The Economics of Land Degradation

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List of Abbreviations

ASSOD	Assessment of Soil Degradation in Asia and Southeast Asia
AVHRR	Advanced Very High Resolution Radiometer
BMZ	German Federal Ministry for Economic Cooperation and Development
CIESIN	Center for International Earth Science Information Network
DEFRA	Department for Environment, Food and Rural Affairs
ELD	Economics of Land Degradation
EU	European Union
FAO	United Nation's Food and Agriculture Organization
FGV	Fundação Getulio Vargas
GDP	Gross domestic product
GIMMS	Global Inventory Modeling and Mapping Studies
GIS	Geographic Information System
GLADA	Global Land Degradation Assessment
GLADIS	Global Land Degradation Information System
GLASOD	Global Assessment of Human-Induced Land Degradation
IFPRI	International Center for Food Policy Research
ISRIC	International Soil Reference and Information Center
NDVI	Normalized Differenced Vegetation Index
NENA	Near East and North Africa
NOAA	U.S. National Oceanic and Atmospheric Association
NPP	Net Primary Production
PES	Payment for Ecosystem Services
SSA	Sub-Saharan Africa
SLM	Sustainable Land Management
SOVEUR	Soil Degradation and Vulnerability Assessment for Central and Eastern Europe
UNCCD	United Nations Convention to Combat Desertification
UNCOD	United Nations Conference on Desertification
UNEP	United Nations Environment Program

USA	United States of America
USD	United States Dollars
USDA-NRCS	United States Department of Agriculture, Natural Resources Conservation Service
WOCAT	World Overview of Conservation Approaches and Technologies
ZEF	Center for Development Research, University of Bonn

Abstract

Healthy soils are essential for sustaining economies and human livelihoods. In spite of this, the key ecosystem services provided by soils have usually been taken for granted and their true value – beyond market value – is being underrated. This pattern of undervaluation of soils is about to change in view of rapidly raising land prices, which is the result of increased shortage of land and raising output prices that drive implicit prices of land (with access to water) upward. Moreover, the value of soil related ecosystems services is being better understood and increasingly valued.

It is estimated that about a quarter of global land area is degraded, affecting about 1.5 billion people in all agro-ecologies around the world. Land degradation has its highest toll on the livelihoods and well-being of the poorest households in the rural areas of developing countries. Vicious circles of poverty and land degradation, as well as transmission effects from rural poverty and food insecurity to national economies, critically hamper their development process.

Despite the need for preventing and reversing land degradation, the problem has yet to be appropriately addressed. Policy action for sustainable land use is lacking, and a policy framework for action is missing. Key objectives of this Issue Paper and of a proposed related global assessment of the Economics of Land Degradation (ELD) are: first, to raise awareness about the need for and role of an assessment of the economic, social and environmental costs of land degradation; and second, to propose and illustrate a scientific framework to conduct such an assessment, based on the costs of action versus inaction against land degradation. Preliminary findings suggest, that the costs of inaction are much higher than the costs of action.

Key words: Economics of Land Degradation, ecosystem services, land degradation neutrality

Introduction

Healthy soils are essential for sustaining economies and people's livelihoods. They provide a wide range of services including provisioning services such as food production, supporting services such as nutrient cycling, regulating services such as carbon sequestration, and cultural services such as heritage. In spite of this, for a long time, the true value of soils has been underappreciated and in particular the ecosystem services they provide have been taken for granted.

However, during the last two decades, a confluence of several factors is bringing about a fundamental paradigm shift in the perceptions of the value of soil resources. The key driving forces of these changes are increasing demand for food, feed, and other uses of biomass, such as for energy, in the new bio-economy age, whereas the land resources are limited. The global consumption of only wheat and maize has increased by about 48% and 112%, respectively, since 1980 (FAOSTAT 2012). During the same period, the global population has increased by about 54%, while average global income per capita has grown by 66% (World Bank 2012). However, the supply of land for agricultural production has remained practically fixed, growing only by about 5% over the last 30 years (ibid.). Critically, the growth rates in crop yields have been slowing down; moreover, the ongoing climate change is forecasted to reduce crop yields in many parts of the world (von Braun 2007, Pingali 2012). In this context, increasing land degradation is something the world simply cannot afford.

Specifically, growing populations with increasing incomes and changing preferences for more animal products-based diets and higher energy consumption are driving up the prices for food, fuel and fiber, consequently leading to higher prices for land and water resources. Moreover, food, energy, land, water, mineral and financial markets have become increasingly intertwined. At the same time, the advances in biosciences are making revolutionary changes in how our economies are possibly shaped in a post fossil fuel age, bringing the world into an era of the bioeconomy and green growth. A key feature of the bioeconomic system is that it values the natural capital, including land and soil resources, as an essential building block of the economy, setting its management on the same level as the management of physical, human and other forms of capital.

On the supply side, increasing degradation of land resources in many parts of the world, manifested in numerous forms such as desertification, soil erosion, secondary salinization, waterlogging, overgrazing of pastures, to name a few, is considerably limiting land productivity and its ability to provide ecosystem goods and services. Figure 1 illustrates the hotspots of this productivity loss between 1981 and 2003 worldwide, measured as a reduction in Net Primary Production - the natural fixation of carbon dioxide from the atmosphere to form vegetation - on which the entire life on Earth depends.

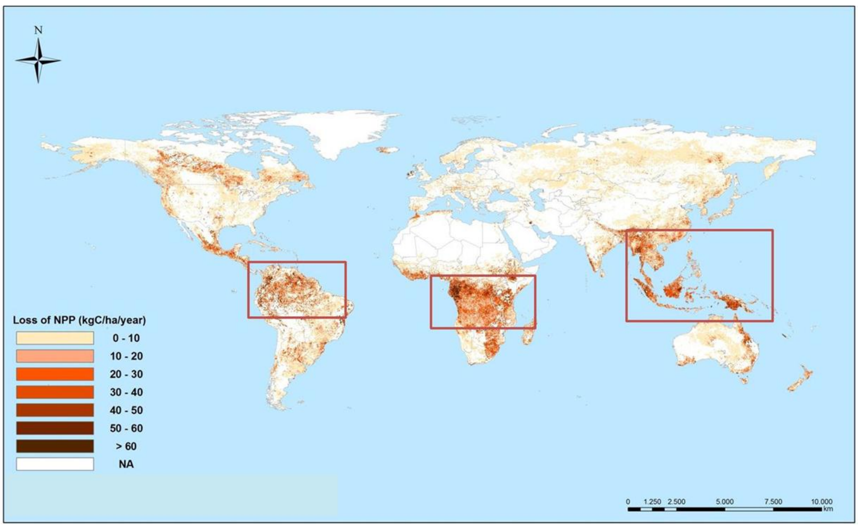


Figure 1. Loss of Net Primary Production between 1981-2003

Cartography: Valerie Graw, in Nkonya et al. (2011); Data Source: FAO GeoNetwork, ISRIC – World Soil Information (2008)

