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ELD THE ECONOMICS OF LAND DEGRADATION

A global initiative for sustainable land management

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List of Abbreviations

AfDB	African Development Bank
AGDP	Agricultural Gross Domestic Product
AVHRR	Advanced Very High Resolution Radiometer
ELD	Economics of Land Degradation
FAO	United Nation’s Food and Agriculture Organization
GDP	Gross Domestic Product
GNP	Gross National Product
GIS	Geographic Information System
GLADA	Global Assessment of Land Degradation and Improvement
ICT	Information Communication Technology
MoFED	Ministry of Finance and Economic Development (Ethiopia)
MEA	Millennium Ecosystem Assessment
NDVI	Normalized Difference Vegetation Index
PES	Payment for Ecosystem Services
RUE	Rainfall Use Efficiency
SSA	Sub-Saharan Africa
SLM	Sustainable Land Management
TEV	Total Economic Value
UNCCD	United Nations Convention to Combat Desertification
UNECA	United Nation Economic Commission for Africa
USD	United States Dollars
WI	Wireless Intelligence
ZEF	Center for Development Research, University of Bonn

Abstract

Land degradation remains a serious impediment to improving livelihoods in the Eastern Africa region. This working paper presents a general overview of the state and extent of land degradation in East Africa, explores its proximate and underlying drivers, identifies the land degradation hotspots in the region, and also discusses the productivity and poverty impacts of land degradation in the region. It is intended to serve as an exploratory tool for the ensuing more detailed quantitative analyses to support policy and investment programs to address land degradation in Eastern Africa. We critically review the strengths and weaknesses of the previous studies on the causes of land degradation in the region. Recent assessments show that land degradation affected 51%, 41%, 23%and 22% of land area in Tanzania, Malawi, Ethiopia and Kenya respectively. The key proximate causes leading to land degradation widely cited in the literature for the region include non-sustainable agricultural practices, overgrazing and overexploitation of forest and woodland resources, while the major underlying causes are believed to be population pressure, poverty and market and institutional failures. Water and wind erosion are the most widespread types of land degradation in the region. The economic damages from land degradation are substantial. To illustrate, this loss is estimated at about 3% of GDP in Ethiopia and about 9.5–11% of GDP in Malawi, annually. The available estimates indicate that yield reduction due to soil erosion may range from 2– 40% depending on the crop and location across the Eastern Africa. In spite of these dynamics, the adoption of sustainable land management (SLM) practices in the Eastern Africa region, and in Sub-Saharan Africa, as a whole, is highly insufficient – just on about 3% of total cropland, according to some estimates. To address land degradation, there is a strong need to substantially increase the investments and strengthen the policy support for sustainable land management.

Keywords: Economics of Land Degradation (ELD), Sustainable Land Management (SLM), Poverty, Eastern Africa.

1 Introduction

Land degradation is a global problem affecting an estimated 1.5 billion people and a quarter of land area in all agro–ecological zones around the world (Lal *et al.,* 2012). Annually, an area of about 5–8 million hectares of formerly productive land goes out of cultivation due to degradation globally (TerrAfrica, 2006). There is no consensus on the relationship between land degradation and poverty (Nkonya *et al.,* 2013; Gerber *et al.,* 2014). However, the inter-linkages between land degradation and poverty are thought to be strong in the rural areas of low income countries where livelihoods predominantly depend on agriculture (Turner *et al.,* 1994). Earlier studies pointed to a bidirectional link between poverty and land degradation; while poverty leads to land degradation, land degradation also contributes to poverty (Barbier, 2000; Lambin et al., 2001; Eswaran et al., 2001).

There is no consensus on the exact extent and severity of land degradation as well as it impacts in the Eastern Africa region or in sub-Saharan Africa (SSA) as a whole (Reich *et al.,* 2001; GEF, 2006). However, in Eastern Africa the resource loss due to land degradation is believed to be huge (Maitima, 2009). To illustrate, about 1 billion tons of topsoil are lost annually in Ethiopia due to soil erosion (MoFED, 2010), costing the country 3% of its Agricultural Gross Domestic Product (AGDP) (Yesuf *et al.,* 2008). In Tanzania, land degradation has been ranked as the top environmental problem since more than 60 years (Assey *et al.,* 2007). Soil erosion is considered to have occurred on 61% of the entire land area in Tanzania (ibid). Chemical land degradation, including soil pollution and salinization/alkalinisation, has led to 15% loss in the arable land in Malawi and Zambia in the last decade alone (Chabala *et al.,* 2012).

Lack of information and knowledge is considered to be one of the major obstacles for reducing land degradation, improving agricultural productivity, and facilitating the uptake of sustainable land management (SLM) among smallholder farmers (Liniger *et al.,* 2011). Farm households in rural areas of low income countries lack many types of information, such as, on available inputs, input and output prices, weather forecasts, SLM practices, etc., needed in making production decisions, raising crop yields, negotiating better prices and improving farm competiveness (Low, 2013). The estimates show that the adoption of SLM practices is very low – just on about 3% of total cropland in SSA (WB, 2010). SLM – also referred to as 'ecosystem approach' – ensures long-term conservation of the productive capacity of lands and the sustainable use of natural ecosystems (such as woodlands, rangelands and forests). In this approach, land is managed with full consideration for the various ecosystem services that it may supply such as food, medicinal plants, regulation of water cycles, provision recreation values.

