (consultation, engagement); identification of types of land degradation, patterns, and pressures (from soil sciences, ecology, agricultural sciences, physical geography, etc.); mapping methods (GIS); establishment of global scenarios.*
6. Cost-benefit analysis and decision making	Cost-benefit analysis (CBA) comparing costs and benefits of an 'action' scenario to that of a 'business-as-usual' scenario to assess whether the proposed land management changes lead to net benefits. ('Action' scenarios include land management changes that can reduce or remove degradation pressures). Mapping of net benefits for identification of the locations for which land management changes are suitable from an economic perspective. This will lead to the identification of "on-the-ground" actions that are economically desirable. **Methods for:** *stakeholder participation (consultation, engagement); cost benefit analysis with participatory establishment of action scenario and business as usual scenario, choice of discount rate, computation of indicators of economic viability; mapping methods (GIS); estimation of shadow interest rates.* **Tools to facilitate the building of cost-benefit analyses (micro-economic level):** *Toolkit for Ecosystem Service at Site-based Assessment (TESSA); Assessment and Research Infrastructure for Ecosystem Services (ARIES); Corporate Ecosystem Services Review (ESR); Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST); Multi-scale Integrated Models of Ecosystem Services (MIMES); Natura 2000, etc.*

7. Take action

- **Land users:**
  implement the most economically desirable 'on the ground' option(s) by changing land management practices or land use, at multiple scales and levels.

Methods for:
stakeholder participation (consultation, outreach, awareness raising, engagement).

- **Private sector:**
  engage in discussions with stakeholders from all sectors directly impacted by changes in ecosystem services to reduce risks associated with a weaker link in the value chain and increasing opportunities for investment in sustainable land management. This requires relevant and suitable impact pathways to be identified, to promote and facilitate actions that can be scaled up and out.

Methods for:
takeholder participation in relation to corporate social responsibility (consultation, outreach, awareness raising, engagement), land materiality screening toolkit, value chain analysis.

- **Policy-/decision-makers:**
  facilitate adoption of most economically desirable option(s) on the ground by adapting the legal, policy, institutional and economic contexts at multiple scales and levels. This requires relevant and suitable impact pathways to be identified, to promote and facilitate actions that can be scaled up and out.

Methods for:
stakeholder participation (consultation, engagement); identification and social construction of impact pathways (e.g., multi-criteria analyses that identify preferences over possible impact pathways).

Tools at the macroeconomic level:
Green accounting using UN System of Environmental-Economic Accounting (SEEA) or using the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) global partnership.

01 Inception

The inception phase is where the scope, focus, spatial scale, and strategic purpose of the study are outlined and agreed upon with stakeholders who will be key in conceiving of and executing any alternative scenarios in sustainable land management. This is done through a structured, participatory process of stakeholder consultations where the basic approach and rationale of the study is explained, and strategic issues are discussed (*Box 1*). Further, to support the development and basis of the study, background papers on the policy, legislative, and institutional contexts and wider socioeconomic and ecological settings should be collated and prepared through desk research in this step (Noel & Soussan, 2010). This will ensure that the cultural, biophysical, and socioeconomic situation needs and drivers are understood before proceeding with scenario development. It is crucial that the scale of the study, whether it is at the community, sub-national (e.g., a province or watershed), or national level, and the specific geographical boundaries and land cover categories are clearly identified. Additionally, relevant partner institution that will support the research and subsequent implementation should be identified and included at this stage.

BOX 1

ELD stakeholder consultations

(compiled from Juepner & Noel (2014); Kisingo et al. (2014); Egemi & Ganawa (2014))

The ELD Initiative is set up to provide support to strengthen existing institutional and stakeholder capacity, and help interested parties build an economic case for the adoption of more sustainable land management practices in line with stakeholder demands and needs. Examples of consultations conducted in relation to the ELD Initiative demonstrated that there are parties interested in the Initiative's activities and goals - especially the fact that it is designed to produce outputs that answer demands of a wide variety of stakeholders, from political decision-makers at national and sub-national levels, to small and large private sector actors, grassroots voices, research institutions, members of the scientific community, etc.

The ELD consultations to date have also shown that the issue of land management is complex, and requires holistic approaches that consider "purely" economic aspects alongside other considerations, such as the formalisation of property rights and their allocation, how to bridge significant knowledge gaps for the effective operationalisation of different methods and concepts, and how to overcome local gaps in capacity.

As an example, ELD Initiative consultations in Narok County, Kenya (Juepner & Noel, 2014) highlighted the potential to:

- Strengthen existing sustainable land management knowledge base by addressing specific, clearly identified knowledge gaps;
- Play a catalytic role in establishing the total economic values of natural resources focusing on valuing contemporary land uses together with their positive and negative impacts;
- Participate in championing sustainable land management and rallying various stakeholders in support of sustainable land management (including the private sector); and
- Help build necessary capacity at local and national levels for the application and mobilisation of resources necessary to implement sustainable land management approaches.

Further ELD Initiative stakeholder consultations have been conducted globally in different locations at various levels (local, national, regional). To date, locations include Tanzania, Sudan, Botswana, Chile, Tunisia, and Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan), with future plans for the Dominican Republic and Haiti in place as of the writing of this guide. Case studies following the ELD Initiative 6+1 step approach are now being set up to complement these initial consultations.

In parallel, CIAT-Kenya has also led a literature review on the economics of sustainable land management based on information available within the CGIAR system. A majority of studies focus on the economic benefit-side of sustainable land management, and could be supplemented by other sources detailing the costs of land management (e.g., World Overview of Conservation Approaches and Technologies (WOCAT)) to derive estimations of net benefits.

02 Geographical characteristics

Land cover assessments and their respective categorisation into agro-ecological zones serve to identify the geographic and ecological boundaries of the chosen study area. Such assessments can be facilitated by the use of GIS programs (see *Box 2* and *Box 3*), which are widely available and have increasing accuracy of geographically referenced data on key variables such as land cover, ecosystems characteristics, altitude, topography, precipitation, slope, etc. Once the study area is mapped using the appropriate GIS program[1], different land cover categories are to be identified and grouped into standard agro-ecological zones. These zone classifications are already available in most countries, but can otherwise be derived from the global agro-ecological zonation produced by the Food and Agriculture Organisation of the United Nations (FAO) (GAEZ, 2015), from international sources found through desk research, or through an analysis of already available remotely sensed satellite data (e.g., Landsat). The latter is demonstrated in *Box 2*.

When the scale of the study is at a local level, secondary sources of GIS data can be supplemented by information gathered within a participatory GIS framework (Nackoney et al., 2013). This entails having detailed discussions with locals, supported by fieldwork where necessary, to create GIS layers that specify precise locations of ecosystem services availability and use. This can include information not normally available through satellite imagery or international databases, such as management regimes, experiences with sustainable levels of resource harvesting, locations of important ecological functions like fish spawning areas, or details of local water management and control systems. Participatory GIS is an effective tool for collecting information that can augment and qualify more conventional GIS data on land cover and use and ecosystems distribution, and can also validate or update outdated data (Etter, 2013).

Land cover and agro-ecological data can also be augmented by the development of GIS layers on human variables such as population distribution and densities, transport networks, water manage-

BOX 2

Mapping land degradation (soil erosion) in Ethiopia

(Hurni et al., 2014)

Hurni et al., (2014) performed a cost-benefit analysis of the existing and potential establishment of soil and water conservation structures in the highlands of Ethiopia. To identify the selected geographical characteristics for the study (in this case, land cover type, existing conservation structures, and soil erosion/deposition), the authors used a combination of Landsat imagery and expert opinion to determine land cover classes, in conjunction with the Unit Stream Power Erosion Deposition (USPED) model. This model predicts degradation patterns by estimating the spatial erosion and deposition patterns of soil matter, and was used in this study with the following parameters:

- Erodibility: Derived from datasets on spatial distribution of soil types, which calibrated erodibility parameters from the literature;
- Management type: From the high-resolution satellite imagery, physical conservation structures were identified using geospatial calculations;
- Soil cover: Using Landsat imagery, the cover of the soil was identified and fed into the USPED module in the GIS-software, and;
- Elevation: A digital elevation model of the study area was used to obtain information on sloping (which needed to be considered here, as greater slopes increase the need for conservation structures) and the sediment transport capacity.