The ongoing climate change is also likely to lead to higher frequency and magnitudes of extreme weather events, such as droughts and floods, putting a further negative pressure on land productivity, especially in tropical and sub-tropical regions of the world. Moreover, climate change

may add yet another layer of complexity to the already highly complicated dynamics of land degradation, as the increased atmospheric fertilization by CO_2 resulting from climate change may mask losses in inherent soil quality due to degradation (Vlek et al. 2010). Thus, the extent and hotspots of human-induced land degradation could be identified more accurately only once the effects of increased atmospheric fertilization are fully incorporated (Figure 2).
Together, all these demand- and supply-side factors are giving rise, though not always smoothly, to a wide-spread recognition of the value of soil fertility as a foundation for future production.

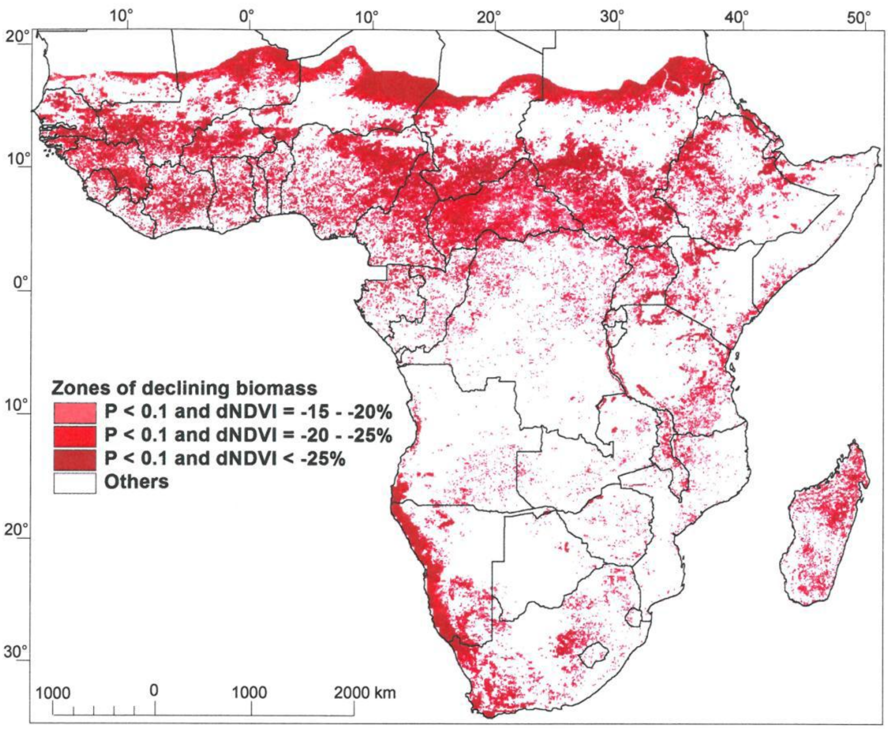
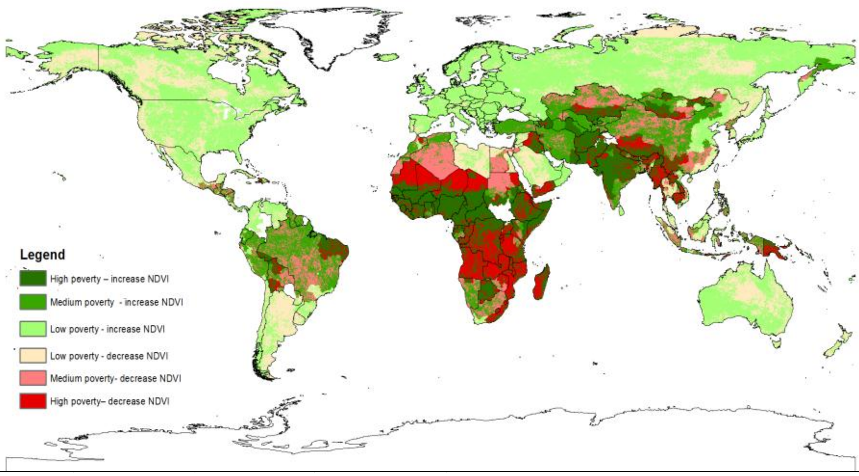


Figure 2. Areas affected by human-induced land degradation in Sub-Saharan Africa

Source: Vlek et al. (2010)

Land degradation is a global problem which affects all of us through higher food prices, potential conflicts and forced migration, and also through lower provision of global ecosystem services, such as, for example, carbon sequestration (Lal 2004). However, the most immediate and costly consequences are felt at the local level, where the poor and vulnerable are hit the hardest. About 42% of the poor around the world depend on degraded and marginal areas for their livelihood, compared with 32% of the moderately poor and 15% of the non-poor (Nachtergaele et al. 2010). However, quite often, the relationship between poverty and land degradation is not uniform, but context-specific (Figure 3). North America, Europe and Australia show low poverty and increase in NDVI, while Africa south of the equator show high poverty and decrease in NDVI.



Variable	Resolution	Baseline	End line	Source of data
NDVI	8km x 8km	1982–84	2003–06	Global Land Cover Facility (www.landcover.org), Tucker, Pinzon, and Brown 2004); NOAA AVHRR NDVI data from GIMMS
Infant Mortality Rate	Sub-district		2005	

Figure 3. Relationship between infant mortality rate and land degradation

Cartography: Zhe Guo. Data sources: Global Land Cover Facility (www.landcover.org), Tucker et al. (2004), NOAA AVHRR NDVI data from GIMMS.

However, NDVI increased in most western and Central African countries north of the equator and south of the Sahelian region. Improvement of government effectiveness and other factors contributed to the improvement of NDVI in areas with severe poverty. Interactions of natural processes, human activities, and social systems play a considerable role in land degradation (Safriel 2007).