However, recent market and technology innovations have transformed the dynamics of gathering and disseminating information. Specifically, the developments in the Information and Communication Technologies (ICT) can provide with new opportunities for awareness-raising and knowledge dissemination (Gantt and Cantor, 2010). The easily accessible mobile phones can now timely, widely and directly deliver useful information such as weather forecasts, farm inputs, market information and also development of SLM practices to farmers (AfDB, UNECA, OECD, 2009). Recent statistics confirm the rapid growth and penetration of mobile phones across Africa albeit at different speeds ranging from 78% in Kenya to just about 17% in Ethiopia (Wireless Intelligence (WI), 2012). However, there has been little research conducted so far on the impact of these innovative infrastructural transformations on land management or even on agricultural growth in general (Aker, 2008; Rashid & Elder, 2009; Muto & Yamano, 2009; Aker & Mbithi, 2010; Lester *et al.,* 2010).

Despite the huge economic losses due to land degradation and the urgent need for action to prevent and reverse land degradation, the problem has yet to be appropriately addressed, especially in the developing countries, including in Eastern Africa. Adequately strong policy action for SLM is lacking, and a coherent and evidence-based policy framework for action across all agro-ecological zones is missing (Nkonya *et al.,* 2013). Reliable estimates on the impact of land degradation on the welfare of farm households are not available. Though investments in SLM are seen as smart and worthwhile, there is an urgent need for evidence-based science, using more data and robust economic tools, to evaluate the economic returns from SLM. This working paper seeks to provide with a broad and critical review of evidence on the following research objectives: i) evaluate the status, dynamics and impacts of land degradation in Eastern Africa, ii) identify hotspot areas most affected by land degradation in the region, iii) review the literature on the drivers of land degradation in those hotspot areas; iv) review the previous studies on the costs and benefits of action versus inaction against land degradation; and v) characterize the effects of land degradation on the welfare of agricultural households.

The rest of this paper is organized as follows: Section 2 provides an empirical review of key studies on drivers and impacts of land degradation in Eastern Africa; Section 3 presents the study methods; Section 4 presents the initial findings of the study; Section 5 concludes.

2 Conceptual Framework

2.1 Land Degradation and Total Economic Value

This study utilizes the Total Economic Value (TEV) approach – that seeks to capture a more comprehensive definition of land degradation costs. TEV of land is broadly sub-divided into two categories; use and non-use values. The use value consists of direct and indirect use. The direct use includes marketed outputs involving priced consumption (such as crop production, fisheries, tourism) as well as un-priced benefits (such as local culture and recreation value). The indirect use value consists of un-priced ecosystem functions such as water purification, carbon sequestration, among others.

On the other hand, non-use value is divided into three categories namely; bequest, altruistic and existence values. All these three benefits are un-priced by markets. In between these two major categories, there is the option value, which includes both marketable outputs and ecosystem services for future direct or indirect use. Land and its provision of ecosystem services are often undervalued because many of these services are not traded in markets. Ideally, the ecosystem services should be considered as capital assets, or natural capital (Daily *et al.,* 2011, Barbier, 2011a); failure to capture them leads to higher rates of land degradation. The 2005 Millennium Ecosystem Assessment defines land degradation as the 'loss of its services, particularly the primary production services' (Millennium Ecosystem Assessment (MEA), 2005). To adequately account for ecosystem services in decision making, the economic values of those services have to be determined. There are various methods to evaluate ecosystem services (Barbier 2010, 2011a, 2011b, Nkonya *et al.,* 2011), however, attributing economic values to ecosystem services is challenging, due to many unknowns and actual measurement constraints.

Dasgupta (2011) indicates that the social worth of natural resources can be decomposed into three parts: their use value, their option value, and their non-use value. These components appear in different proportions, depending on the resource. It is noteworthy that estimating the value of environmental (accounting prices) is not just to value the entire environment; rather, it is to evaluate the benefits and costs associated with changes made to the environment due to human activities. Earlier, Dasgupta (2000) identified two causes of resource degradation, namely; institutional failure and poverty, contending that the links between rural poverty and the state of the local natural–resource base in poor countries can offer a possible pathway along which poverty and resource degradation is synergistic over time. This implies that the erosion of the local natural resource base can make certain categories of people deprived even while the country's economy – Gross National Product (GNP) – increases (ibid).

Balmford *et al.* (2008) criticizes the TEV approach by noting that non-use and indirect use values are mostly not traded in markets; thus posing a big challenge in measuring them. Balmford *et al.* (2008) and Barbier (2010) further criticize TEV in that it has the potential of double-counting of benefits from ecosystems services. This study carefully identifies different benefits to avoid double counting.

2.2 Productivity and Poverty Effects of Land Degradation

Research on poverty and its linkages to land degradation has grown immensely in the past few decades. Yet, there are still major gaps in studying the impact of poverty on crop productivity and land degradation or vice versa. This is partially due to the intricacy and context specificity of the linkages as well as a lack of systematic approaches adequately dealing with the effects of confounding factors. Extensive analyses of the complex linkages of these three key variables – poverty, declining agricultural productivity and land degradation – is important, especially in developing countries where the objective of meeting food security is still not fully achieved.

