

# The Economics of Land Degradation

---

*An Issue Paper for Global Soil Week, Berlin November 18. – 22., 2012*

**Joachim von Braun\*, Nicolas Gerber\*, Alisher Mirzabaev\*, Ephraim Nkonya#**

**\*Center for Development Research (ZEF), University of Bonn**

**#International Food Policy Research Institute (IFPRI), Washington D.C.**

**October 10, 2012**

**Table of Contents**

List of Figures and Tables..... iii  
List of Abbreviations .....iv  
Abstract..... v  
Introduction ..... 1  
The Changing Value of Land..... 6  
Assessment of Land Degradation ..... 9  
Conceptual Framework of ELD Assessment ..... 14  
Preliminary Research Findings ..... 16  
Policy and Research Perspectives..... 21  
References..... 22

## List of Figures and Tables

|   |    |
|---|----|
| Figure 1. Loss of Net Primary Production between 1981-2003.....                       | 2  |
| Figure 2. Areas affected by human-induced land degradation in Sub-Saharan Africa..... | 3  |
| Figure 3. Relationship between infant mortality rate and land degradation.....        | 4  |
| Figure 4. Farmland price dynamics in selected countries around the world.....         | 7  |
| Figure 5. The Conceptual Framework of ELD Assessment – Action Scenario.....           | 15 |
| Figure 6. Relationship between NDVI and population density.....                       | 18 |
| Figure 7. Relationship between NDVI and Gross Domestic Product.....                   | 19 |
| Figure 8. Relationship between NDVI and government effectiveness.....                 | 19 |
| Figure 9. Relationship between NDVI and agricultural intensification.....             | 20 |
| Figure 10. Cost of action as percent of cost of inaction in six case studies.....     | 20 |
| Table 1. Proximate and underlying causes related to land degradation (selective)..... | 11 |
| Table 2. Selected variables used to analyze the relationship with NDVI.....           | 17 |

## 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

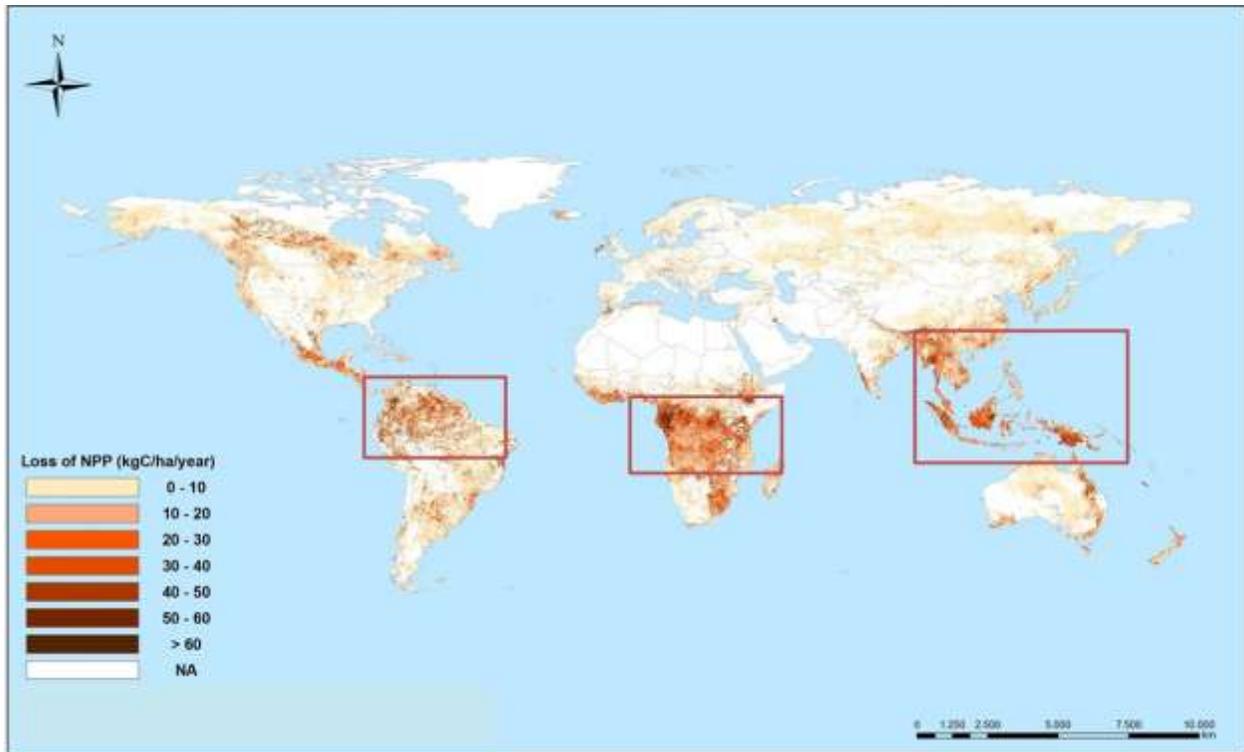
Healthy soils are essential for sustaining economies and people's livelihoods. They provide a wide range of services including provisioning services such as food production, supporting services such as nutrient cycling, regulating services such as carbon sequestration, and cultural services such as heritage. 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, 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.