Once the land degradation has occurred, it generates negative feedback loops influencing human activities, as well as social and natural processes. Achieving land degradation neutrality, i.e. when the pace of restoring the already degraded land is at least equals, but preferably exceeds, the rate of new land degradation, is thus essential to achieve the Millennium Development Goal of reducing poverty (Lal et al. 2012). The Rio+20 Conference has called for zero land degradation. Without zero net land degradation, it would be also very difficult to meet other global sustainable development targets such as preventing further biodiversity loss, or mitigating and adapting to climate change (ibid.)

Despite these dynamics requiring urgent attention to prevention of land degradation, the problem has not been appropriately addressed, especially in the developing countries. Policy action is lacking, and a policy framework for action is missing. While sound information is available on the natural resource loss due to land and soil degradation, this has apparently not been sufficient to foster policy action. To trigger action, we need to raise awareness about what is at stake in terms of lost economic opportunities and livelihoods. To achieve that purpose, an assessment of the economic consequences of land degradation and the costs of related inaction, compared against the costs of action for sustainable land use, is required.

A key contribution of the initiated *global assessment of the Economics of Land Degradation* (ELD Initiative (http://eld-initiative.org/), conducted by partners including the Center for Development Research (ZEF) at the University of Bonn, the International Food Policy Research Institute (IFPRI) and numerous other international and regional organizations around the world, supported by the German Federal Ministry for Economic Cooperation and Development (BMZ), European Commission, and

UNCCD is to provide this strongly needed comprehensive framework to make the adverse economic consequences of land degradation visible, in order to facilitate policy actions and investments to effectively address the land degradation problems. The global assessment of ELD, both through global overview and representative country and local studies, strives to capture a full valuation of losses incurred due to land degradation going beyond specific on-site market goods and services derived from land resources (see box).

Box: Questions about a global ELD assessment

1. Top down or bottom up? Do both, ground-proofing is a must!
2. Market or non-market valuation of land and it‘s degradation? Do both, with strong emphasis on valuing non-market ecosystem services!
3. Global or national/local? Do both, and integrate across scales by modeling!
4. Science- driven or practitioner-oriented? Combine both, with strong involvement by local partners and farming communities!
5. Focus on rehabilitation or prevention of degradation? Do both in a sustainable land use framework, but prevention is better than cure!
6. Focus on land degradation or on people affected by it? Link the two from the beginning.

It is not limited only to the costs of lower agricultural productivity due to land degradation in the agro-ecosystems, but seeks to properly account for the wider ecosystem services provided by land, especially in the context of the off-site effects of land degradation. It also seeks to incorporate the indirect costs of land degradation through economic and social leakages affecting poverty and food security. Finally, the global assessment of ELD is combined with remote sensing and geographic information system (GIS) analysis of the appropriate data to link those data to existing global land degradation monitoring tools and evidence-based and evidence-checked modeling.

In the next sections, the changing value of land in a world of increasing land scarcity is highlighted first, followed by a review of the status of land degradation and of economic research on land degradation, including causes and consequences of land degradation. Then, the conceptual framework of the global assessment of ELD is presented, followed by an overview of the results of the preliminary scoping analysis conducted in the preparatory stage to the global assessment (Nkonya et al. 2011). The final section concludes with major policy implications and perspectives for addressing land degradation. It also provides an overview of key future research directions related to the economics of land degradation.

The Increasing Value of Land

Land prices are rising all around the world (Figure 4). For example, in Argentina and Poland, land prices have multiplied by more than 4 times over the last decade. As already highlighted, the key drivers behind this trend of increasing land prices have been the interaction between the growing demand for food, feed and other uses of biomass and strongly inelastic supply of land.

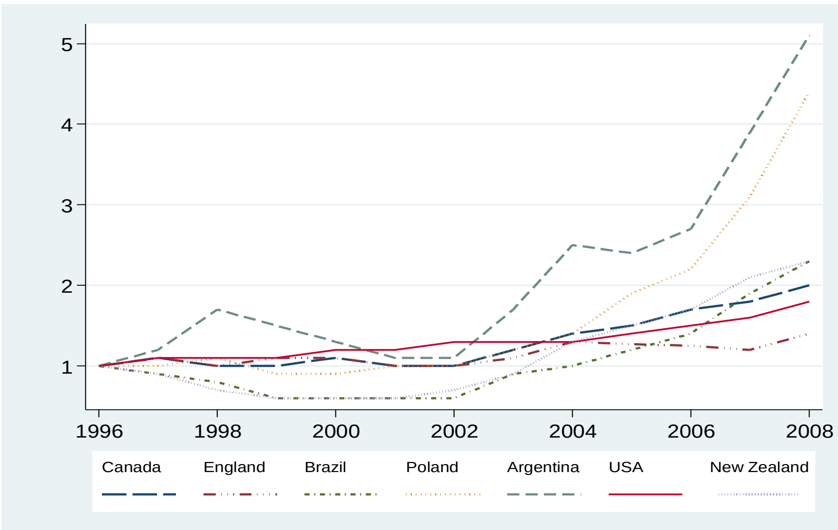


Figure 4. Farmland price dynamics in selected countries around the world

Source: authors' calculation based on data from various sources, including Nickerson et al. (2012), FGV, Statistics Canada, CAdeTierras, DEFRA, Sikorska (2010), Shi and McCArthy (2011), Savills Research (2009). The original nominal price series in local currencies were converted to US Dollar at the corresponding exchange rates, then the resulting price series in USD were adjusted for inflation with 2005 as the base year, finally the depicted price index was created using 1996 as the base year for the index.

Although, in practice, there may be further reasons for rising land prices, such as demand for real estate development or farm subsidy programs or demand for holding assets that are not much affected by money inflation, the worldwide nature of land price rises and strong co-movement of this trend with the general increase in agricultural commodity prices indicates that the key proximate factor behind these recent land price increases has been the growth in agricultural commodity prices; simply speaking: land has become more profitable.

Structurally this interaction could be described as follows: higher demand for agricultural commodities increases their prices; higher agricultural commodity prices raise the returns from land assets, which then drives up the land prices. The very inelastic nature of overall land supply and increasing degradation of agricultural lands, make land resources even scarcer and intensify these dynamics.