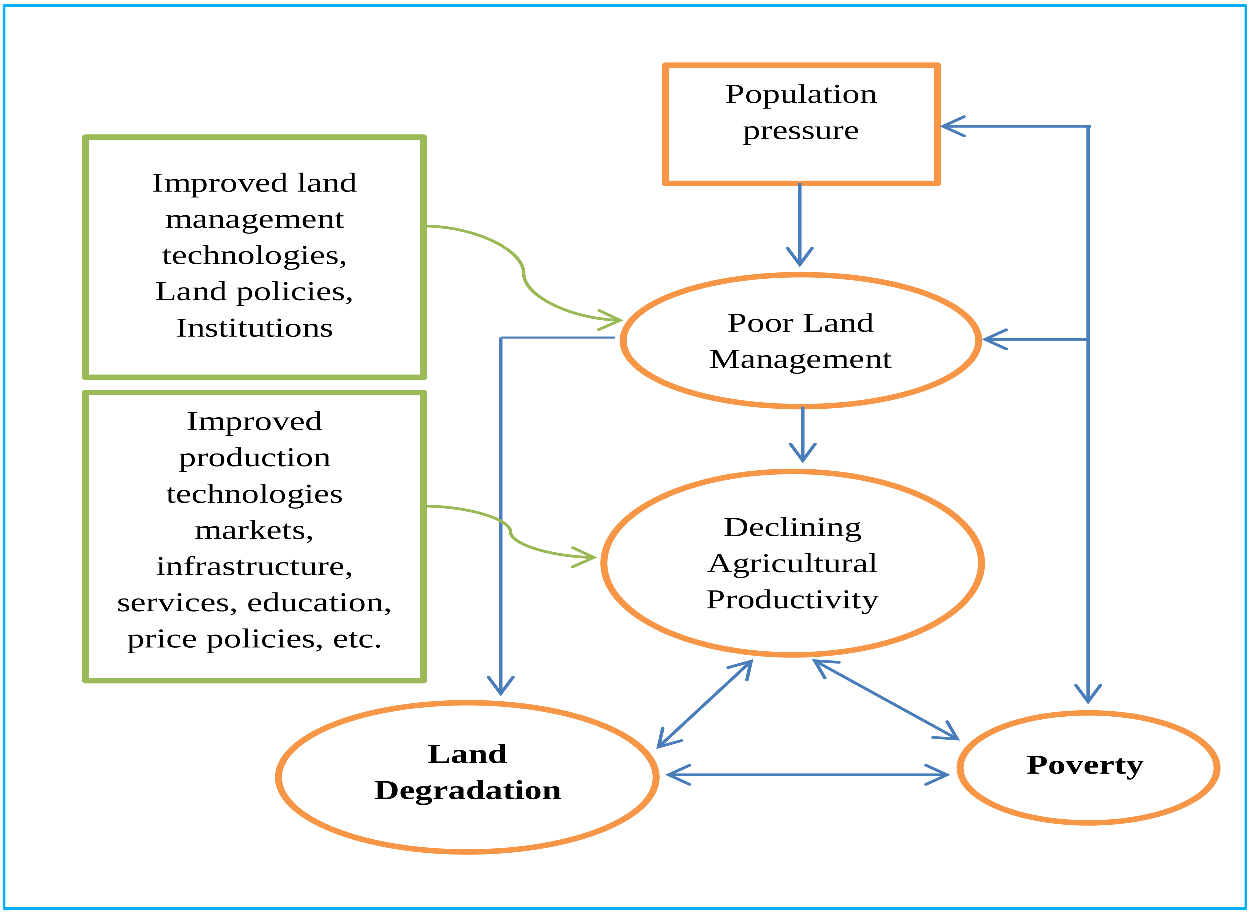
A summary of the critical review of the vast literature relating to poverty, land degradation and agricultural productivity is shown in Figure 2. This figure (Figure 2) is very schematic; the relationships are not linear and they do not comprehensively cover the entire issues but only the topics and causal relationships under the focus in this current paper. Some of the identified "poverty – land degradation linkages" are as follows: land degradation is seen to contribute to declining agricultural productivity, and this in turn increases poverty (Barbier, 2000, Readon and Vosti, 1995). On the other hand, poverty also leads to land degradation though declining land productivity (Reardon & Vosti, 1995; Lambin *et al.,* 2001). Land degradation can contribute directly to poverty, not necessarily through its impact on agricultural productivity (Buys, 2007). However, other studies find this relationship not tenable. For example, Reardon & Vosti (1995) Scherr & Yadav (1996), Scherr (2000) and Nkonya *et al.,* (2008) do not find correlation between poverty and land degradation always to be consistent. Some places with higher poverty rates report less land degradation.

A rapidly growing population without proper support policies is seen to catalyze these dynamics. It may drive a region faster to the point where human activities have harmful consequences on the resource base (Dasgupta 2000). An increasing population increases demand for fuel, building materials, land for crops and livestock; forcing people onto new land. The original vegetation cover of the new land is removed as less fertile (marginal) land is brought into agricultural production. Marginal land is less suitable for production and more prone to degradation due to its shallow soil, poor soil properties and unfavorable topographic conditions. However, there is some evidence that increasing population pressure and land scarcity may act as a stimulus to improved resource management especially when the population-supporting capacity of the land is not exceeded. Similarly, earlier studies postulated that poverty contributes to rapid population growth (Cleaver & Schreiber 1994; Dasgupta 2000, Nkonya et al., 2008).