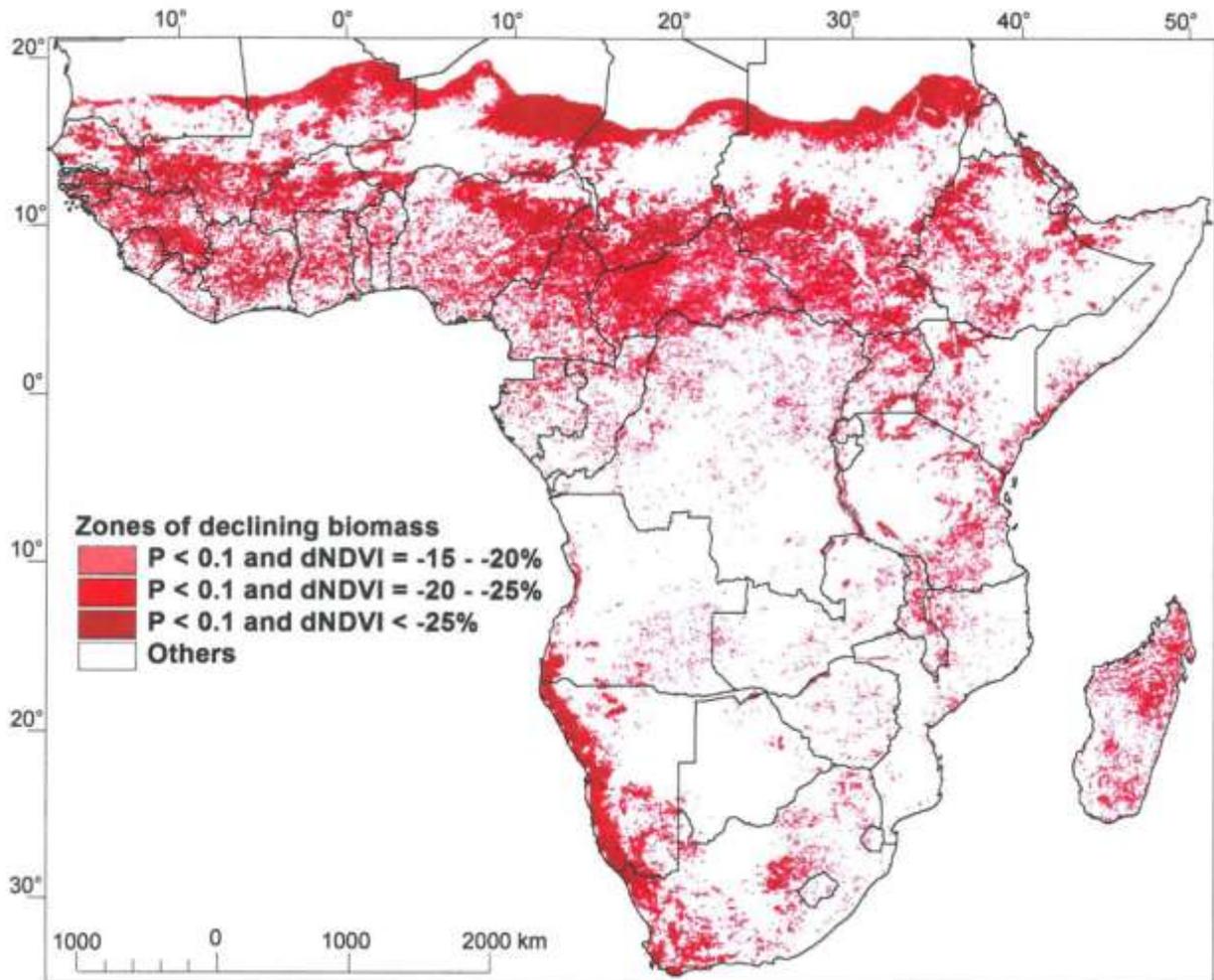


**Figure 1. Loss of Net Primary Production between 1981-2003**

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<sub>2</sub> 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.