Despite rapidly increasing land prices, land and soils are still undervalued. Even though the increasing land prices are a clear market signal on the importance and urgency of addressing land degradation, they do not capture all the costs of land degradation, as many of the essential ecosystem services provided by soils, such as, for example, nutrient cycling, are not marketed goods and do not have market prices. Hence, the market prices of land do not capture, in fact, undervalue, the true value of land. The lack of market prices for ecosystem services means that the benefits derived from these goods (often public in nature) are usually neglected or undervalued in decision making. Land use decisions rarely consider public benefits and mostly focus only on localized private costs and benefits. Benefits that occur after a long-term horizon, such as that from climate regulation, are frequently ignored. This neglect leads to a systematic undervaluation of ecosystem services, because values that are not part of financial or economic considerations are somehow ignored. The failure to capture these values causes land degradation.

Degradation of an ecosystem may not translate directly or immediately into a loss of services. Ecosystems can take up to a certain level of degradation and then start to decline rapidly (TEEB 2009). The impacts of specific land degradation processes and of the actions used to mitigate them are felt through time, in a way that is most often nonlinear. For instance, whereas terracing might have a direct and stable effect on erosion levels, the impact of afforestation on nitrogen cycling is clearly time-dependent. With such dynamic processes and links, we must ideally value ecosystem services in a non-static way, aggregating the economic value of terrestrial ecosystem benefits through time. The cost of preventing land degradation will be much smaller than the cost of rehabilitating already severely degraded lands. Hence, costs of action will increase the more actions against land degradation are delayed.

Land degradation is an outcome of policy and institutional failures, basically, a consequence of missing markets and consequently wrong incentives. Imperfect or unenforced land rights, distorted and volatile market prices, lack of information about future damages related to degradation, and imperfect or missing credit markets are among the factors that may prevent farmers from investing in potentially profitable sustainable land management (SLM) practices and soil conservation measures. Anything that creates uncertainty about the future benefits of conservation measures reduces farmers' incentives to adopt them. As a result of wrong or confused institutional and policy signals, SLM practices would be under-supplied below their economic optimal levels. So there is a need for appropriate market and supply management measures for SLM, through national and international policies, that provide clear signals for implementing sustainable land management practices, with the term "land" comprising both soil and water resources, as good soil and water management are mutually essential. Otherwise, the market signals for addressing land degradation sent by rising land prices might be ignored, or even misused leading to short-term land speculation and soil mining, rather than action against land degradation.

Assessment of Land Degradation

As the problem of land degradation is complex, the existing definitions of land degradation and the methods for its assessment are varied and sometimes conflicting. Moreover, the term "land" refers to more than just soil. The UNCCD defines land as "the terrestrial bio-productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system" (UNCCD, 1996, Part 1, Article 1e). One of the more comprehensive definitions of land degradation identifies it as the "reduction in the capacity of the land to provide ecosystem goods and services over a period of time" (Nachtergaele et al. 2010).

Global cooperation in addressing land degradation issues emerged through United Nations conferences in the 1980s. Due to these initiatives and international cooperation, there have been several global studies seeking to identify the extent of land degradation with strongly varying results and accuracy, such as by UNCOD in 1977, GLASOD between 1987-1990, ASSOD in 1995, SOVEUR in 1998, UNEP through the World Atlas of Desertification, WOCAT since 1992, USDA-NRCS between 1998-2000, GLADA during 2000-2008, Millennium Ecosystem Assessment in 2005, and GLADIS in 2010. Most of these studies have focused on deforestation, overgrazing, salinization, soil erosion, and other visible forms of land degradation rather than on the degradation of less visible characteristics of soils (e.g. carbon content, top soil depth, etc.) or the less direct consequences of land degradation such as human suffering and the loss of ecosystem services. Nonetheless, some of the studies – namely GLADA and GLADIS - make strong use of the new geographical information system (GIS) technologies, which facilitates the collection of large quantities of global time series data using satellite imagery and lead to a significant increase in the accuracy of land degradation assessments. Over the years, the emphasis has also shifted towards the impact of land degradation on the provision of ecosystem goods and services. More attention is also now being paid to incorporating socio-economic factors and not only physical determinants of land degradation as, for example, under GLADIS. The new focus could help identify strategies for taking action against land degradation. GIS and remote sensing technologies have definitely improved the past methods, which used to rely heavily on subjective expert opinions or extrapolation of localized estimations, and offer great prospects in the context of a socio-economic assessment of land degradation. In spite of this, more research and systematic approaches are needed to identify which socioeconomic factors to select and how to include them in an economic assessment of land degradation, based on sound theoretical underpinnings.

The consensus estimate of the extent of global land degradation based on these and other numerous studies conducted so far is that about a quarter of global land area has been degraded (Lal et al. 2012). For example, GLADA, one of the latest global studies using remote sensing and analysis of satellite data indicates that between 1981–2003 about 24% of the global land area shows signs of a land degradation trend, affecting about 1.5 bln people, mostly in the poorest parts of the world (Bai et al. 2008, Figure 1). Measured as net primary production (NPP), without taking atmospheric fertilization into account, land degradation caused a total loss of 9.56×10^{8} tons of carbon between 1981 and 2003, which amounts to $48 billion in terms of lost carbon fixation using a shadow price of carbon of 50 USD per ton by the British treasury in February 2008 (ibid.). Arguably, the true scale of the problem may actually be even bigger if we take into account the areas which had already been degraded to their low equilibrium before 1981, especially in the drylands, and also the fact that technological improvements and atmospheric fertilization may mask losses in inherent soil quality due to degradation (Vlek et al. 2010), as well as the well-known limitations of NPP and NDVI as measures of land degradation, such as, for example, failure to detect changes in the botanical composition of the vegetation brought about by invasive species.

Land degradation can be classified into physical, chemical, and biological types. These types do not necessarily occur individually; spiral feedbacks between processes are often present (Katyal and Vlek 2000). *Physical land degradation* refers to erosion; soil organic carbon loss; changes in the soil‘s physical structure, such as compaction or crusting and waterlogging. *Chemical degradation*, on the other hand, includes leaching, salinization, acidification, nutrient imbalances, and fertility depletion. *Biological degradation* includes rangeland degradation, deforestation, and loss in biodiversity, involving loss of soil organic matter or of flora and fauna populations or species in the soil (Scherr 1999).