Poverty may lead to poor land management, which causes land degradation and a decline in agricultural productivity, which in turn can cause further impoverishment –, i.e. a vicious cycle (Deininger, 2003). The declines in agricultural productivity and poverty are shown to be a bi-directional relationship; poverty may reduce agricultural productivity through farmers' inability to use productivity enhancing inputs (Deininger and Feder, 2001). This is further exacerbated by poverty and a host of other factors such as poor policies, missing institutions, and unaffordable technologies (ibid).

The situation can, however, be curtailed in a number of ways. The two green boxes (to the left of Figure 1) show some of important aspects that can reverse the land degradation situation. For instance, improving agricultural productivity can be achieved by providing incentives for the development and dissemination of SLM technologies as well as innovative institutions and land use policies. These may include policies providing incentives for SLM investments at household, community, regional and national level, such as improving land tenure and users' rights, improving access to markets for buying inputs and selling agricultural products and other outputs. Awareness raising, promotion, training and financial or material support for best SLM practices is also important. Some other good practices recommended in the literature that can enhance productivity include better production technologies such as well-maintained irrigation systems, improved seed varieties and cultivars, adaptive farming systems (Huang *et al.,* 2002; Stoop *et al.,* 2002; Wale & Yalew, 2007). An improvement in the macroeconomic environment, better access to markets and to higher quality public services, better infrastructures, extension services to farmers may increase the adoption of SLM. This may also serve as an indirect means to reducing poverty by improving agricultural productivity (Barrett *et al.,* 2001; Pretty *et al.*, 2003). Directly targeting the poor with specific poverty reduction strategies is helpful.

Figure 1: Conceptual framework land degradation, poverty and productivity effects



Source: Author's creation.

3 Results and Discussions

3.1 Overview of land degradation in Eastern Africa

The total population of Sub-Saharan Africa (SSA) is currently estimated at 750 million people (UNDP, 2005), but this is projected to grow past the one billion mark by 2020 (ibid). The region is the poorest in the world, with an estimated one in every three people living below the poverty line. The demand for food is putting greater pressures on the natural resource base. Assessments of land degradation in the region vary in methodology and outcome (Stoosnijder, 2007; Lal & Stewart, 2013; Zucca *et al.,* 2014). The GLASOD survey, based on expert opinion, concluded that in the early 1980s about 16.7% of SSA experienced serious human-induced land degradation (Middleton & Thomas, 1992; Yalew, 2014). Using standardized criteria and expert judgment, Oldeman (1994) revealed that about 20% of SSA was affected by slight to extreme land degradation in 1990. These assessments were done based on 'experts' opinion and in varying time periods

The data from the FAO TERRASTAT maps 67% (16.1 million km^2) of the total land area of SSA as degraded (FAO, 2000; Table 1), with country-to-country variations. These differences are quite large: Ethiopia is the most seriously affected (25% of territory degraded) while Kenya and Tanzania records 15% and 13%, respectively. Malawi is the least affected (9%). These figure for Tanzania (13%) is quite low compared to a later study (Assey *et al.,* 2007) based on expert opinion that showed about 61% of the territory affected by land degradation. The TERRASTAT dataset allows the further classification of the degraded lands by the relative degree of severity of degradation. Thus the out of the 67% degraded land in SSA, the four sub-categories exist, namely; light (24%), moderate (18%), severe (15%), and very severe (10%). In contrast, the GLASOD data shows that about 25%, 14% and 13% of land area is degraded in Ethiopia, Kenya and Tanzania respectively. However, the main weakness of these studies is that it is based on subjective expert judgment and must be approached with caution. Following Vlek *et al.,* (2010), the land degradation 'hotspots' map (Figure 2) shows that Ethiopia, Kenya, Tanzania and Malawi are the most affected in the Eastern Africa region, thus we select them as our case studies countries.

Table 1: Land degradation severity in Eastern Africa

	Land area (%) affected by degradation					Total Degraded Area (%)	
Country	None	Lightly	Moderately	Severely	Very severely	TERRASTAT	GLASOD
Ethiopia	75	0.3	12.7	2.1	10.4	95	25.4
Kenya	85	1.0	3.9	5.7	4.1	93	14.6
Malawi	92	0.1	8.4	0.0	0.0	61	8.5
Tanzania	87	2.5	5.4	5.2	0.4	87	13.4
SSA	83	0.96	3.4	5.1	7.3	67	16.7
Global	83	1.4	4.1	6.8	4.4	64	16.7

Source: Adopted from UNEP/ISRIC, 1991 & FAO, 2000.

GLASOD global survey (Nachtergaele, 2006) and FAO`s global forest resource assessment (2005) identified six main types of land degradation predominant across SSA countries (Table 2). Among them, water and wind erosion are undoubtedly the most widespread type of land degradation (46% and 38% respectively), followed by chemical and physical deterioration of soils (16%). The other types of land degradation include salinization and water logging, decline in soil fertility, and loss of habitat (especially forest and woodland). Previous studies have not been successful in quantifying the extent and severity of these types of land degradation in East Africa. However, it is notable that water erosion, declining soil fertility and nutrient depletion are important in all the four countries. While salinization (especially of irrigated land) is severe in Kenya (30%) and Tanzania (27%), loss of forest and woodland in these countries is estimated at 0.7% per annum. In terms of population affected, available statistics show that declining soil fertility (with varying degree) affects almost every individual (100%), while water and soil erosion affects 97% and 18% of the total population respectively (ibid).