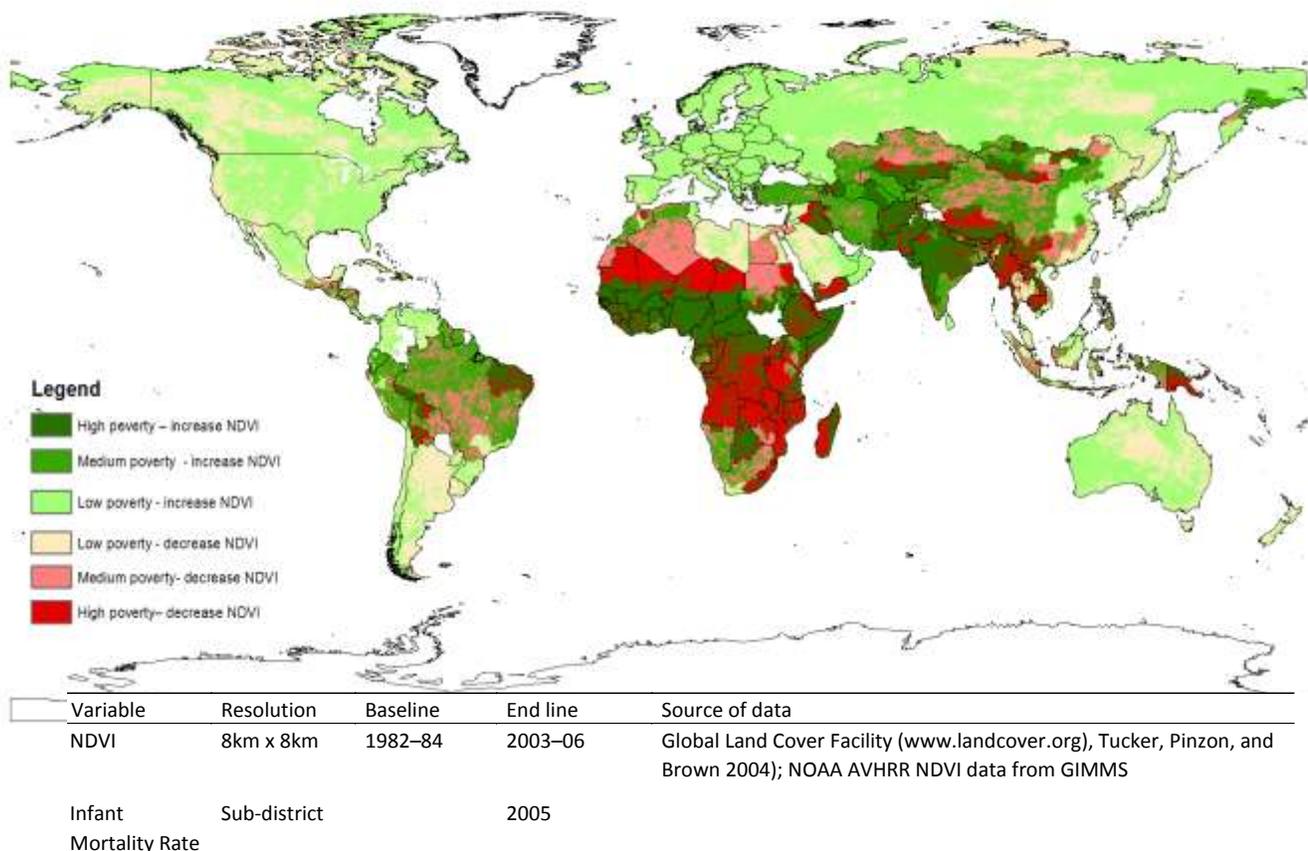


**Figure 2. Areas affected by human-induced land degradation in Sub-Saharan Africa**

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. 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.)



**Figure 3. Relationship between infant mortality rate and land degradation**

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

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.

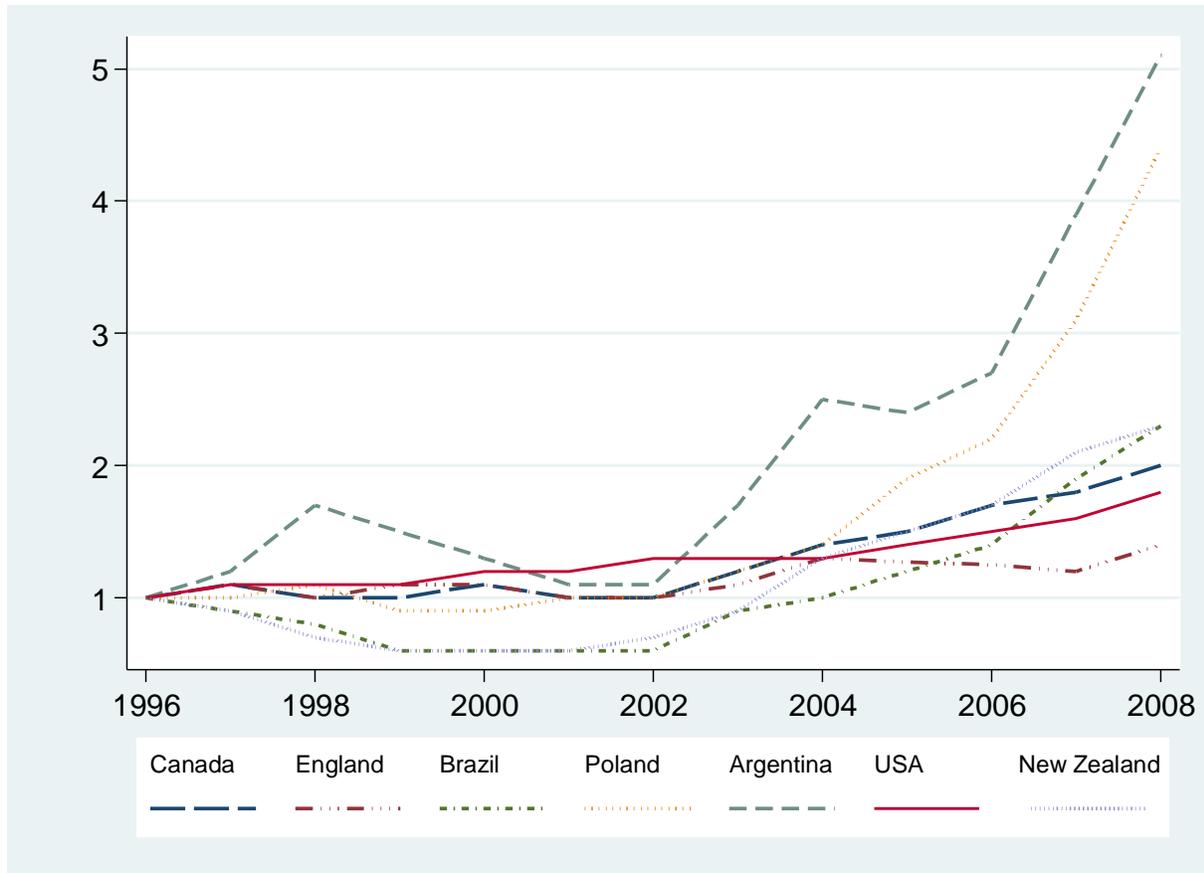
It is not limited only to the costs of lower agricultural productivity due to land degradation in the agro-ecosystems, but seeks to properly account for the wider ecosystem services provided by

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. 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.



**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.

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 use 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  $9.56 \times 10^8$  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  | Wischmeier (1976)<br>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)<br>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)<br>Barrow (1991)   |
| Soil erodibility | proximate and natural               | Some soils, for example those with high silt content, could be naturally  | Bonilla and Johnson (2012)                  |

| Factors                       | Type                        | Examples of causality  | References   |
|-------------------------------|-----------------------------|--|--|
|                               |                             | 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)<br>Nkonya et al (2008)<br>Pender and Kerr (1998)   |
| Infrastructure Development    | proximate and anthropogenic | Transport and earthmoving 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.<br>Population density leads to land improvement<br><br>Population density leads to land degradation  | Bai et al. (2008); Tiffen et al. (1994), Boserup (1965)<br><br>Grepperud (1996)                                      |
| Market access                 | underlying                  | No definite answer.<br>Land users in areas with good market access have more incentives to invest in good land management.<br><br>High market access raises opportunity cost of labor, making households less likely to adopt labor-intensive sustainable land management practices.   | Pender et al. (2006)<br><br>Scherr and Hazell (1994)   |
| Land tenure                   | underlying                  | No definite answer.<br>Insecure land tenure can lead to the adoption of unsustainable land management practices.<br><br>Insecure land rights do not deter farmers from making investments in sustainable land management.  | Kabubo-Mariara (2007)<br><br>Besley (1995),<br>Brasselle et al. (2002)   |
| Poverty                       | underlying                  | No definite answer.<br>There is a vicious cycle between poverty and land degradation. Poverty leads to land degradation and land degradation leads to poverty.<br><br>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 | Way (2006);<br>Cleaver and Schreiber (1994);<br>Scherr (2000)<br><br>de Janvry et al. (1991)<br>Nkonya et al. (2008) |