Causes of land degradation are classified into proximate and underlying. Proximate causes of land degradation are those that have a direct effect on the terrestrial ecosystem. The proximate causes are further divided into biophysical proximate causes (natural) and unsustainable land management practices (anthropogenic). The underlying causes of land degradation are those that indirectly affect the proximate causes of land degradation. For example, poverty could lead to the failure of land users to invest in sustainable land management practices. Population density could lead to intensification (Boserup 1965, Tiffen et al. 1994) or to land degradation (Grepperud 1996), depending on other conditioning factors. Table 1 selectively summarizes the current knowledge on the major proximate and underlying causes of land degradation.

As one can see from Table 1, the causes of land degradation are numerous, interrelated and complex. Quite often, the same causal factor could lead to diverging consequences in different contexts because of its varying interactions with other proximate and underlying causes of land degradation. The results imply that targeting one underlying factor is not, in itself, sufficient to address land degradation. Rather, a number of underlying and proximate factors need to be taken into account when designing policies to prevent or mitigate land degradation. Hence when devising solutions for sustainable land management, it is essential not to look for individual SLM options, but rather develop context-specific SLM packages including relevant technological, policy and institutional mixes which need to be implemented jointly to reduce land degradation in the most cost effective way. From the research point of view, studies on land degradation should be able to identify the effects of various combinations of underlying and proximate causes on land degradation in a robust manner.

In terms of the costs of land degradation, most of the economic studies of land degradation (mainly limited to soil erosion) give estimates ranging between 1-10% of the agricultural gross domestic product (GDP) for various countries worldwide. The decrease in agricultural productivity represents an on-site cost. Other socioeconomic on-site effects include the increase of production costs due to the need for more inputs to address the negative physical impacts of land degradation.

Table 1. Proximate and underlying causes related to land degradation (selective)

Factors	Type	Examples of causality	References
Topography	proximate and natural	Steep slopes are vulnerable to severe water-induced soil erosion	Wischemeier (1976) Voortman et al. (2000)
Land cover	proximate and natural/anthropogenic	Conversion of rangelands to irrigated farming with resulting soil salinity. Deforestation.	Gao and Liu (2010) Lu et al. (2007)
Climate	proximate and natural	Dry, hot areas are prone to naturally occurring wildfires, which, in turn, lead to soil erosion. Strong rainstorms lead to flooding and erosion. Low and infrequent rainfall and erratic and erosive rainfall (monsoon areas) lead to erosion and salinization.	Safriel and Adeel (2005) Barrow (1991)
Soil erodibility	proximate and natural	Some soils, for example those with high silt	Bonilla and Johnson (2012)

Factors	Type	Examples of causality	References
		content, could be naturally more prone to erosion.	
Pest and diseases	proximate and natural	Pests and diseases lead to loss of biodiversity, loss of crop and livestock productivity, and other forms of land degradation	Sternberg (2008)
Unsustainable Land Management	proximate and anthropogenic	Land clearing, overgrazing, cultivation on steep slopes, bush burning, pollution of land and water sources, and soil nutrient mining are among the major causes of land degradation	Nkonya et al (2011) Nkonya et al (2008) Pender and Kerr (1998)
Infrastructure Development	proximate and anthropogenic	Transport and earth-moving techniques, like trucks and tractors, as well as new processing and storage technologies, could lead to increased production and foster land degradation if not properly planned	Geist and Lambin (2004)
Population Density	underlying	No definite answer. Population density leads to land improvement Population density leads to land degradation	Bai et al. (2008); Tiffen et al. (1994), Boserup (1965) Grepperud (1996)

Factors	Type	Examples of causality	References
Market access	underlying	No definite answer. Land users in areas with good market access have more incentives to invest in good land management. High market access raises opportunity cost of labor, making households less likely to adopt labor-intensive sustainable land management practices.	Pender et al. (2006) Scherr and Hazell (1994)
Land tenure	underlying	No definite answer. Insecure land tenure can lead to the adoption of unsustainable land management practices. Insecure land rights do not deter farmers from making investments in sustainable land management.	Kabubo-Mariara (2007) Besley (1995), Brasselle et al. (2002)
Poverty	underlying	No definite answer. There is a vicious cycle between poverty and land degradation. Poverty leads to land degradation and land degradation leads to poverty.	Way (2006); Cleaver and Schreiber (1994); Scherr (2000)

Factors	Type	Examples of causality	References
		The poor heavily depend on the land, and thus, have a strong incentive to invest their limited capital into preventing or mitigating land degradation if market conditions allow them to allocate their resources efficiently.	de Janvry et al. (1991) Nkonya et al. (2008)
Access to agricultural extension services	underlying	No definite answer. Access to agricultural extension services enhances the adoption of land management practices Depending on the capacity and orientation of the extension providers, access to extension services could also lead to land-degrading practices.	Clay et al. (1996) Paudel and Thapa (2004) Benin et al. (2007), Nkonya et al. (2010)
Decentralization	underlying	Strong local institutions with a capacity for land management are likely to enact bylaws and other regulations that could enhance sustainable land management practices	FAO (2011)
International policies	underlying	International policies through the United	Sanwal (2004)

Factors	Type	Examples of causality	References
		Nations and other organizations have influenced policy formulation and land management	
Non-farm employment	underlying	Alternative livelihoods could also allow farmers to rest their lands or to use nonfarm income to invest in land improvement.	Nkonya et al. (2008)

Source: authors' compilation.

The off-site costs and benefits also need to be appropriately accounted for, because they are high. They may include the deposition of large amounts of eroded soil in streams, lakes, and other ecosystems through soil sediments that are transported in the surface water from eroded agricultural land into lake and river systems. For example, globally, the cost of the siltation of water reservoirs is about $18.5 billion (Basson 2010).

The beneficial off-site effects of soil erosion include the deposition of alluvial soils in the valley plains, which forms fertile soils and higher land productivity. For example, the alluvial soils in the Nile, Ganges, and Mississippi river deltas are results of long-term upstream soil erosion, and they all serve as breadbaskets in riparian countries (Pimentel 2006). Methods to assess land degradation are as manifold as the process itself. The availability of satellite imagery and remote sensing information is generally helping alleviate the dearth of data land degradation in developing countries. The use of radar and microwave remote sensing must be integrated more often in actual land degradation assessment techniques. A global approach is needed that uses standardized methods and a bottom-up technique that starts at the local level, enabling the adaptation of global analysis data to the local level. Global monitoring is still a challenge, with continued lack of precise data at the global level. Global maps on land degradation and desertification do give good overviews, but their information is quite often not corroborated by local ground-truthing. This local-level information is needed for policymakers and for more adapted research on land use management.