Table 2: Land degradation types and extent in Sub Saharan Africa

Type of land degradation	Affected land (% of total)	Affected population (% of total)	Countries affected	Main cause(s)
Water Erosion	46	97	All countries in eastern Africa (Kenya, Tanzania, Ethiopia, Malawi, Zambia)	Deforestation, overgrazing, agric. practices
Wind Erosion	38	18	Botswana, Chad, Djibouti, Eritrea, Mali, Niger, South Africa and Sudan	Overgrazing, deforestation
Salinization			Severe in Kenya (30%), Tanzania (27%)	Water management
Soil fertility and nutrient depletion	Approx. 100	Approx. 100	All countries	Agric. practices, overgrazing, deforestation,
Loss of Habitat (Deforestation)	0.7% of annual change of Forest & Woodland area in East & Southern Africa		Hotspots: Burundi (-5.2%), Comoros (-7%), Nigeria (-3.3%), Togo (-4.5%), Uganda (-2.2%), Zimbabwe (-1.7%)	Deforestation, overgrazing, agricultural practices

Source: Adopted from FAO Global Forest Resource Assessment (2005) and Nachtergaele, (2006).

More recently, satellite–based imagery and remote sensing have been utilized to identify the magnitude and processes of land degradation at global, regional and national levels. This involves the use of Normalized Difference Vegetation Index (NDVI) derived from Advanced Very High-Resolution Radiometer (AVHRR) data. Several studies have applied this technique, including; Evans & Geerken, 2004; Bai *et al.,* 2008; Hellden & Tottrup, 2008; Vlek *et al.*, 2010. While using rain-use efficiency (RUE) adjusted NDVI, Bai *et al.* (2008) map the global land degradation trend. Their assessment shows that land degradation has affected about 26% of SSA. The areas affected are also different from those reported by the GLASOD and TERRASTAT survey and by Oldeman (1994).

Unlike this GLASOD and TERRASTAT assessment, Bai *et al.,* (2008) estimated that about 24% of the global land area has been degrading in 25 years. Much of the areas they identify do not overlap with those indicated in the GLASSOD survey. However, Sub Saharan Africa region remains the most affected. Country estimates (Table 3) show that Tanzania was the most affected country; 41% of its land territory degraded. Ethiopia and Malawi both had 26% of their territories degraded while about 18% of Kenya land area was degraded in the same period. In terms of populations affected; about 40% and 36% of people in Tanzania and Kenya were directly affected by land degradation. Similarly, about 30% and 20% of the Ethiopian and Malawian population was affected by land degradation over the same period. It is however notable that these estimates do not take into account the effect of atmospheric fertilization, the rainfall factor and the effect of soil moisture in sparse vegetative areas.

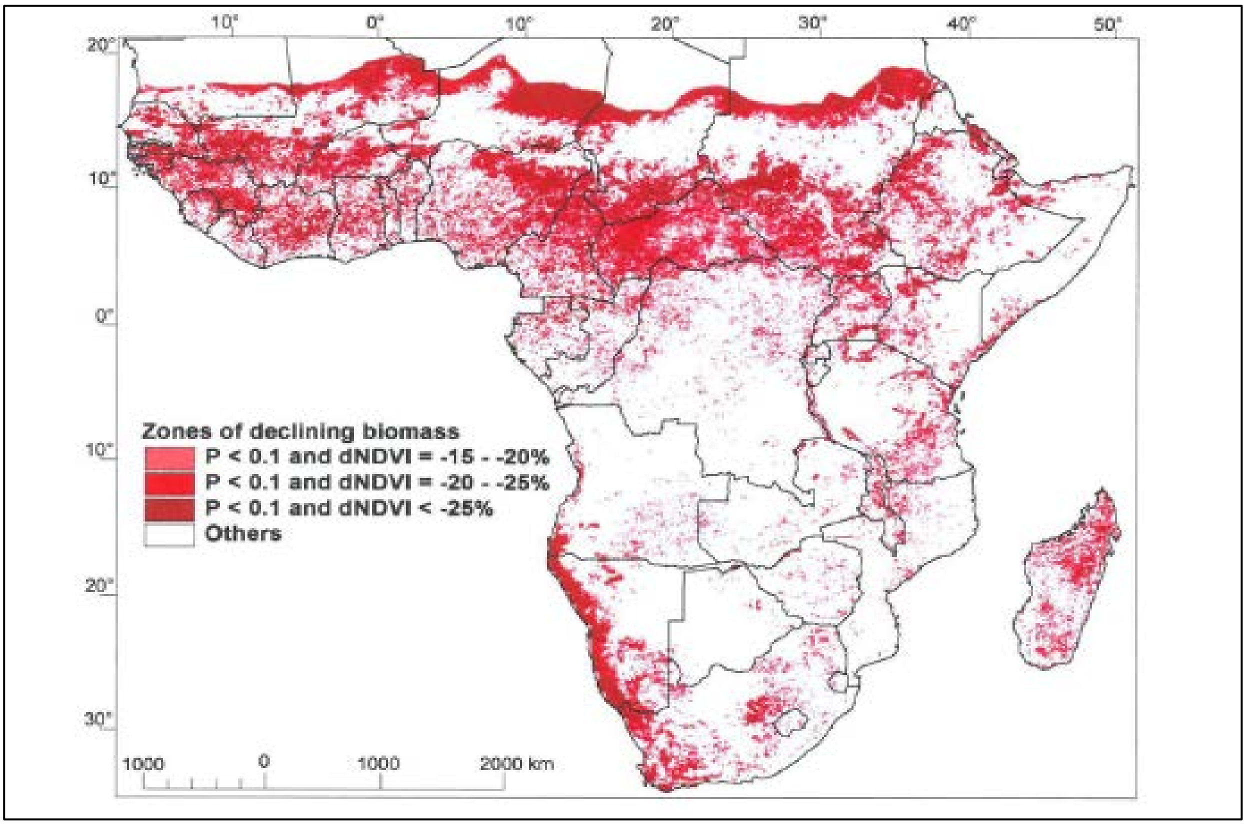
Table 3: Statistics of degrading areas by country for Eastern Africa (1981–2003)