The resulting information was also ground-truthed with expert opinion, to ensure that the land cover identification as well as estimates of land degradation (soil erosion) and its impacts (deposition) were correct. On this basis, the authors had a firm foundation from which they could develop alternative land management scenarios and compare them against 'business-as-usual' in a cost benefit analysis.

1 *For further information on how to choose appropriate software if one is not already available, see Eldrandaly & Naguib (2013). A knowledge based system for GIS software selection. The International Arab Journal of Information Technology, 10(2): 152-159.*

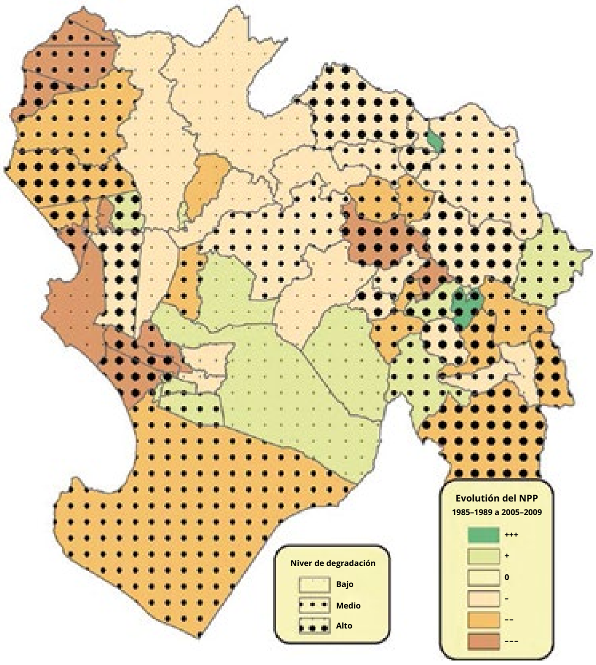
ment infrastructure (e.g., dams, levies, canals), data on farming systems and livelihood patterns, social factors (e.g., distribution of ethnic minorities), etc. These outputs can provide the data for an assessment of existing land cover patterns and systems. Furthermore, where suitable time series data is available, the analysis of existing land cover patterns can be supplemented by looking at trends in changing land cover over time. This can be of particular importance for users to identify where present and future degradation pressures are, and can reveal where augmenting existing land resource exploitation values through land management regimes changes could be prioritized.

A GIS-based approach can provide a straightforward and replicable method for assessing key patterns and trends in land resources. Its use tends to be more common in countries that have developed extensive databases but can be adapted to low capacities and low resources contexts (Etter, 2013; Hurni et al., 2014; Morales et al., 2015). This can require more complex models to assess future trends in land cover pattern changes, and several models exist for this purpose already. This includes the Conversion of Land Use and its Effects (CLUE) model, which statistically allocates land use changes to the most suitable locations (Verburg et al., 2002). Another model is the Landscape Ecological Decision and Evaluation Support System (LEDESS) model (Eupen et al., 2002). LEDESS is a GIS-based computer model used to assess and evaluate the effects of land use changes on ecological functions. Originally developed to assess changes in habitat and ecological suitability, it can be adapted to work within an ecosystems services framework to analyse changes to land resource values. The model also allows the implications of different sustainable land management approaches to be assessed in terms of their anticipated effects on basic ecological characteristics of different land cover types, and resulting consequences on the availability of ecosystem service values. One advantage of LEDESS is that it combines empirical quantitative data with values derived from expert opinion and assessments. This is useful where verified empirical data is not available for key parameters needed for the analysis (Noel & Soussan, 2010).

BOX 3

Assessing land degradation through GIS in Peru: Piura case study

The following map was developed by Morales et al. (2015) for the ELD Initiative, based in the Piura region of Peru. It highlights the net primary production trend, based on information obtained from the World Atlas of Desertification by the Joint Research Centre of the European Commission and Piura Regional Government. Authors compared the trend between 1982 and 2009, and calculated an index by overlaying the different datasets in GIS with land degradation (erosion) that was associated with high slopes. Shaded areas represent levels of degradation within the different districts – information that was obtained from the regional government of Piura and adapted through local stakeholder workshops. Overlaying these various GIS datasets helped to validate and confirm the findings of participatory consultations on the ground.



Other examples of GIS use in the ELD Initiative include the study by Hurni et al., 2014, the ongoing work of the ELD Working Group on Data and Methodology (see for example, Turner et al., 2015), and ELD case studies in Central Asia that are on-going (expected to be published late 2015).

03 Types of ecosystem services

This step involves refining the analysis within agro-ecological zones and assessing the type and state of ecosystems services stocks and flows for each land cover category (Fisher & Turner, 2008) that has been identified for the study in the previous two steps. Agro-ecological ecosystem categorisation can be based on the ecosystem service framework of the Millennium Ecosystems Assessment (2005), i.e., provisioning, regulating, cultural, and supporting services (*Box 4*). In general, ecosystem services have been valued through a range of valuation methods following methodological developments, varying study objectives, and data availability constraints, with little attention paid to the non-use value, in particular of cultural services (Quillérou & Thomas, 2012).

A range of tools have been released for assessing ecosystem services (see ELD Initiative Scientific Interim Report (2013), pg. 42), such as the Natural Capital Project's Integrated Valuation of Environmental Services and Tradeoffs (InVEST) tool or the ARtificial Intelligence for Ecosystem Services (ARIES) modelling platform. These tools aim to help map ecosystem service provision and model their evolution with time, associate them to an economic value, identify scenarios, and help decision-makers assess trade-offs between these scenarios for informed decision-making. GLUES (Global Assessment of Land Use Dynamics, Greenhouse Gas Emissions and Ecosystem Services) is a project led by the German Ministry of Education and Research that publicly shares datasets and data related to sustainable land management and optimal use of land and land services. The Australian Investment Framework for Environmental Resources (INFFER) is a privately operated system that aims to develop and prioritise projects

addressing environmental issues such as reduced water quality, biodiversity, environmental pests, and land degradation. MIMES (Multiscale Integrated Models of Ecosystem Services) is an initiative lead by the University of Vermont which also aims to evaluate ecosystem services. TESSA (Toolkit for Ecosystem Service at Site-based Assessment) compares the net changes of estimates of alternative land use scenarios (e.g., before and after changes in land use) and assesses the benefits for human well-being that may be gained or lost. ESR (Corporate Ecosystem Services Review) provides a method in developing strategies to manage business risks and opportunities linked to a company's dependence on ecosystems and their services.

Some of these assessment techniques are summarised in *Table 2*, together with their features (e.g., scope and data demand) and resource requirement (i.e., skills, knowledge, time, manpower, and cost).

BOX 4

Examples of ecosystem services

There are four general types of ecosystem services (Turner et al., 2015):

- **Provisioning services** – these services combine with built, human, and social capitals, resulting in food, timber, fibre, water, fuel, minerals, building materials and shelter, biodiversity and genetic resources, or other 'provisioning' benefits. For example, grains are delivered to people as food, but require tools (built capital), farmers (human capital), and farming communities (social capital) to produce.