| Factors                                   | Type       | Examples of causality  | References  |
|---|------------|--|---|
|   |            | allow them to allocate their resources efficiently.  |   |
| Access to agricultural extension services | underlying | No definite answer.<br>Access to agricultural extension services enhances the adoption of land management practices<br><br>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)<br>Paudel and Thapa (2004)<br><br>Benin et al. (2007),<br>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 Nations and other organizations have influenced policy formulation and land management   | Sanwal (2004)   |
| 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).

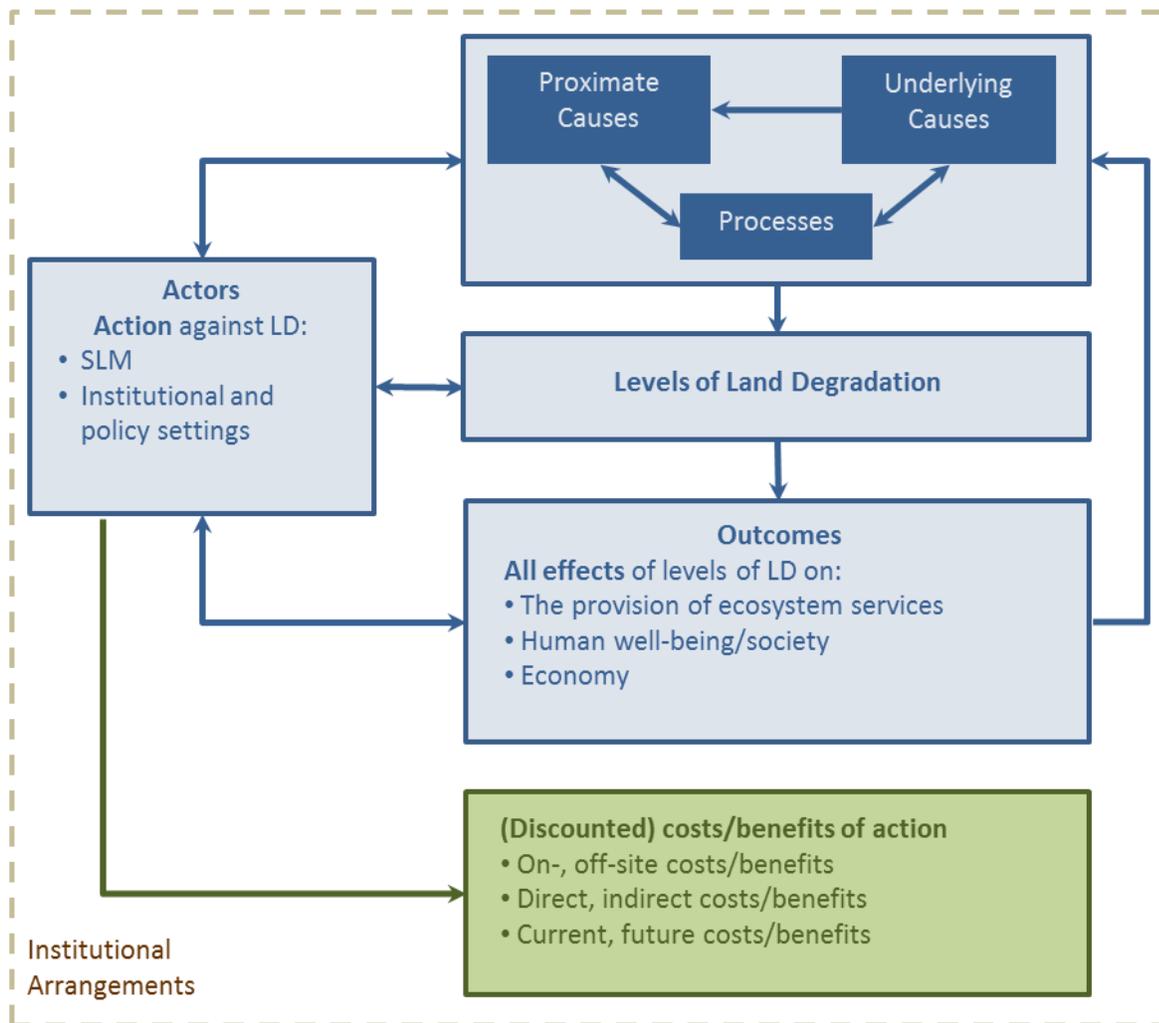
The beneficial off-site effects of soil erosion include the deposition of alluvial soils in the valley plains, which forms fertile soils and higher land productivity. For example, the alluvial soils in the Nile, Ganges, and Mississippi river deltas are results of long-term upstream soil erosion, and 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.



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

Source: adapted from Nkonya et al. (2011)

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 individuals 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.

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.