Country	Degrading area (km2)	% Territory	% Global degrading area	Total NPP loss (ton C⁄ 23 years)	% Total population	Affected people
Ethiopia	296812	26.33	0.843	14276064.5	29.10	20650316
Kenya	104994	18.02	0.294	6612571.4	35.59	11803311
Malawi	30869	26.05	0.089	1370894.6	19.89	2486085
Tanzania	386256	40.87	1.081	22603896.1	39.48	15300003

Source: Bai *et al.,* 2008.

Similarly, the work of Vlek *et al.* (2008) estimated that 10% of SSA was significantly affected by land degradation. More recently, Vlek *et al.* (2010) map the geographic extent of areas in SSA affected by land degradation processes over the period of 1982–2003 (Figure 2). While utilizing long-term NDVI, they show that about 27% of the land is subject to degradation processes including, soil degradation, overgrazing, or deforestation.

Figure 2: Geographic overview of land degradation in SSA



Source: Adopted from Vlek *et al.,* 2010.

Note: The geographic spread of the area subject to human-induced degradation processes among the different climatic zones of SSA. The red spots show the pixels with significantly declining dNDVIhuman/dt

Some of the key hotspots areas include west and southern regions Ethiopia, western part of Kenya, southern parts of Tanzania and eastern parts of Malawi (Figure 2). The hotspot areas in Ethiopia are characterized by high population pressure (on land and forests), farming activities on steep slopes and frequent famines occasioned by unreliable rainfall. The hotspots in Kenya are characterized by intensive crop farming that increases pressure on soils. The arid and semi-arid conditions of the southern parts of Tanzania and eastern parts of Malawi may also be a contributing factor to the high degradation levels. Detailed studies will be carried out in these Eastern Africa countries.

More recently, Le, Nkonya and Mirzabaev (2014) analyzed global land degradation using decline in NDVI over 1982-2006 period by main land cover/use types counted globally for each country. Unlike Bai *et al.,* (2008) they carry out a number of adjustments to the data such as correction of RF (rainfall factor) and AF (atmospheric fertilization), and account for seasonal variations in vegetation phenology. The results (Table 4) show that a total of about 453,888km^2 (51%) and 38,912 km^2 (41%) of Tanzania's and Malawi's land area was degraded respectively. In Ethiopia, land degradation was reported in about 228,160 km^2 (23%) and just about 127,424 km^2 (22%) in Kenya. These areas varied across the main land cover-land use type by country. For example, in Ethiopia much of degradation (32%) was experienced in areas with sparse vegetation, in Kenya the highest proportion of degradation was experienced in forested areas (46%) while shrub-land and mosaic vegetation and crop each had 42%. In Malawi highest proportion of degradation was experienced in mosaic forest-shrub/grass (57%) and grasslands (56%) while in Tanzania 76% of degradation reported in degradation was experienced in mosaic forest- shrub/grass and in grasslands.

Table 4: Area (km^2 and percentage) of long-term (1982-2006) NDVI decline

	Area (km^2) of NDVI decline and in percentages for the corresponding land use							
Country	Cropland	Mosaic vegetation-crop	Forested land	Mosaic forest-shrub/grass	Shrub land	Grassland	Sparse vegetation	*Total*
Ethiopia	35904 (18%)	30976 (19%)	9984 (16%)	59776 (27%)	37824 (20%)	7808 (14%)	45888 (32%)	228160 (23%)
Kenya	15808 (31%)	40512 (42%)	21568 (46%)	9664 (10%)	21952 (42%)	15232 (18%)	2688 (4%)	127424 (22%)
Malawi	576 (50%)	6720 (31%)	11072 (34%)	1088 (57%)	17984 (51%)	1472 (56%)	N/A	38912 (41%)
Tanzania	12608 (32%)	112768 (62%)	139968 (36%)	18688 (76%)	93504 (70%)	75712 (76%)	640 (30%)	453888 (51%)

Source: Le, Nkonya and Mirzabaev (2014).

In summary, various methods have been used to estimate the extent/levels of land degradation in the Eastern Africa region all resulting in different results. They include expert opinions and, more recently, use of NDVI measures. A number of deficiencies are associated with these approaches. For instance expert opinion methodologies: (i) have unknown magnitudes and directions of measurement errors, and related point, (ii) they are perception-based and semi quantitative and therefore not built on objective measurements. However, recent empirical research shows a shift from expert opinion approach to the quantitative data based interpretation of aerial photography and satellite imagery (NDVI and NPP) and further to a more model-based approach involving indicators and proxy variables measurable over large areas and over longer periods (Le, Nkonya and Mirzabaev (2014)).