- **Regulating services** – these combine with t built, human, and social capital to regulate processes such as climatic events with water flow regulation (e.g., for increased flood or drought control, storm protection), pollution control, decrease in soil erosion, nutrient cycling, human disease regulation, water purification, air quality maintenance, pollination, pest control, and climate control with carbon storage and sequestration. For example, storm protection by coastal wetlands requires built infrastructure, people, and communities to be protected. These services are generally not marketed but have clear and direct value to society.

- **Cultural services** – these combine with built, human, and social capital to produce more material benefits linked to recreation (tourism) and hunting as well as non-material benefits such as spiritual or aesthetic, education, cultural identity, sense of place, or other 'cultural' benefits. For example, production of a recreational benefit requires a beautiful natural asset (a mountain), in combination with built infrastructure (a road, trail, etc.), human capital (people able to appreciate the mountain experience), and social capital (family, friends and institutions that make the mountain accessible and safe). Such cultural services would tend to be mostly experienced through tourism or religious practices.

- **Supporting services** – these maintain basic ecosystem processes and functions such as soil formation, primary productivity, biogeochemistry, soil formation, and nutrient cycling. They affect human well-being indirectly by maintaining processes necessary for provisioning, regulating, and cultural services. For example, net primary production is an ecosystem function that supports climate control through carbon sequestration and removal from the atmosphere, which combines with built, human, and social capital to provide climate regulation benefits. Some argue that these supporting 'services' should be rather defined as ecosystem 'functions', since they have not yet clearly interacted with the other three forms of capital to create benefits in terms of increased human well-being but that support or underlie these benefits. Supporting ecosystem services may sometimes be used as proxies for benefits when the benefits cannot be easily measured directly.

For examples of ecosystem service categorisation, see Haines-Young & Potschin (2012) and Maes et al., (2013).

TABLE 2

Overview of ecosystem service assessment techniques
(sourced from Peh et al., 2013)

Approach/tool	Description	Feature				Capacity/resources requirement				
		Scope	Data demand	Resolu-tion	Valuation focus	Computing skill	Specialist technical knowledge	Time	Man-power	Cost
Toolkit for Ecosystem Service at Sitebased Assessment (TESSA)	A practical suite of tools for measuring and monitoring ecosystem services at a site scale	Landscape	Low-High	Low-High	Low-High	Intermediate	Low	Low	Low	Low
Assessment Research Infrastructure for Ecosystem Services (ARIES)	A modelling approach for quantifying environmental services and faktors influencing their values, in a geographical area and according to needs and priorities set by its users	Landscape-Global	Low-High	Low-High	Low	Intermediate-High	Low-High	Low	Low	Low
Corporate Ecosystem Services Review (ESR)	A series of questions for developing strategies to manage risks and opportuni-ties arising from the company's depend-adnce on natural resources	Landscape-Global	Low	Low	Low	High	High	Low	Low	High
Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)	A computer-based platform for assessing how distinct scenarios might lead to different ecosystem service and human-wellbeing related outcomes in a geographical area	Landscape-Global	Low-High	Low-High	High	High	High	Low	Low	High
Multi-scale Integrated Models of Ecosystem Services (MIMES)	A suite of models for assessing how distinct managemem scenarios might lead to different ecosystem service and human-wellbeing related outcomes	Landscape-Global	Low-High	Low-High	High	High	High	Low	Low	High
Natura 2000	A tool for assessing the total overall socio-economic benefits and value of a site, and for determining more monetary vallues of individual benefits provided by the site.	Landscape	Low	Low	High	Intermediate	Low	Low	Low	Low

Role of ecosystem services and economic valuation

This step identifies the role of the assessed ecosystems services in the livelihoods of the communities living in each land cover area, and in the overall economic development of the study zone. This requires estimating the total economic value of these services (use and non-use values), to estimate the benefits of action or the cost of inaction (i.e., the maximum benefits from action that could be derived).

Overview of valuation methods

Figure 1 outlines the range of valuation methods that can be used for each sub-component of the total economic value.

Non demand-based methods do not involve the estimation of a demand curve (i.e., a graph that shows the relationship between the price of a service – vertical axis – and the quantity of the service demanded – horizontal axis) for each service and are based on market prices, replacement costs, dose-response estimation, avoided damage costs, mitigation costs and opportunity costs (ELD Initiative, 2013; Favretto et al., 2014a). Methods based on the estimation of the demand curve (demand-based) include revealed preference methods, which rely on actual behaviour in existing markets, and stated preference methods, which estimate the value of services not usually purchased and sold in actual markets. Under the revealed preference, the hedonic price method provides an estimation of the economic value of an ecosystem service from the price paid for something that includes it. The travel cost method estimates how much money the user is willing to pay for travel in order to benefit from an ecosystem service. Under the stated preference methods, contingent valuation is an estimation of the economic value of a service based on the expression of how much people are willing to pay for it (or willing to accept for its reduction), while choice experiment

estimates the economic value of a service based on the preferences of individuals over a range of alternative options presented in a choice set. Benefit transfer provides economic estimates of the value of a service based on data available elsewhere.

The most common methods used to capture the economic value of the different ecosystem service are identified in *Table 3*, as well as the ease of which the ecosystem service translates into values and how the values can be used for sites.

The choice of method varies according to the objective of the study, but also to the availability of data and local capacity to implement each method (Mersmann et al., 2010). In order to choose the appropriate method, it is essential to first decide the type of environmental problem that will be analysed and consider what information is needed to address such problem under a specific method (*Box 5*). This must be followed by an assessment of what information is readily available, the time-frame for collecting any missing data, and the cost of such exercise (ELD Initiative, 2013). An overview of all methods is provided in *Appendix 1*, with a

FIGURE 1

The total economic value concept and existing valuation methods
(ELD Initiative (2013), pg. 33)