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

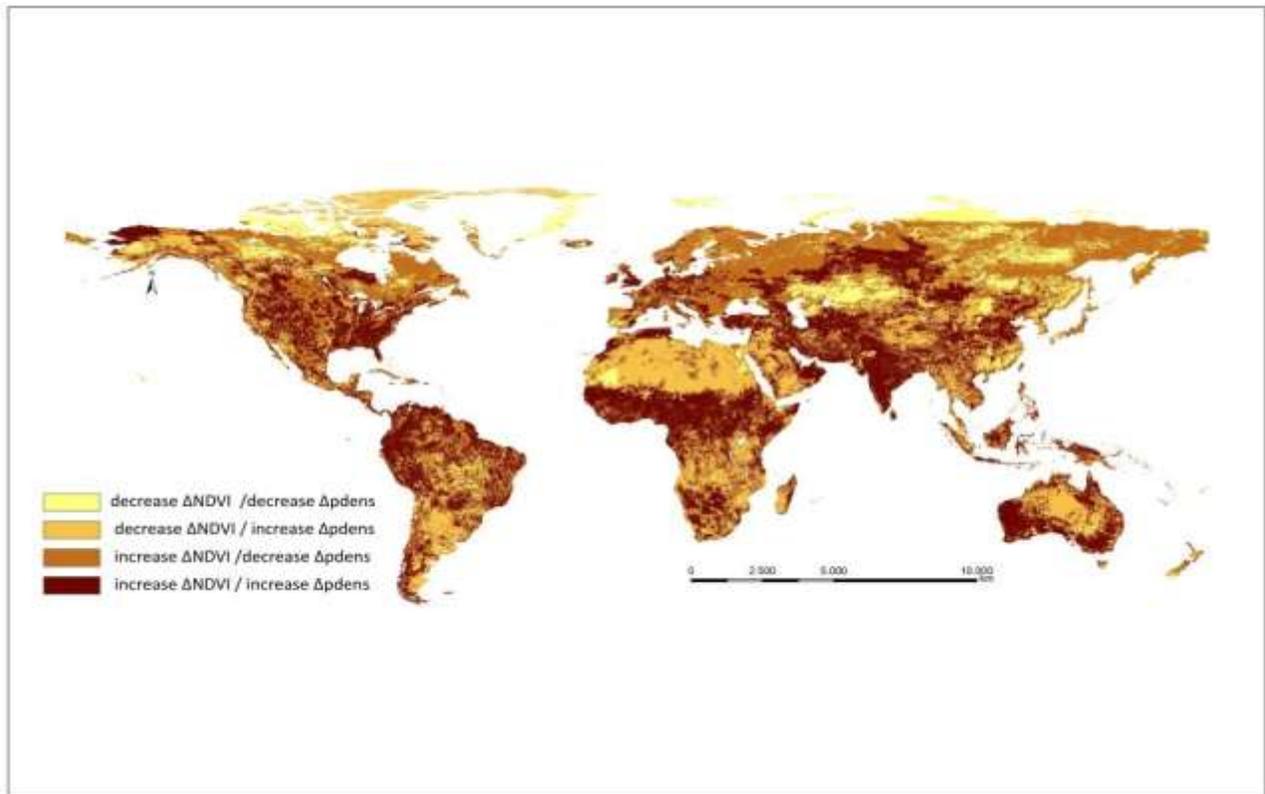
(from 1981 to 2006) and some key biophysical and socioeconomic variables, such as precipitation, population density, government effectiveness, agricultural intensification and Gross Domestic Product (GDP) (Table 2, Figures 6-9). In addition, Nkonya et al. (2011) also present a number of case studies 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**

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

Source: Nkonya et al. (2011)

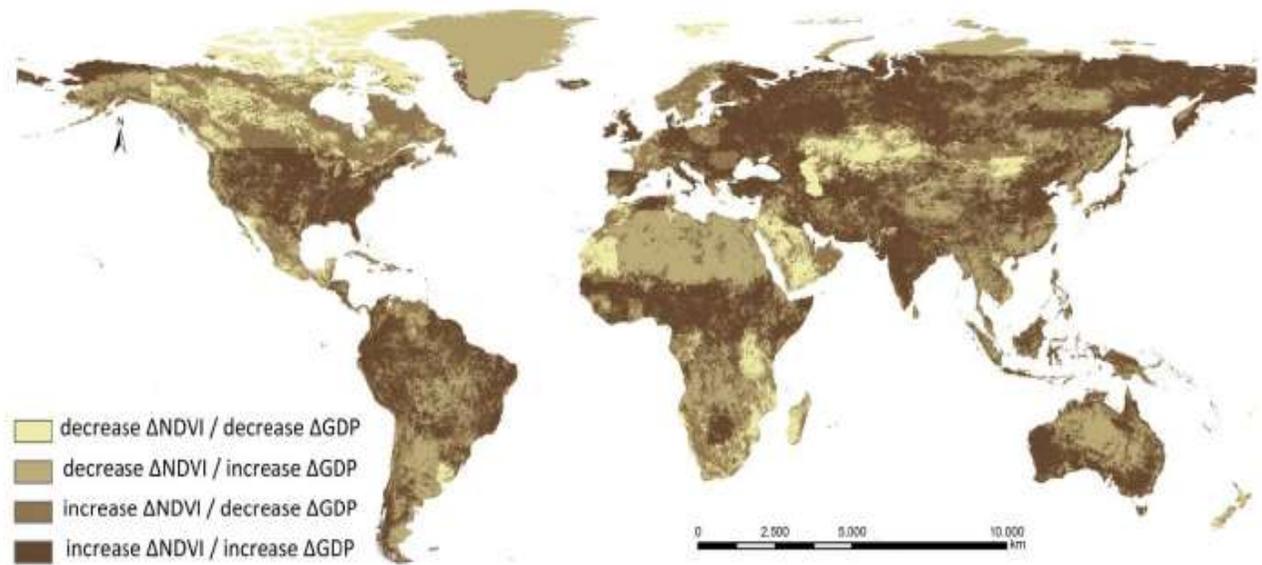
The global analysis showed a negative correlation between change in population density and NDVI in all regions except Sub-Saharan Africa (SSA), the European Union (EU), and Near East and North Africa (NENA). This is contrary to Bai et al. (2008), who observed a positive correlation between NDVI and population 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**