Some caveats associated with NDVI/NPP methodologies include: site-specific effects of vegetation/crop structure and site conditions autocorrelation, effect of atmospheric fertilization and intensive fertilizer use on NDVI, seasonal variations in vegetation phenology and time-series, large errors('noises') in the NDVI data, and the effect of soil moisture in sparse vegetative areas. Detailed steps to address these caveats are presented in Le (in press). Further, to ensure accuracy of observations they need to be ground-truthed and triangulated with household/plot level data analysis. There are several and complex proximate and underlying drivers of land degradation; identifying them by main land-use types will add value to earlier studies in the case study countries.

3.2 Drivers of Land degradation in Eastern Africa

Causes of land degradation can be grouped into two categories, namely; proximate and underlying causes (Lambin & Geist, 2006; Lal & Stewart, 2013; Pingali *et al.,* 2014). Proximate causes are those that have a direct effect on the terrestrial ecosystem. These include biophysical (natural) conditions related to climatic conditions and extreme weather events such as droughts and coastal surges, which may, for example, cause land to become saline. Proximate causes are also related to unsustainable land management practices (anthropogenic) such as over-cultivation, overgrazing and excessive forest conversion. On the other hand, the underlying causes are those factors that indirectly affect proximate causes (ibid). Lack of institutions, poverty, and insecure land tenure may underlie land degradation by hampering incentives to invest in sustainable land management practices (Kabubo-Mariara, 2007; FAO, 2011). Nkonya et al., (2013) presents a detailed discussion of global proximate and underlying drivers of land degradation. We present a summary of some of the empirical studies undertaken to identify and assess proximate and underlying causes of land degradation in the selected countries in Eastern Africa region in Table 5.

From Table 5, we can summaries that there are a number of important proximate and underlying causes of land degradation in Eastern Africa from a series of studies carried out in these countries thus far. Some of these factors are common across borders among the Eastern Africa countries. Key proximate causes include; climatic conditions, topography, unsuitable land uses and inappropriate land management practices (such as slash and burn agriculture, timber and charcoal extraction, deforestation, overgrazing) and uncontrolled fires. The dry aid and semi-arid arid lands are prone to fires which may lead to serious soil erosion (Voortman *et al.,* 2000; D'Odorico, 2013). The erratic rainfall in these areas may also be thought to induce salinization of the soil (Safriel & Adeel, 2005; Wale & Dejenie, 2013).

Similarly, farming on steep slope will accelerate the effects of soil erosion. Another key proximate cause of soil erosion is the practicing unsustainable agriculture such as land clearing, overstocking of herds, charcoal and wood extraction, cultivation on steep slopes, bush burning, pollution of land and water sources, and soil nutrient mining. It is further notable that improperly planned infrastructural development such as transport and earthmoving techniques by trucks and tractors nurture land degradation processes (Rademaekers *et al.,* 2010). Charcoal burning and firewood extraction is also significant driver of land degradation in the region. Most deforestation exercises are associated with the continued demand for agricultural land, fuel-wood, charcoal, construction materials, large-scale timber logging and resettlement of people in forested areas. This often happens at the backdrop of ineffective institutional mechanisms to preserve forests. Grazing pressure and reduction of the tree cover continues to diminish the productivity of rangelands (Hein & de Ridder, 2005; Waters *et al.,* 2013).

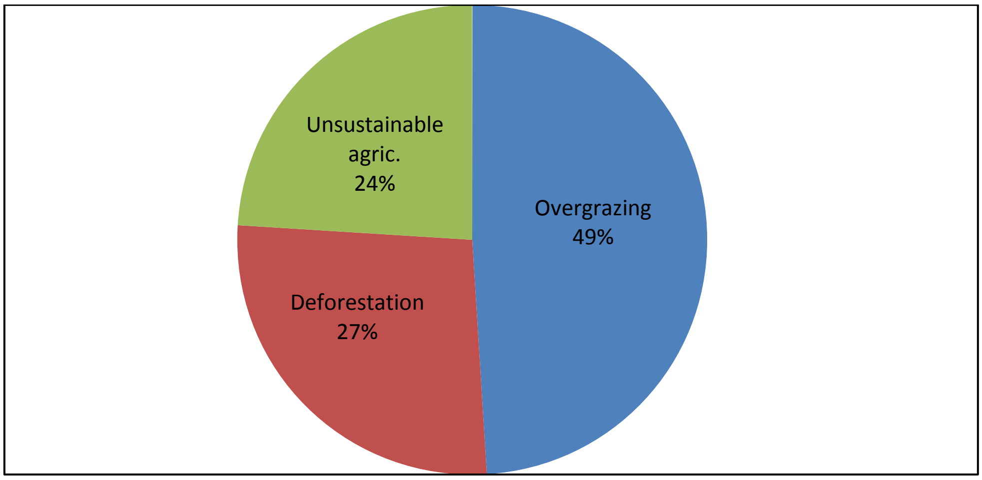
Table 5: Empirical review on proximate and underlying causes of land degradation in SSA