Conceptual Framework of ELD Assessment

The conceptual framework used in the global assessment of ELD is based on comparing the costs of action against land degradation versus the costs of inaction (Figure 5). As elaborated in the previous section, the causes of land degradation are divided into proximate and underlying, which interact with each other to result in different levels of land degradation. The level of land degradation determines its outcomes or effects - whether on-site or offsite - on the provision of ecosystem services and the benefits humans derive from those services. Actors can then take action to control the causes of land degradation, its level, or its effects.

Many of the services provided by ecosystems are not traded in markets, so the different actors do not pay for negative or positive effects on those ecosystems. The value of such externalities is not considered in the farmer's land use decision, which leads to an undervaluation of land and its provision of ecosystem services. The failure to capture these values causes higher rates of land degradation. To adequately account for ecosystem services in decision making, the economic values of those services have to be determined. There exist various methods to evaluate ecosystem services (Nkonya et al. 2011), however, attributing economic values to ecosystem services is challenging, due to many unknowns and actual measurement constraints. As economic values are linked to the number of (human) beneficiaries and the socioeconomic context, these services depend on local or regional conditions. This dependence contributes to the variability of the values (TEEB 2010). As TEEB (2010) indicates, a global framework that identifies a set of key attributes and then monitors these by building on national indicators could help answering this challenge.

The green square box at the bottom of the figure deals with the economic analysis that is carried out, and the green arrow shows the flow of information that is necessary to perform the different elements of the global economic analysis. Ideally, all indirect and off-site effects should be accounted for in the economic analysis to ensure that the assessment is from society's point of view and includes all existing externalities, in addition to the private costs that are usually considered when individu-

als decide on land use. Similarly, actions against land degradation have direct benefits and costs - the costs of specific measures and economy-wide indirect effects - that is, opportunity costs. In other words, resources devoted for these actions cannot be used elsewhere. Thus, mobilizing those resources to prevent or mitigate land degradation affects other sectors of the economy as well. This assessment has to be conducted at the margin, which means that costs of small changes in the level of land degradation, which may accumulate over time, have to be identified. Bringing together the different cost and value types to fully assess total costs and benefits over time and their interactions can be done within the framework of cost–benefit analysis and mathematical modeling. In doing this, care should be taken in the choice of the discount rates because the size of the discount rate, as well as the length of the considered time horizon, can radically change the results. Discount rates relate to people‘s time preferences, with higher discount rates indicating a strong time preference and attaching a higher value to each unit of the natural resource that is consumed now rather than in the future. Moreover, such analysis would also involve appropriately dealing with different kinds of inherent uncertainties.
Institutional arrangements, or the "rules of the game" that determine whether actors choose to act against land degradation and whether the level or type of action undertaken will effectively reduce or halt land degradation, are represented as dotted lines encapsulating the different elements of the conceptual framework. It is crucial to identify and understand these institutional arrangements in order to devise sustainable and efficient policies to combat land degradation. For example, if farmers over-irrigate, leading to salinization of the land, it must be understood why they do so. As an illustration, it may be that institutional arrangements, also referred to as distorting incentive structures, make it economically profitable for farmers to produce as much crops as possible. Missing or very low prices of irrigation water in irrigation schemes act as such an incentive in a misleading institutional setup.

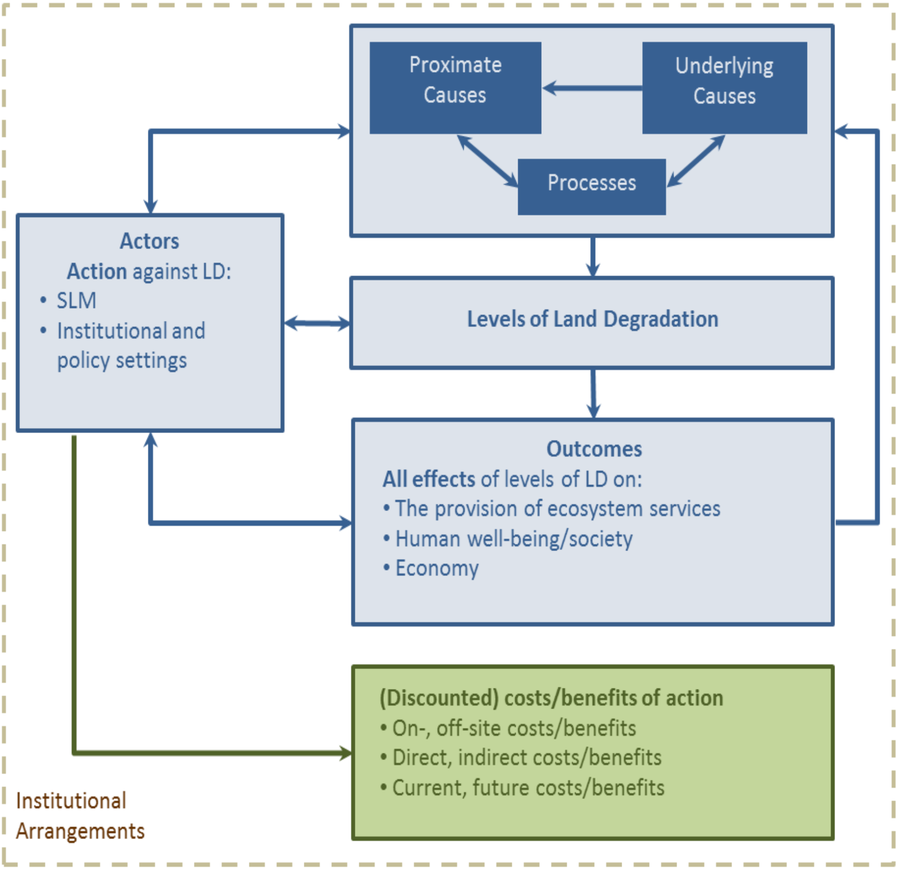


Figure 5. The Conceptual Framework of ELD Assessment – Action Scenario

Source: adapted from Nkonya et al. (2011)

Finally, it is also essential for the analysis to identify all the important actors of land degradation, such as land users, landowners, governmental authorities, and industries, as well as identify how institutions and policies influence those actors. Transaction costs and collective versus market and state actions are to be considered. In general, the institutional economics is particularly important in the assessment of land degradation when it comes to the definition and design of appropriate actions against land degradation, as well as of the inaction scenarios serving as a benchmark.