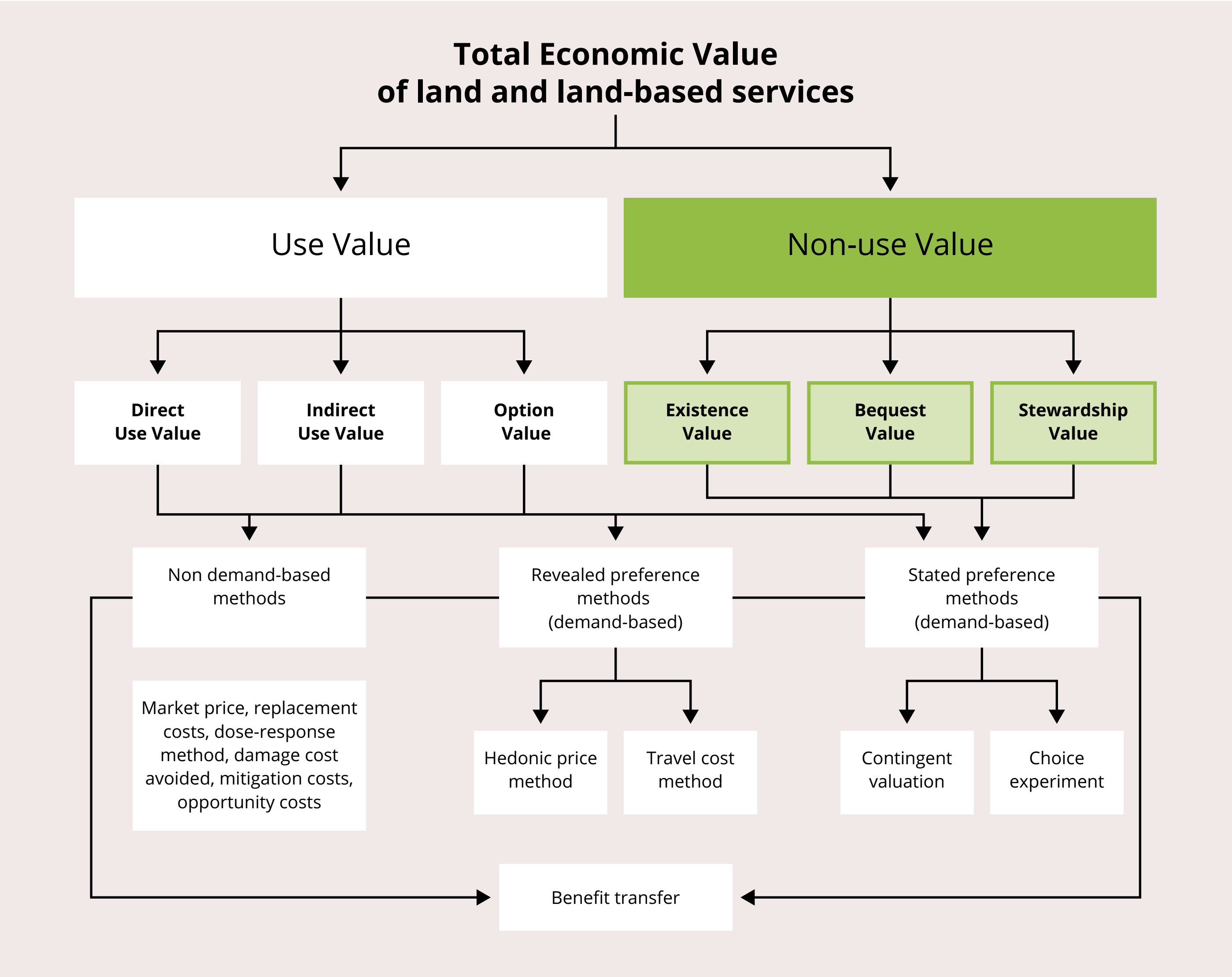


TABLE 3

Valuation methods for the different types of ecosystem services
(from Farber et al., 2006)

Ecosystem service	Amenability to economic valuation	Most appropriate method for valuation	Transfer-ability across sites
Gas regulation	Medium	Contingent valuation, avoided cost, replacement cost	HIgh
Climate regulation	Low	Contingent valuation	High
Disturbance regulation	High	Avoided cost	Medium
Biological regulation	Medium	Avoided cost, production approach	High
Water regulation	High	Avoided cost, replacement cost, hedonic pricing, production approach, contingent valuation	Medium
Soil retention	Medium	Avoided cost, replacement cost, hedonic pricing	Medium
Waste regulation	High	Replacement cost, avoided cost, contingent valuation	Medium to high
Nutrient regulation	Medium	Avoided cost, contingent valuation	Medium
Water supply	High	Avoided cost, replacement cost, market pricing, travel cost	Medium
Food	High	Market pricing, production approach	High
Raw materials	High	Market pricing, production approach	High
Genetic resources	High	Market pricing, avoided cost	Low
Medicinal resources	High	Avoided cost, replacement cost, production approach	High
Ornamental resources	High	Avoided cost, replacement cost, hedonic pricing	Medium
Recreation	High	Travel cost, contingent valuation, ranking	Low
Aesthetics	High	Hedonic pricing, contingent valuation, travel cost, ranking	Low
Science and education	Low	Ranking	High
Spiritual and historic	Low	Contingent valuation, ranking	Low

description of the steps in implementing them, the type of economic value captured, some examples, and their advantages and disadvantages. The 2014 ELD MOOC course content[2] details those methods with supporting examples found in the ELD Practitioner's Guide (2014).

Advantages and risks of economic valuations

Economic valuation can help measure ecosystem services that do not have a market price but still play indirect roles in the market. They can combine non-use values (which are normally difficult to quantify) with use-values, giving a holistic societal perspective rather than a purely market-based financial one. These integrations can provide useful insights for novel and alternative market establishment and development.

It must be noted that non-use values may not always be easily materialised in actual financial capital. Potential biases in the assessment of economic values (e.g., in the estimates of the willingness to pay) may lead to overly high expectations over future financial gains and lead to loss of stakeholder motivation when promised/expected gains do not materialise. These approaches may be unable to fully capture the shared and cultural dimensions of sustainable land management (Reed et al., 2014).

2 *2014 ELD MOOC course material can be found at http://mooc.eld-initiative.org/*

BOX 5

Ecosystem services valuation in Sudan

An ELD Initiative study performed by IUCN took place in 2014 in Gedaref, Sudan (Aymeric et al., 2014). Researchers set out to assess the value of sustainable land management in a future scenario that integrated agroforestry, when compared to the baseline ('business-as-usual') scenario. Historically, the area of Gedaref was known as a breadbasket, but the past few decades saw unsustainable agriculture practices like near-monocropping and low nutrient replenishment. These practices lead to land degradation, which significantly impacts ecosystem function and provisioning of ecosystem services.

To assess a pathway forward in Gedaref that was suitable for both economic and environmental health, authors performed an ex-ante cost-benefit analysis to compare the ecosystem services and economic impact of the future landscape restoration scenario against the baseline scenario. The restoration scenario they proposed was agroforestry, using *Acacia senegal*, known for its soil nitrogen enhancing properties and production of gum Arabic (for which there is demand on the international market), intermixed with sorghum, Sudan's primary staple crop. This scenario would ideally support both economic and environmental health. To estimate potential societal net benefits, a household survey was implemented in the village of Um Sagata, where over a hundred surveys were provided. These were complemented by detailed land use and land cover classification maps based on biophysical production functions using AquaCrop (an integrated soil and water balance model) and a soil and water assessment tool (ArcSWAT) with a GIS plugin. Ecosystem services assessed included impacts of land use change on yields and productivity, groundwater infiltration, water runoff, and carbon sequestration.

Authors found that the aggregate value of all ecosystem services provided by sustainable land management interventions, as outlined in the future landscape restoration scenario, provides 1.3 billion USD for the entire watershed. The valuation methods used and related ecosystem services that were assessed are outlined below.

Type of valuation method	Purpose of valuation method	Ecosystem service assessed
Productivity change	Estimates economic values of ecosystem services that contribute to the production of commercially marketed goods	Differences in yields with or without soil erosion, as measured by soil moisture and nitrogen fixation
Market price	Estimates economic values of ecosystem services that are bought/sold in commercial markets	Financial values of changes in supplies of fuelwood and gum Arabic
Avoided damage and replacement cost	Estimates economic values of ecosystem services from either avoiding damages from lost services or the cost of replacing them	Enhanced soil moisture and nitrogen fixation, and carbon sequestration (for avoided damage) and groundwater recharge functions (for replacement costs)

Further examples of ecosystem services valuation can be found in Nelson et al. (2009), de Groot et al. (2012), and the ELD Practitioner's Guide (2014).

Patterns and pressures

This step involves the identification of land degradation patterns, and drivers and pressures on the sustainable management of land resources. It includes the spatial distribution of such resources and the assessment of factors causing degradation. This information is needed to inform the development of alternative scenarios for cost-benefit analyses that will be carried out under Step 6 (*Box 6*).