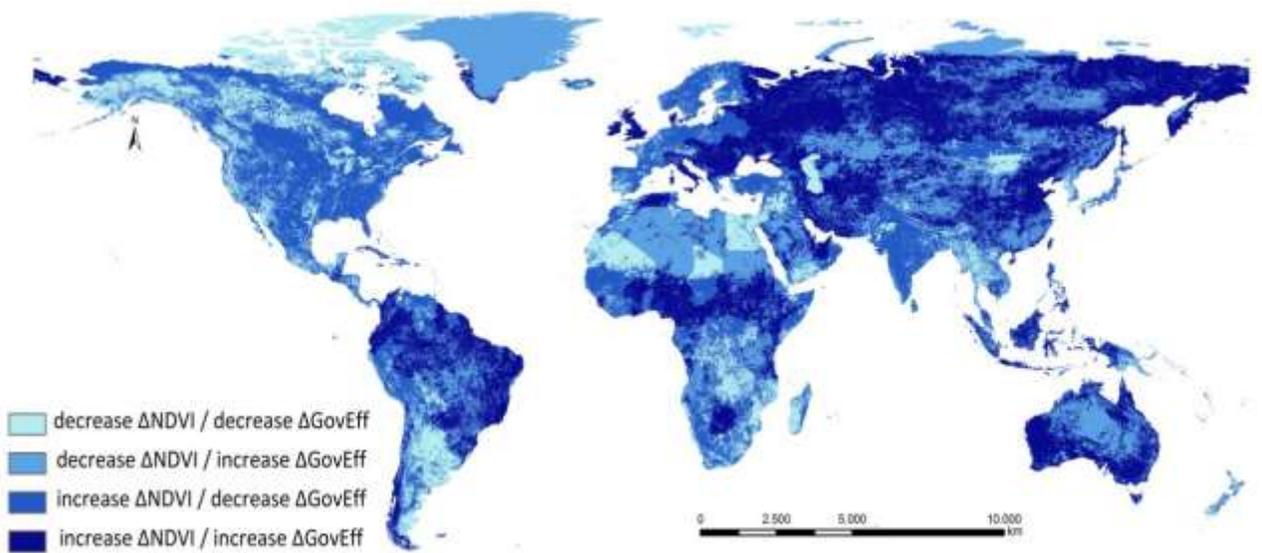
Source: Nkonya et al. (2011), please see Table 2 above for details

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).



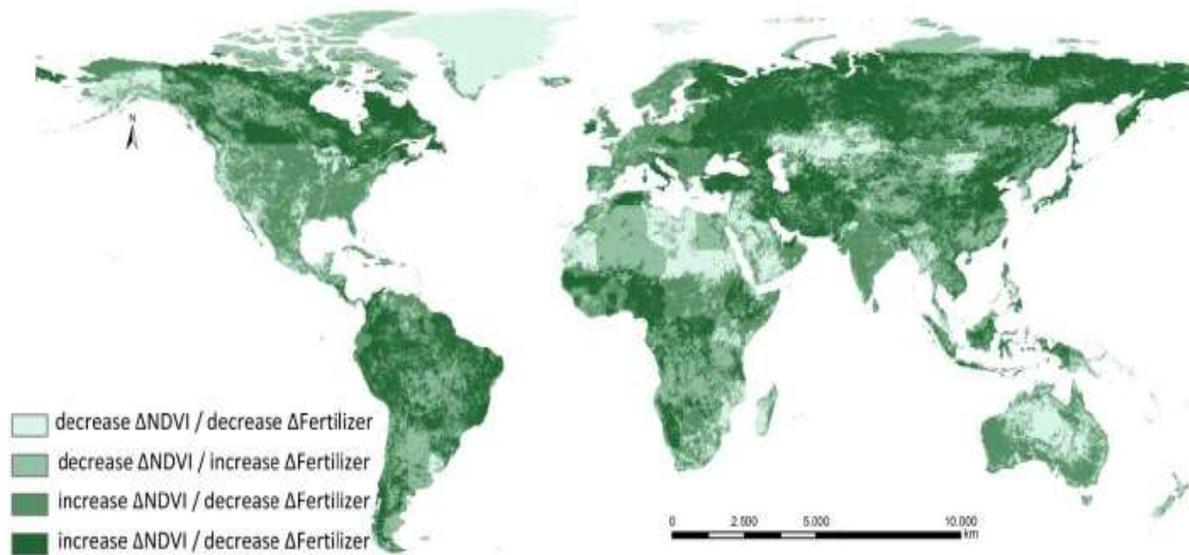
**Figure 7. Relationship between NDVI and Gross Domestic Product**