Preliminary Research Findings

As an initial scoping stage in the assessment of the economics of land degradation, ZEF and IFPRI carried out a global-level estimation of the relationship between changes in the NDVI (from 1981 to 2006) and some key biophysical and socioeconomic variables, such as precipitation, population density, government effectiveness, agricultural intensification and Gross Domestic Product (GDP) (Table 2, Figures 6-9). In addition, Nkonya et al. (2011) also present a number of case studies on the costs of land degradation. Figure 10 summarizes some of their major findings.

Table 2. Selected variables used to analyze the relationship with NDVI

Variable	Resolution	Baseline	End line	Source of Data
NDVI	**8km x 8km**	**1982-84**	**2003-06**	Global Land Cover Facility (www.landocver.org), Tucker et al. (2004), NOAA AVHRR NDVI data from GIMMS
Population density	**0.5° x 0.5°**	**1990**	**2005**	CIESIN (2010)
Government effectiveness	**0.5° x 0.5°**	**1996-98**	**2007-09**	Worldwide Governance Indicators (www.worldbank.org)
Agricultural intensification	**Country**	**1990-92**	**2007-09**	FAOSTAT
Gross Domestic Product	**Country**	**1981-84**	**2003-06**	IMF (www.imf.org/external/pubs/ft/weo/2010/02)

Source: Nkonya et al. (2011)

The global analysis showed a negative correlation between change in population density and NDVI in all regions except Sub-Saharan Africa (SSA), the European Union (EU), and Near East and North Africa (NENA). This is contrary to Bai et al. (2008), who observed a positive correlation between NDVI and population density on a global scale. The population density was positively correlated with NDVI in the SSA, EU, and NENA regions. In SSA, population density is the highest in the most fertile areas, such as mountain slopes (Voortman et al. 2000). This leads to the positive correlation between NDVI and population density even in areas south of the equator, which have seen severe land degradation (Bai et al. 2008). Figure 6 also shows that there was a positive correlation between population density and NDVI in central Africa, India, North America, and Europe. There is also an increase in NDVI accompanied with negative population density in Russia. Figure 7 shows an increase of both GDP and NDVI in North America, Russia, India, central Africa (north of the equator), and China.

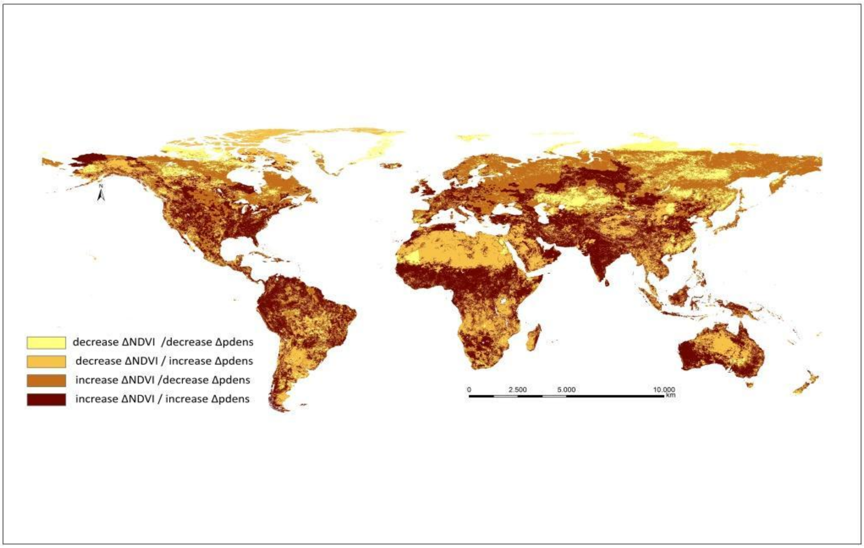


Figure 6. Relationship between NDVI and population density

Source: Nkonya et al. (2011), please see Table 2 above for details

Consistent with expectations, government effectiveness is positively correlated with NDVI (Figure 8). It was negative only in the EU and North America, which is largely due to a decrease in government effectiveness during the period under review accompanied by an increase in NDVI in both regions. With the exception of the EU, North America, Oceania, and SSA, the correlation between agricultural intensification (proxied by fertilizer application) and NDVI is positive, as expected (Figure 9).

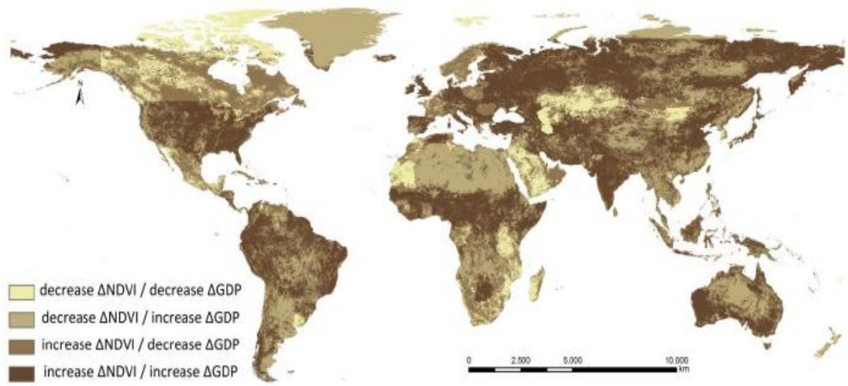


Figure 7. Relationship between NDVI and Gross Domestic Product
Source: Nkonya et al. (2011), please see Table 2 above for details