BOX 6

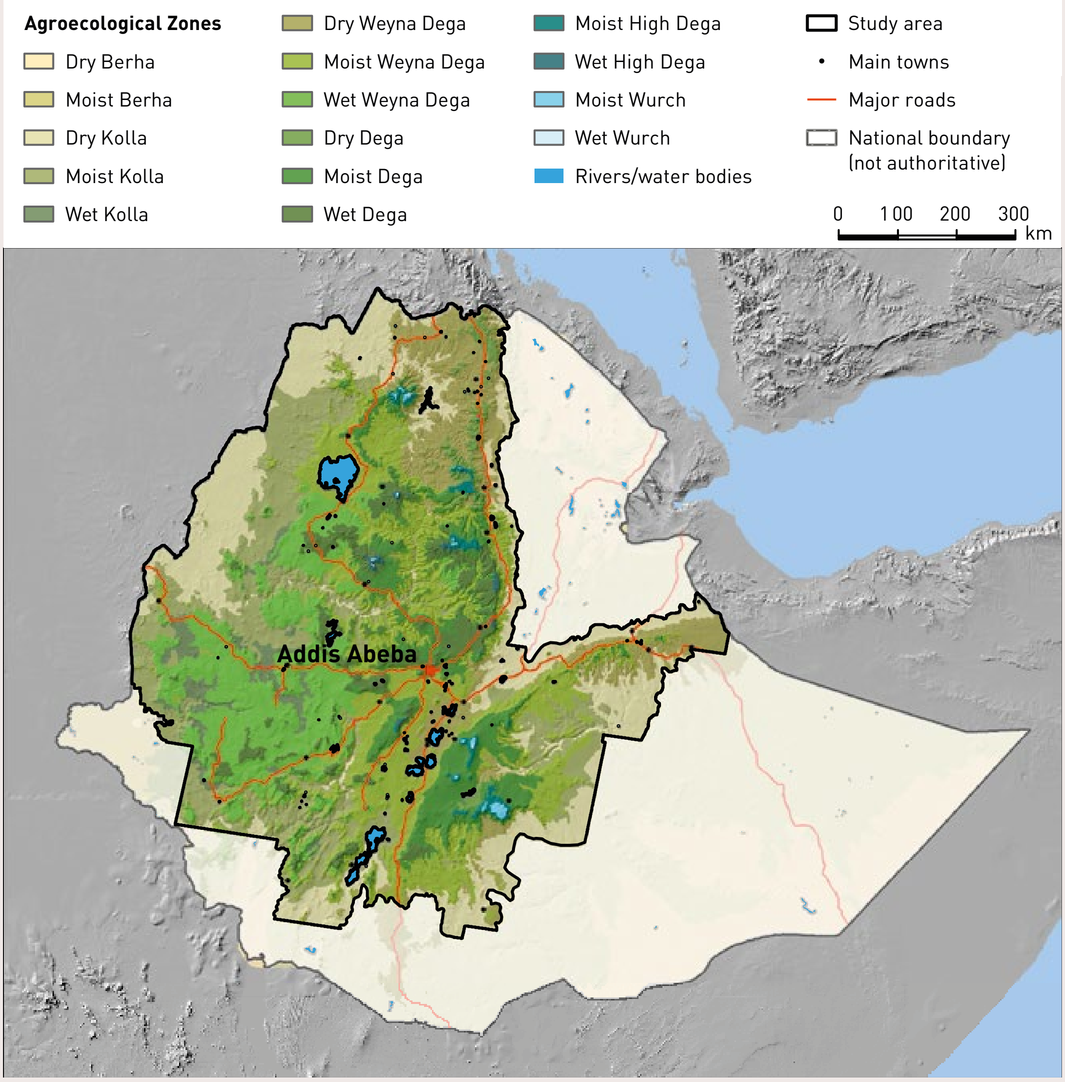
Scenario planning in Ethiopia

The ELD Ethiopia case study performed by Hurni et al. (2014) (*see Box 2*) covered an area of 614,000 km^2 (or 54 per cent of the country) where rainfed agriculture is practised. By using Landsat imagery and the Homogenous Image Classification Units (HICUs) approach, a high-resolution land cover map was produced using 50 cover types from forest to grassland, from cropland to settlement, from bare land to water body (*Figure 2*). Multiple information sources were used in the HICU development, including altitude, terrain, farming system, rainfall pattern and soil.

BOX 6 (CONT)

FIGURE 2

Land cover types of the study area in the ELD Ethiopia Case Study
(Hurni et al.. 2015)



The occurrence of soil and water conservation structures and fertiliser application on cropland in the case study area was modelled, and a database including the information required to model soil erosion and deposition was created. Erosion and deposition estimates were then derived using a USPED model, and the resulting maps are outline in *Figure 3*.

This allowed for the estimation of crop production and ultimately, the identification of 8 scenarios to be used for the cost-benefit analysis, including business as usual, increased fertiliser use, planting suitable fodder grasses, etc. (*Table 4*).

Using conservation structures as the basis for comparison, crop production was estimated for each scenario over the next 30 years with ‘business-as-usual’ (Scenario 1) associated with the lowest productivity, and the highest potential was found in optimal growth conditions (Scenario 4).

BOX 6 (CONT)

FIGURE 3

Estimated net erosion/deposition from the USPED model for the ELD Ethiopia Case Study area

(Hurni et al., 2015)

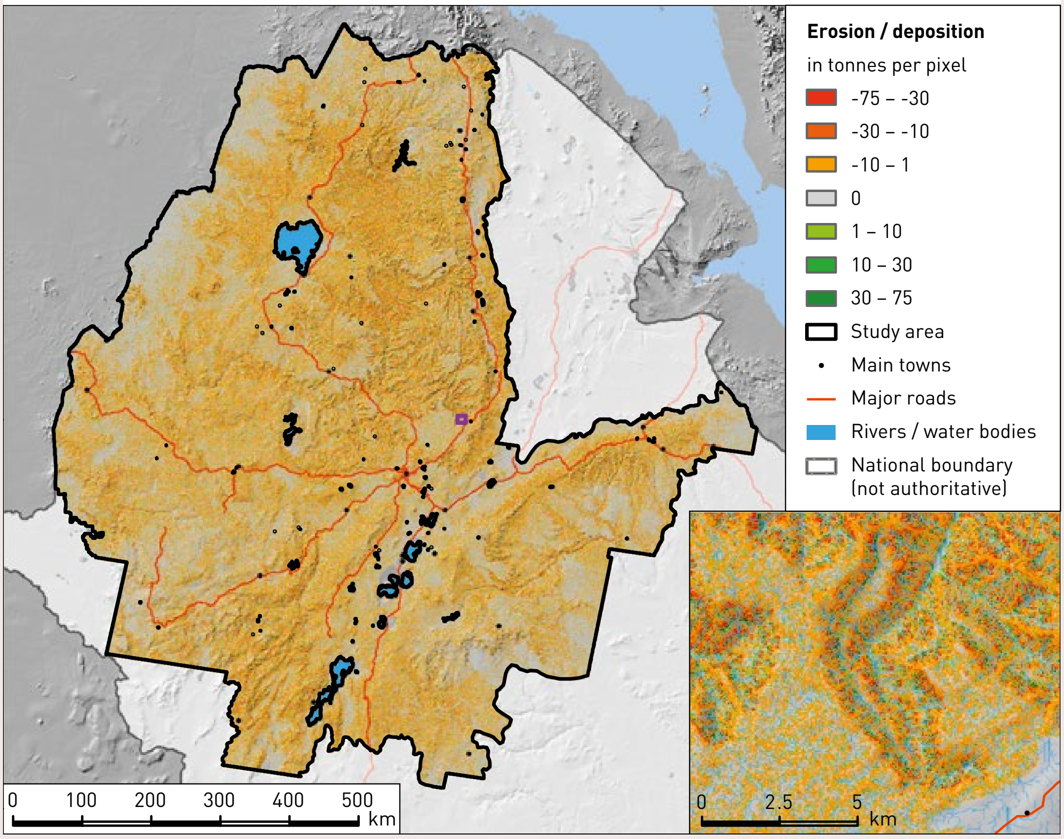


TABLE 4

Systematic overview of scenarios on rainfed croplands in Ethiopia

Scenario	Current conservation structures on cropland	Conservation structures on all cropland	Currently fertilized croplands	Fertilizer on all cropland	Grasses on current conservation structures	Grasses on all conservation structures
1	×		×			
2	×		×		×	
3	×			×		
4	×			×	×	
5		×	×			
6		×	×			×
7		×		×		
8		×		×		×

Further readings: Kosmas et al. (2013), Sheperd et al. (2013)

06 Cost-benefit analysis and decision-making

This step involves the assessment of sustainable land management options that can reduce or remove degradation pressures, including analysis of their economic viability and identification of locations for which they are suitable. Cost-benefit analyses are used for this purpose, as it compares the costs of adopting a sustainable land management practice against the benefits derived from it (ELD Initiative, 2013). Such costs and benefits are estimated using the methods detailed in Step 4, and depend upon the level of action taken and changes achieved. By detracting costs from benefits, the net economic benefit from action can be determined.