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



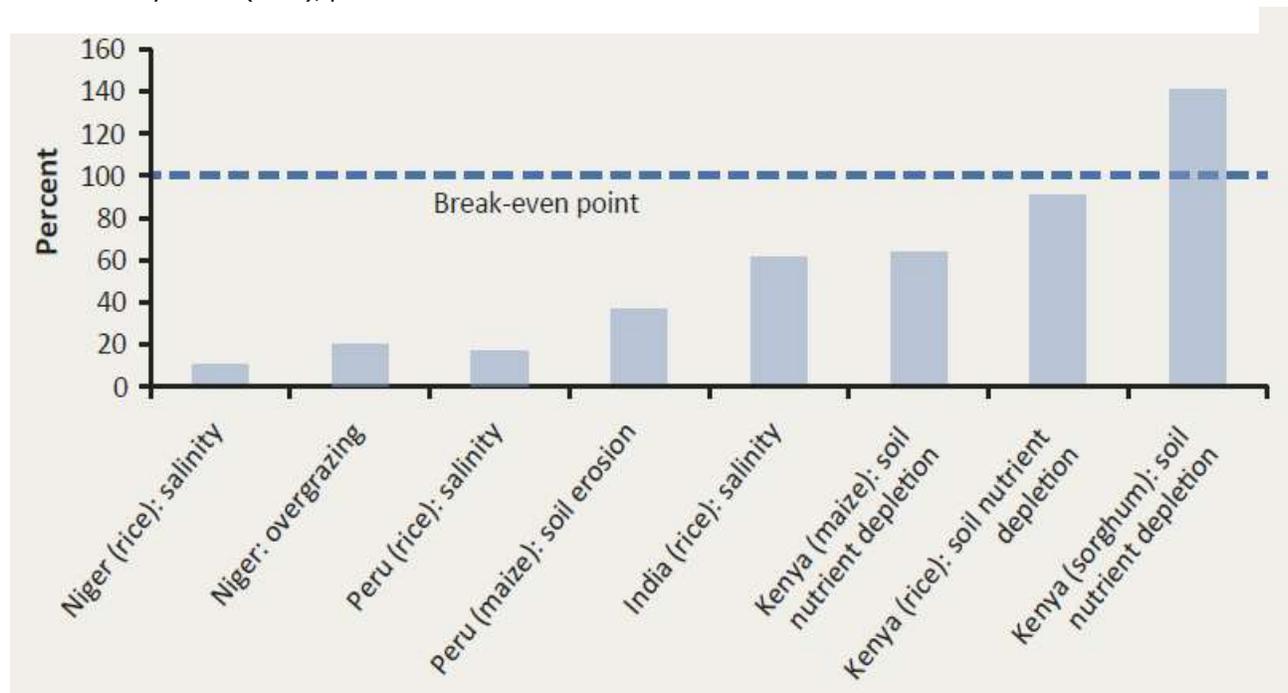
**Figure 8. Relationship between NDVI and government effectiveness**

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. 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).

## References:

Bai Z, Dent D, Olsson L and Schaepman M (2008) Proxy Global Assessment of Land Degradation. *Soil Use and Management* 24 (3): 223–234.

Barrow C (1991) *Land Degradation: Development and Breakdown of Terrestrial Environments*. Cambridge University Press, Cambridge, UK.

Basson G (2010) Sedimentation and Sustainable use of reservoirs and river systems. *International Commission on Large Dams (ICOLD) Bulletin*. <http://www.waterpowermagazine.com/>

Benin S, Nkonya E, Okecho G, Pender J, Nahdy S, Mugarura S, Kato E and Kayobyo G (2007) *Assessing the Impact of the National Agricultural Advisory Services (NAADS) in the Uganda Rural Livelihoods*. IFPRI Discussion Paper 00724. Washington, DC: International Food Policy Research Institute.

Besley T (1995) Property Rights and Investment Incentives: Theory and Evidence from Ghana. *The Journal of Political Economy* 103 (5): 903–937.

Bonilla C and Johnson O (2012) Soil erodibility mapping and its correlation with soil properties in Central Chile. *Geoderma*, Volumes 189–190, November 2.

Boserup E (1965) *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*. Aldine Press. New York, USA.

Brasselle F, Brasselle A, Gaspart F, and Platteau JP (2002) Land Tenure Security and Investment Incentives: Puzzling Evidence from Burkina Faso. *Journal of Development Economics* 67: 373– 418.

CIESIN (Center for International Earth Science Information Network). 2010. *Global Distribution of Poverty*. Palisades, NY. [http://sedac.ciesin.columbia.edu/povmap/ds\\_info.jsp](http://sedac.ciesin.columbia.edu/povmap/ds_info.jsp).

Clay DC, Byiringiro FU, Kangasniemi J, Reardon T, Sibomana B, Uwamariya L, Tardif- Douglin D (1996) *Promoting Food Security in Rwanda through Sustainable Agricultural Productivity: Meeting the Challenges of Population Pressure, Land Degradation, and Poverty*. Food Security International Development Policy Syntheses 11425. East Lansing: Michigan State University, Department of Agricultural, Food, and Resource Economics.

Cleaver KM and Schreiber GA (1994) *Reversing the Spiral: The Population, Agriculture, and Environment Nexus in Sub-Saharan Africa*. The World Bank. Washington, USA.

De Janvry A, Fafchamps M and Sadoulet E (1991) Peasant Household behavior with missing markets: some paradoxes explained. *The Economic Journal* 101: 1400-1417.

FAO (2011) State of the World's Forests. Rome, Italy.

FAOSTAT (2012) Online statistical database at <http://faostat3.fao.org/home/index.html>

Gao J, and Liu Y (2010) Determination of Land Degradation Causes in Tongyu County, Northeast China via Land Cover Change Detection. *International Journal of Applied Earth Observation and Geoinformation* 12: 9–16.

Geist HJ and Lambin EF (2004) Dynamical Causal Patterns of Desertification. *BioScience* 54 (9): 817–829.

Grepperud S (1991) Soil conservation as an investment in land. Discussion Paper 163. Oslo, Statistisches Norvège.

Kabubo-Mariara J (2007) Land Conservation and Tenure Security in Kenya: Boserup's Hypothesis Revisited. *Ecological Economics* 64: 25–35.

Katyal JC and Vlek PL (2000) Desertification: Concept, Causes, and Amelioration. Center for Development Research. Bonn, Germany.

Lal R (2004) Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. *Science* 304: 1623–1627.

Lal R, Safriel U, and Boer B (2012) Zero Net Land Degradation: A New Sustainable Development Goal for Rio+ 20. A report prepared for the Secretariat of the United Nations Convention to Combat Desertification (<http://www.unccd.int/Lists/SiteDocumentLibrary/secretariat/2012/Zero%20Net%20Land%20Degradation%20Report%20UNCCD%20May%202012%20background.pdf>)

Lu D, Batistella M, Mausel P and Moran E (2007) Mapping and Monitoring Land Degradation Risks in the Western Brazilian Amazon Using Multitemporal Landsat TM/ETM+ Images. *Land Degradation and Development* 18: 41–54.