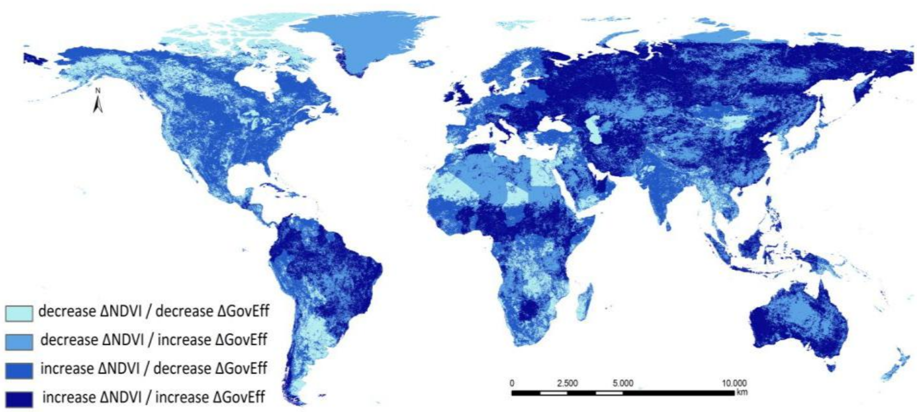


Figure 8. Relationship between NDVI and government effectiveness
Source: Nkonya et al. (2011), please see Table 2 above for details

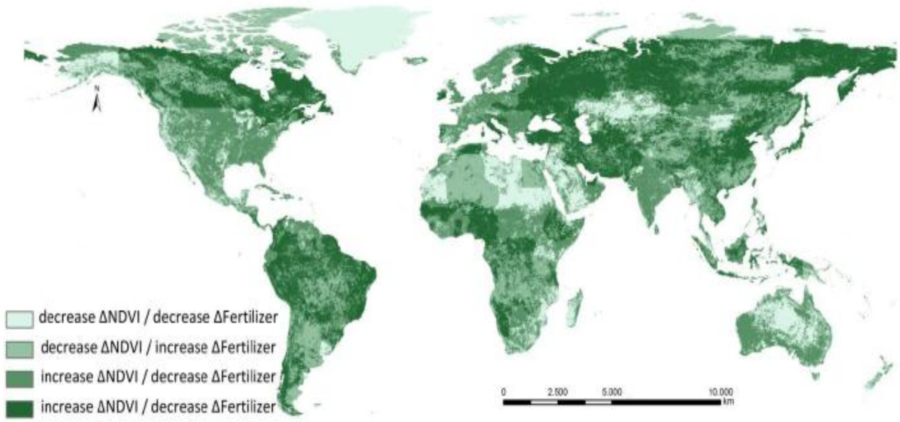


Figure 9. Relationship between NDVI and agricultural intensification

Source: Nkonya et al. (2011), please see Table 2 above for details

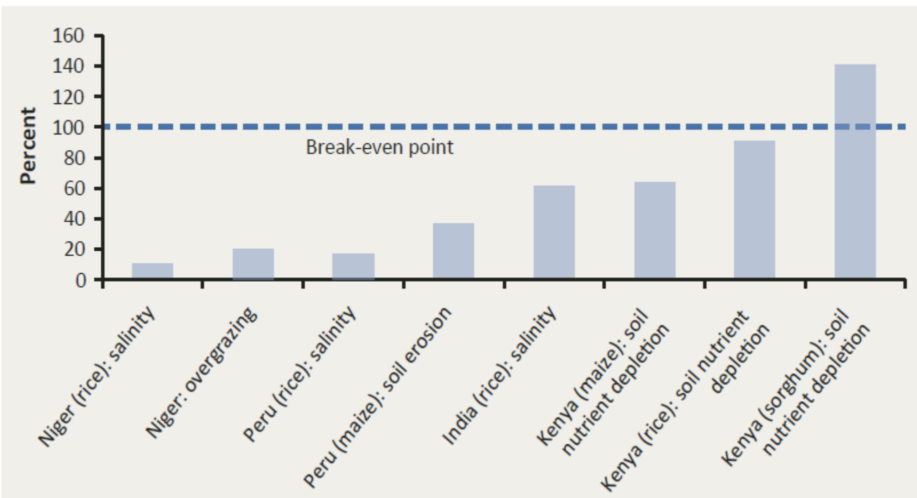


Figure 10. Cost of action as percent of cost of inaction - case studies
Source: based on Nkonya et al. (2011, Section 6).

The EU, North America, and Oceania have seen a decrease in fertilizer application, which could explain the apparent negative correlation with

NDVI. In SSA, land conversion to agriculture is responsible for the declining NDVI.

The case studies' results reported in Nkonya et al. (2011) also suggest that the cost of action is lower than the cost of inaction for seven of the eight cases considered (Figure 10), even when the costs of degradation are defined only in terms of decreased crop yields. These results suggest the need to explore other reasons for not taking action—for example, lack of access to markets and rural services, such as agricultural extension services, institutional and policy reasons for failing to take action against land degradation.

Policy and Research Perspectives

Early global assessments of land degradation have focused on dry areas and a few types of land degradation but played a key role in raising global awareness. Presently, the developments in remote sensing and spatial technologies have opened new possibilities for better assessments of land degradation, its underlying causes, and its impacts on human welfare. The institutions responsible for policy actions against land degradation now need to evolve with the current scientific, evidence-based knowledge of land degradation.

Understanding the underlying causes of land degradation will help in the design of appropriate actions for preventing or mitigating land degradation. Taking action to prevent or mitigate land degradation requires an economic analysis of the costs of land degradation and the costs and benefits of preventing or mitigating land degradation.

When devising solutions for sustainable land management, it is essential to look not for individual land degradation drivers, but rather develop context-specific SLM packages including relevant technological, policy and institutional mixes which need to be implemented jointly to reduce land degradation in the most cost effective way. From the research point of view, studies on land degradation should be able to identify the effects of various combinations of underlying and proximate causes on land degradation in a robust manner.

A sustainable green growth strategy must include achieving zero net land degradation. Otherwise, the protection of the asset base of green growth strategy would not be assured. Such an approach needs an economic underpinning, not just a bio-physical foundation. Moreover, combatting land degradation should also become an important part of the post-Millennium Development Goals agenda. Lal et al. (2012) advocate adapting a Protocol on Zero Net Land Degradation to the Convention to Combat Desertification and creating an Intergovernmental Panel on Land and Soil (IPLS) to provide credible and policy-relevant scientific information. The use of payment for ecosystem services (PES) should serve as a supportive policy option for attaining zero net land degradation. PES can also be used as performance payment for restoring degraded land evaluated by well-defined measures (Lal et al 2012). The recent downward trend of demand for carbon - mainly resulting from the imminent expiration of the Kyoto Protocol and lack of global consensus in carbon negotiations poses a challenge to PES effort. This requires new thinking and strategies for spurring carbon market.

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