Key steps in performing a cost-benefit analysis include (Snell, 2011):

(i) Definition of the target group to be guided or informed;
(ii) Definition of criteria: the timeframe for analysis and categories of benefits and costs must be defined in advance. A discount rate is also needed to be able to compare the costs and benefits in time and produce three indicators of success (i.e., net present value, internal rate of return, and benefit-to-cost ratio) to assess whether the action is financially (or economically) worth undertaking;
(iii) Calculating economic benefits and costs under alternative scenarios (e.g., business-as-usual or changes in land use);
(iv) Comparing net benefits of action to net benefits from business-as-usual to estimate the 'added value' of action compared to what is already being done;
(v) Deriving economic indicators of viability to assess whether an action is worth taking from an economic point of view; and,
(vi) Undertaking a sensitivity analysis to determine the degree and impact of uncertainty.

An example of how cost-benefit analyses can be applied to scenario planning is provided by the ELD Ethiopia Case Study (*Box 7*).

BOX 7

Cost-benefit analysis in Ethiopia: Estimating and mapping net present values for several land management alternatives

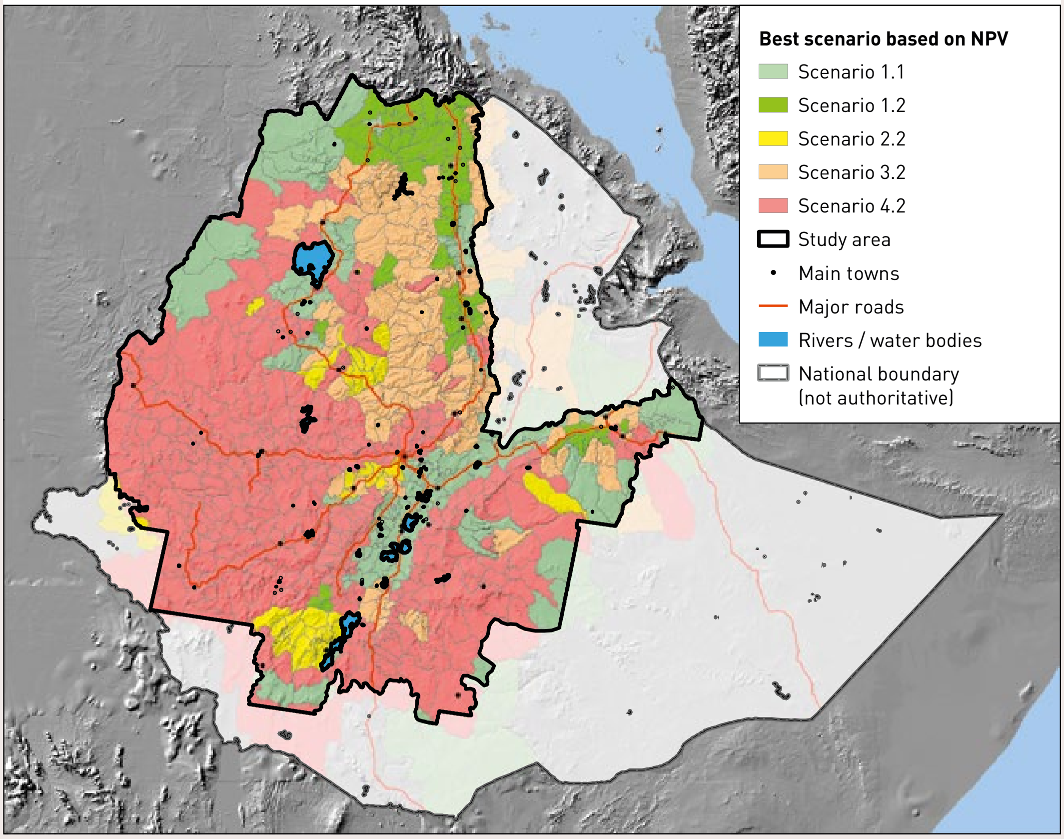
The ELD Initiative case study in the Ethiopian Highlands (mentioned previously) also provides a case example for comparing different cost-benefit analyses across scenarios to determine the most optimal scenario.

Using conservation structures as the basis for comparison, authors developed a matrix of eight possible scenarios using combinations of current and future fertiliser and grass applications. Crop production was then estimated for each scenario over the next 30 years. The analysis showed that 'business-as-usual' (Scenario 1) showed the lowest productivity, whereas the highest potential was found in optimal growth conditions (Scenario 4).

Authors then applied a cost-benefit analysis to each of the proposed scenarios across different regions to determine the added profitability and economic viability of each management option compared to 'business as usual', using a 12.5 per cent discount rate. They found that the most optimal scenario actually varied across the regions, depending on which situation already existed in situ. For example, some areas have shallow soils, so fertiliser application would have limited effects that would not necessarily offset the costs, whereas in other areas it would. Maps from the study help to visualise which option would lead to the most net economic benefit in different locations (*Figure 4*).

FIGURE 4

The best scenario based on net present value (NPV) for different regions in the ELD Ethiopia Case Study area
(Hurni et al., 2015)



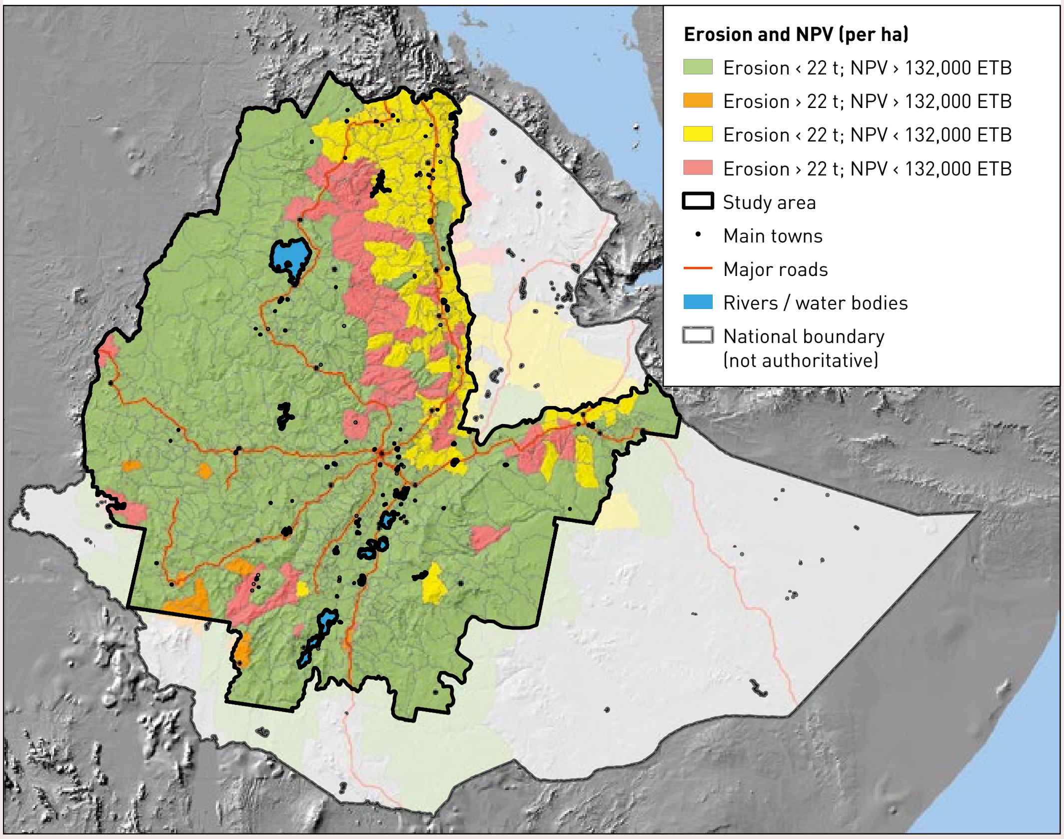
BOX 7 (CONT)