Montanarella L (2007) Trends in Land Degradation in Europe. In Sivakumar MV and Ndiangui N (eds.) *Climate and Land Degradation*. Springer- Verlag. Berlin-Heidelberg, Germany, pp 83–105

Nachtergaele F, Petri M, Biancalani R, Van Lynden G, and Van Velthuisen H (2010) Global Land Degradation Information System (GLADIS). Beta Version. An Information Database for Land Degradation Assessment at Global Level. *Land Degradation Assessment in Drylands Technical Report*, no. 17. FAO, Rome, Italy.

Nickerson C, Morehart M, Kuethe T, Beckman J, Ifft J and Williams R (2012) Trends in U.S. Farmland Values and Ownership. EIB-92. U.S. Dept. of Agriculture, Econ. Res. Serv.

Nkonya E, Pender J, Kaizzi K, Kato E, Mugarura S, Ssali H and Muwonge J (2008) Linkages between land management, land degradation, and poverty in Sub-Saharan Africa: The case of Uganda. IFPRI Research Report 159, Washington D.C., USA.

Nkonya E, Phillip D, Mogue T, Pender J and Kato E (2010) From the Ground Up: Impacts of a Pro-poor Community-Driven Development Project in Nigeria. IFPRI Research Monograph. Washington, DC, USA.

Nkonya E, Gerber N, Baumgartner P, von Braun J, De Pinto A, Graw V, Kato E, Kloos J, Walter T (2011) *The Economics of Land Degradation – Towards an Integrated Global Assessment*. Peter Lang.

Paudel GS and Thapa GB (2004) Impact of Social, Institutional, and Ecological Factors on Land Management Practices in Mountain Watersheds of Nepal. *Applied Geography* 24 (1): 35–55.

Pender J and Kerr J (1998) Determinants of Farmers' Indigenous Soil and Water Conservation Investments in Semiarid India. *Agricultural Economics* 19: 113–125

Pender J, Nkonya E, Jagger P, Sserunkuuma D and Ssali H (2006) Strategies to Increase Agricultural Productivity and Reduce Land Degradation in Uganda: An Econometric Analysis. In Pender J and Ehui S (eds) *Strategies for Sustainable Land Management in the East African Highlands*. International Food Policy Research Institute, Washington, DC, USA, pp 165–190

Pimentel (D) 2006. Soil Erosion: A Food and Environmental Threat. *Environment, Development, and Sustainability* 8: 119–137.

Pingali P (2012) Green Revolution: Impacts, limits, and the path ahead. *Proc Natl Acad Sci USA*. 109:12302–12308.

Safriel UN (2007) The Assessment of Global Trends in Land Degradation. In Sivakumar MV and Ndiangui N (eds.) *Climate and Land Degradation*. Springer- Verlag, Berlin-Heidelberg, Germany, pp 2-38

Safriel UN and Adeel Z (2005) Dryland Systems. In Hassan R and Scholes R and Ash N (eds) *Ecosystems and Human Well-being: Current State and Trends*. Vol. 1, Washington, DC: Island Press. pp 623–662

Sanwal M (2004) Trends in Global Environmental Governance: The Emergence of a Mutual Supportiveness Approach to Achieve Sustainable Development. *Global Environmental Politics* 4 (4): 16–22.

Savills Research (2009) *International Farmland Markets 2009*.

Scherr S (1999) *Soil Degradation: A Threat to Developing-Country Food Security by 2020, food, Agriculture and the Environment*. International Food Policy Research Institute, Washington, DC, USA

Scherr S and Hazell P (1994) *Sustainable Agricultural Development Strategies in Fragile Lands*. Environment and Production Technology Division Discussion Paper, no. 1. International Food Policy Research Institute, Washington, DC, USA

Scherr S (2000) Downward Spiral? Research Evidence on the Relationship between Poverty and Natural Resource Degradation. *Food Policy* 25 (4): 479–498.

Shi S and McCarthy I (2011) Dairy Farmland Prices and Return Expectations in New Zealand. A paper presented in the 17th Pacific Rim Real Estate Society Conference, Gold Coast, Australia, 17-19 January 2011.

Sikorska A (2010) The socio-economic factors affecting the development of agricultural land market in Poland. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*. Volume LVIII. pp 445-452

Sternberg T (2008) Environmental challenges in Mongolia's dryland pastoral landscape. *J Arid Environ* 72:1294–304

TEEB (The Economics of Ecosystems and Biodiversity) (2010) *Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*. Malta.

Tiffen M, Mortimore M and Gichuki F (1994) *More People, Less Erosion: Environmental Recovery in Kenya*. Wiley and Sons, London, UK

Tucker CJ, Pinzon JE and Brown ME (2004) Global Inventory Modeling and Mapping Studies. NA94apr15b.n11-VIg, 2.0, Global Land Cover Facility, University of Maryland, College Park, Maryland, USA

Vlek PL, Le QB and Tamene L (2010) Assessment of Land Degradation, Its Possible Causes, and Threat to Food Security in Sub-Saharan Africa. In Lal R, Stewart BA (eds) Food Security and Soil Quality, CRC Press, Boca Raton, FL, USA, pp 57– 86.

Voortman RL, Sonneveld BG and Keyzer MA (2000) African land ecology: Opportunities and constraints for agricultural development. Center for International Development Working Paper 37. Harvard University, Cambridge, Mass., U.S.A

von Braun J (2007) The World Food Situation: New Driving Forces and Required Actions. IFPRI. Washington, USA.

Way SA (2006) Examining the Links between Poverty and Land Degradation: From Blaming the Poor toward Recognizing the Rights of the Poor. In Johnson P, Mayrand K, Paquin M (eds) Governing Global Desertification: Linking Environmental Degradation, Poverty, and Participation, Ashgate, Burlington, VT, pp 27–41.

Wischmeier W and Smith D (1978) Predicting Rainfall Erosion Losses: A Guide to Conservation planning (Handbook 537). U.S. Department of Agriculture, Washington, DC, USA

World Bank (2012) Online statistical database on World Development Indicators at [www.databank.worldbank.org](http://www.databank.worldbank.org)