Beyond just comparing the scenarios, authors also looked at the relationship between current soil erosion rates and net present value for the determined best management option. This type of information can be useful in planning and prioritising development interventions to reduce soil erosion or other aspects of land degradation. For example, areas with high erosion rates and high net present values could be prioritised for action.

FIGURE 5

Combination of the most optimal scenario's net present value with current soil erosion rates

(Hurni et al., 2015)



Detailed readings on the use of cost-benefit analysis can be seen in: Boardman et al. (1996), and Zerbe (2008).

One of the major strengths of cost-benefit analyses is that by quantifying everything homogeneously (in monetary units), it allows for direct comparisons between costs and benefits across different scenarios. This can help provide an idea of the scale of desired implementation (e.g., from a village market to international trade) and also to identify the most economically efficient and sustainable practice for a given scientific, political, legal, cultural, or social context. As a result, cost-benefit analyses can be used to simulate the impact of and dimension economic incentives or policy instruments for sustainable land management (ELD Initiative, 2013).

Scenarios that derive maximum benefits from action can be based on optimistic assumptions (e.g., there are/will be no implementation barriers, everyone collaborates and shares the same ideas about sustainability, etc.). Optimally determined scenarios should be thus used as a guiding ideal, but analyses must stress what can be feasibly achieved in the real world, without creating false expectations of potential benefits.

BOX 8

Alternatives to current rice and mango production practices in the Piura region: benefit-to-cost ratios
(Barrionuevo, 2015)

This study compares the costs of action to the benefits from action for rice and mango production in the Piura region, both dominating agricultural production in the region.

Rice production in the Piura region is affected by soil salinisation, which reduces crop yields. Two more sustainable land management alternatives are considered for economic assessment of benefit-to-cost ratios: horizontal desalination for rice production and replacing rice by quinoa production. The first option is very costly and not really economically attractive. The economic potential of quinoa production is very attractive but depends on demand for quinoa and its market price.

Mango production in the Piura region constitutes 75 per cent of mango exports of Peru. Organic production is seen as helping to reduce soil erosion and salinisation, and improve water retention capacity. Organic produce is in demand and is the first alternative to current production practices considered. The second alternative is mango production as part of an agro-forestry system. Both are financially viable but agro-forestry has higher profitability.

This study did not rely on a full cost-benefit analysis because investment costs were not available, but gives an idea of profitability once the investment has been made.

+1

Take action: change, adapt and facilitate

This final step is the actual implementation of the most economically desirable option(s) and is the responsibility of private and public decision-makers rather than scientists. This requires actions by both land users (e.g., change of land management practices for more economically beneficial ones) and policy and public decision-makers (e.g., adapting the legal, political, and economic contexts to enable the adoption of the most economically desirable option(s), and removing existing barriers to adoption).

These actions can target either the state or process of land degradation. If the target land is already degraded (state), then there is a need to invest in restoration. If it is being degraded (process), then actions are needed to invest into reducing the rate of land degradation. Overall, investments into improvement of land productivity may encompass the following: (i) investment into restoration or rehabilitation of degraded land (state); (ii) investment into reduction of degrading land (pace of land degradation, process); and (iii) improvement in productivity in non-degraded land.

Working at different scales and engaging inclusively with multiple stakeholders is required when taking action, in order for maximum impact and effectiveness to be achieved. Local participation must be ensured through review and integration of the different approaches and decisions by local actors. To that end, multi-criteria decision analyses have been proven as a useful facilitation tool to promote local participation and stakeholder engagement (see *Box 9*).

BOX 9

Use of multi-criteria decision analysis to engage with stakeholders in drylands' research in Botswana

(Favretto et al., 2014b)

Multi-criteria decision analysis (MCDA) was used in Botswana to engage with local stakeholders in the assessments of the socio-economic and environmental dimensions of land degradation in the southern Kalahari District. Alternative land use options (i.e., communal grazing areas, private cattle ranches, private game ranches, and wildlife management areas) were ranked through MCDA by quantifying, scoring and weighting a range of quantitative and qualitative criteria. The criteria corresponded to the key ecosystem services mapped in the study area, for which their use and non-use values were translated into a homogenous MCDA score. MCDA proved as a useful tool to engage with stakeholders throughout the following phases of research:

- **Research design.** Alternative options (including their indicators – defined as criteria – and their weights) to be valued can be identified in the initial stage of research through a group consultation. In this study, weights for each criterion were defined as an outcome of group interaction through a policy workshop held in Gaborone, where local experts from different sectors (i.e., policy-making, international organisations, and civil society) provided their perspectives through a questionnaire. Ratings (i.e. criteria weights) were obtained on a 9-point scale ranging from most important (9) to least important (1) criteria. The individual priorities of each stakeholder were then aggregated into a single representative weight for the entire group.
- **Planning.** Study sites were identified in cooperation with local actors (e.g., government representatives and village committees).
- **Data collection.** Local knowledge is recognised as a key source of information on land use practices and environmental change. It was assessed through MCDA by using multiple research methods (including semi-structured interviews with the farming community).
- **Implementation.** The policy workshop allowed for the dissemination of findings, as well as to gather feedback and discuss the findings with input from a policy audience. Research gaps were identified and a future research agenda was elaborated.

Based on the lessons learnt from the use of MCDA for stakeholders' engagement, the following 'secrets' to success of well-designed participation can be derived:

- Identify key people and organisations (develop a set of shared and achievable goals);
- Be a good facilitator and create an engaging atmosphere;
- Make it relevant: negotiate which outputs the stakeholders want to get out of their participation.

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Appendix – Economic valuation methods

(Adapted from Adhikari & Nadella 2011, pgs. 138 – 139; Nkonya et al. 2011, pg. 72; Requier-Desjardins, et al. 2011, pgs. 287 – 289)

Method	Description	Steps in implementing the method	Type of economic value captured	Example	Data and methods: Advantages	Data and methods: Limitations
Non demand-based						
Market price	Gives an estimate of the total economic value (people's actual willingness to pay) in theory, often of the direct use value in practice	▪ Costs to buy or sell a good or product ▪ Collect market data on prices ▪ Estimate quantity consumed/sold ▪ Multiply price by quantity	Total economic value in theory (in practice, use value)	Crop prices	**Method:** direct estimation of value, associated to actual money flows	**Method:** missing or distorted markets
					Data: market prices can be recorded easily	**Data:** market prices can be missing or inaccurately recorded
Replacement costs	Estimates the costs of replacing ecosystem services and goods	▪ Ascertain benefits associated with good/service ▪ Identify most likely alternative to provide equivalent level of benefits ▪ Calculate costs of installing and running replacement	Use value	Costs of fertilisers to replenish soil nutrients	**Method:** easy to implement	**Method:** the assumption that the artificial replacement is equivalent may not be true and the replacement cost may only reflect part of the total economic value.
					Data: market prices of replacements can be recorded easily	**Data:** replacement costs can be incomplete or inaccurately recorded

Method	Description	Steps in implementing the method	Type of economic value captured	Example	Data and methods: Advantages	Data and methods: Limitations
Dose-response	Estimates by how much price or quantity change for a change in production inputs quantity. Also called production function–based or productivity change approaches.	▪ Determine contribution of good/service to related source of production ▪ Specify relationship between changes in good/service and changes in related output ▪ Relate change in provision of good/service to physical change in output ▪ Estimate market value of change in production	Use value	Estimation of changes in crop yields (causing losses in agricultural profits) for a change in fertiliser quantity.	**Method:** easy to implement in a production setting, with clear inputs and outputs relationships	**Method:** the relationship between change in ecosystem services (dose) and production (response) is not always easy to model or estimate, and may not be applicable in different settings
					Data: based on biophysical data with records often available in a production setting	**Data:** fairly data intensive to build a model
Damage cost avoided	Estimates the use value of the avoided costs of land degradation	▪ Identify protective functions of good/service ▪ Identify damages caused by loss of different degrees of protection ▪ Locate infrastructure, output, or population that would be affected ▪ Obtain information on likelihood and frequency of damage occurring ▪ Cost damages associated with given loss of good/service	Use value (indirect)	Benefits from reduced (avoided) silting of watercourses, reduced (avoided) coastal erosion	**Method:** easy to implement	**Method:** prone to overestimation. Avoided damage costs may not be equal to economic benefits. It is not always easy to estimate because it has been avoided (hypothetical situation)
					Data: based on a mix of biophysical and economic data	**Data:** avoided damage costs can be difficult to measure (hypothetical situation)

Method	Description	Steps in implementing the method	Type of economic value captured	Example	Data and methods: Advantages	Data and methods: Limitations
Mitigation costs	Estimates the use value as the costs of mitigating or averting the loss of ecosystem good or service	▪ Identify hazards arising from loss of good/service ▪ Locate area and population that would be affected ▪ Obtain information on peoples responses and measures taken to cope with effects of loss ▪ Cost the mitigation response	Use value (indirect)	Costs of maintaining hedges or dry stone walls to reduce soil erosion	**Method:** easy to implement **Data:** easy to measure	**Method:** prone to overestimation **Data:** mitigation costs can be incomplete or inaccurately recorded
Opportunity costs	Estimates use value as the profit made under the next best alternative land use	▪ Identify the next best alternative land-use ▪ Estimate costs and benefits of this next best alternative ▪ Calculate the forgone profit from this next best alternative as the measure of opportunity costs	Use value	The opportunity cost of a forest stand is the profit from agricultural production that could be made by converting forested land to agriculture. This opportunity cost is usually lower than the economic value of current land use (forest), or the land would already be converted to agriculture	**Method:** allows to consider alternative land uses considering that the current one is the most economically profitable **Data:** easy to measure for existing nearby alternative land uses	**Method:** second-best alternative underestimates the benefits from the current (first-best) one **Data:** alternative land use costs and benefits can be difficult to transfer to a given context (hypothetical situation)

Method	Description	Steps in implementing the method	Type of economic value captured	Example	Data and methods: Advantages	Data and methods: Limitations
Demand-based methods: Revealed preference (use value)						
Hedonic price method	Estimates use value as a proportion of surrogate market prices	▪ Find a surrogate market where the value of the good or service to be valued is embedded into ▪ Identify characteristics that influence the surrogate good market price ▪ Decompose the price of the surrogate market good into individual characteristic prices ▪ Estimate the demand curve and compute the willingness to pay. Alternatively, take the unit price for the good or service to be valued.	Use value	Value of a nearby park or sea view captured in house prices to determine entry fee or tax level	**Method:** relies on an existing surrogate market **Data:** can be easy to obtain	**Method:** the surrogate market may be distorted or imperfectly recorded, and may imperfectly capture the use value of the good or service to value **Data:** may be incomplete or inaccurately recorded
Travel cost method	Uses travel costs to estimate use value	▪ Identify area from which visitors come, how much time and money they spent to get to the area to be valued, and their socio-economic characteristics ▪ Estimate the cost of one trip as a function of the number of visitors, travel costs, travel time, and visitors socio-economic characteristics ▪ Introduce a hypothetical entry fee and calculate the expected number of visitors from the new total cost (demand curve) ▪ Calculate consumer surplus from this demand curve	Use value	Value of a national park inferred from observed travel costs to set an entry fee	**Method:** can be easily implemented through a survey of visitors at a given geographical spot **Data:** easy to collect through survey of visitors	**Method:** limited to recreational benefits linked to a trip **Data:** dedicated database which is specific to a given site and time of survey

Method	Description	Steps in implementing the method	Type of economic value captured	Example	Data and methods: Advantages	Data and methods: Limitations
Demand-based methods: Stated preference (Total Economic Value)						
Contingent valuation	Estimates the economic value from stated amount people are willing to pay (or accept)	Survey of respondents: ▪ Present a hypothetical situation describing the environmental good or service, the institutional context, and payment means (tax, fee) in a credible way ▪ Ask respondents their willingness to pay (accept) for an increase (loss) in good or service ▪ Draw up a frequency distribution relating willingness to pay (accept) statements to number of people making them ▪ Cross tabulate willingness to pay (accept) responses with explanatory variables (income, age, education) ▪ Carry out multivariate analysis to correlate responses to explanatory variables ▪ Sum up sample results	Total economic value	Stated value of a nearby park, biodiversity hotspot, symbolic species (blue whale, tigers, mountain gorillas, pandas)	**Method:** easy to understand and implement	**Method:** is prone to many biases, often leads to overestimating the actual willingness to pay, and does not allow to estimate trade-offs between different goods or services
					Data: easy to collect through survey or focus groups	**Data:** dedicated database which is specific to a given site and time of survey

Method	Description	Steps in implementing the method	Type of economic value captured	Example	Data and methods: Advantages	Data and methods: Limitations
Choice experiment	Estimate the economic value from stated willingness to pay (or willingness to accept) for a range of attributes (liked to the same or other economic activities) and the trade-offs between them.	Survey of respondents: ■ Present a hypothetical situation describing the environmental good or service, the institutional context and payment means (tax, fee) in a credible way ■ Establish alternative options, each of which are defined by various attributes and a price ■ Design unique choice cards by selecting combinations of alternative options. The respondent should choose only one option from each choice card ■ Aggregate results and estimate willingness to pay overall and for each attribute	Total economic value	Trade-offs between conservation measures such as the preservation of emblematic species, a biodiversity hotspot or a nearby park, and other economic activities such as agricultural production or mining	**Method:** only method that allows for the estimation of both total economic value, and trade-offs between goods and services **Data:** complete dataset	**Method:** potential biases; context specific **Data:** very data intensive
Benefit transfer						
Benefit transfer	Results obtained in a specific context are transferred to another comparable site	■ Identify "source" site(s), that is, the site(s) from which the economic value will be transferred from, and their characteristics (income levels, type of land use, area covered, type of area: hot spot or other, geography) ■ Estimate the willingness to pay as a function of the source site(s) characteristics ■ Use the characteristics of the site to be valued in the willingness to pay equation obtained and derive the willingness to pay	Depends on the method used in the original context, before transfer	The value of a biodiversity hotspot is estimated from values of several other biodiversity hotspots and adjusting for specific characteristics (size, income level of stakeholders, etc.).	**Method:** easy to conceptualise and implement **Data:** based on data available in previous studies and does not require primary data collection	**Method:** can be very data intensive. Results can be inaccurate depending on how different social preferences in different places are, and economies of scale and scope. **Data:** previous study results can be biased

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