Country	Proximate Drivers	Underlying drivers	References
Ethiopia	Topography, unsustainable agriculture, fuel wood consumption, conversion of forests, woodlands, shrub-lands to new agricultural land (deforestation)	Weak regulatory environment and institutions, demographic growth, unclear user rights, low empowerment of local communities, poverty, infrastructural development, population density	Pender *et al.,* 2001; Jagger & Pender, 2003; Holden *et al.,* 2004; Rudel *et al.,* 2009, Bai *et al.,* 2008; Belay *et al.,* 2014; Tesfa & Mekuriae, 2014.
Kenya	Topography, deforestation and charcoal production, overgrazing, unsustainable agricultural practices	Poor/weak governance & institutional weakness in agric. sector, lack of defined property rights, poverty, population density	Pender *et al.,* 2004a; Bai & Dent, 2006; Waswa, 2012; Waswa *et al.,* 2013; Nesheim *et al.,* 2014.
Tanzania	Topography, climate change, settlement and agric. expansion, overgrazing, firewood, timber and charcoal extraction, uncontrolled fires.	Market and institutional failures, rapid population growth, rural poverty, insecure tenure, and absence of land use planning, development of infrastructure	Pender *et al.,* 2004b; de Fries *et al.,* 2010; Fisher, 2010; Wasige *et al.,* 2013; Ligonja & Shrestha, 2013; Heckmann, 2014.
Malawi	Charcoal and wood fuel use (for domestic and commercial), timber production; unsustainable agricultural methods (slash and burn with increasingly shorter rotations), mining.	Past and current development processes in energy, forestry, agriculture and water sectors; poverty; lack of alternative energy sources; weak policy environment, lack of planning; insecure land tenure.	Pender, 2004; Rademaekers *et al.,* 2010; Lambin & Meyfroidt, 2010; Thierfelder *et al.,* 2013; Kiage, 2013; Harris *et al.,* 2014.

Source: own compilation

Arid and semi-arid climatic conditions with high evaporation rates; together with poor management of irrigation water (in the 4.5% irrigated cropland of SSA) is a major cause of salinization. Similarly, fragmentation, overexploitation of the forest resources and conversion of forest lands to agriculture has turned SSA as world's highest annually deforested area. Overstocking is identified to primarily drive degradation of rangelands, decline of vegetation productivity (and eventually livestock productivity), and loss of resilience of the rangeland for droughts (WRI, 1994). Indeed, overgrazing was estimated to causes about 50% of all soil degradation in semi-arid and arid regions of Africa (ibid). GLASOD and TERRASTAT indicate that the proximate causes contributing to land degradation in Eastern Africa include; non-sustainable agricultural practices, overgrazing and overexploitation of forests and woodlands resources (Lal & Stewart, 2010). Figure 3 shows that overgrazing caused about half (49%) of land degradation in SSA followed by deforestation (27%) and unsustainable agricultural practices (24%). The ever increasing demand for food with an increasing population in Eastern Africa but with stagnant or declining agricultural productivity has led to rapid expansion of agricultural land and reduced rehabilitation of soil fertility through shortening of the fallow periods in extensive land use systems.

Figure 3: Human-induced drivers of land degradation

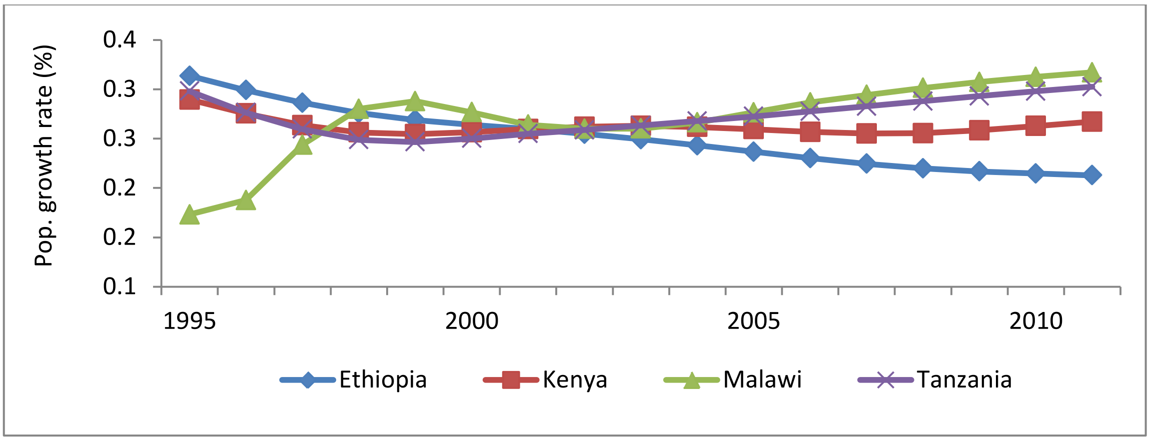


Source: Authors' compilation – data from FAOSTAT

Important underlying drivers of land degradation across the four counties include land tenure, poverty, population density and weak policy and regulatory environment in the agricultural and environmental sectors (Table 5). Insecure land tenure may act as a disincentive to investment in sustainable agricultural practices and Technologies (Kabubo-Mariara, 2007). Similarly, a growing population without proper support policies and proper land management will exhaust the capacity of land to provide ecosystem services (Tiffen *et al.,* 1994). It is also argued that population pressure leads to expansion of agriculture into fragile areas and reduction of fallow periods in the cultivated plots. However, this is not always the case. Population pressure has been found to increase agricultural intensification and higher land productivity as well as technological and institutional innovation that reduce natural resource degradation (Tiffen *et al.,* 1994; Nkonya *et al.,* 2008).

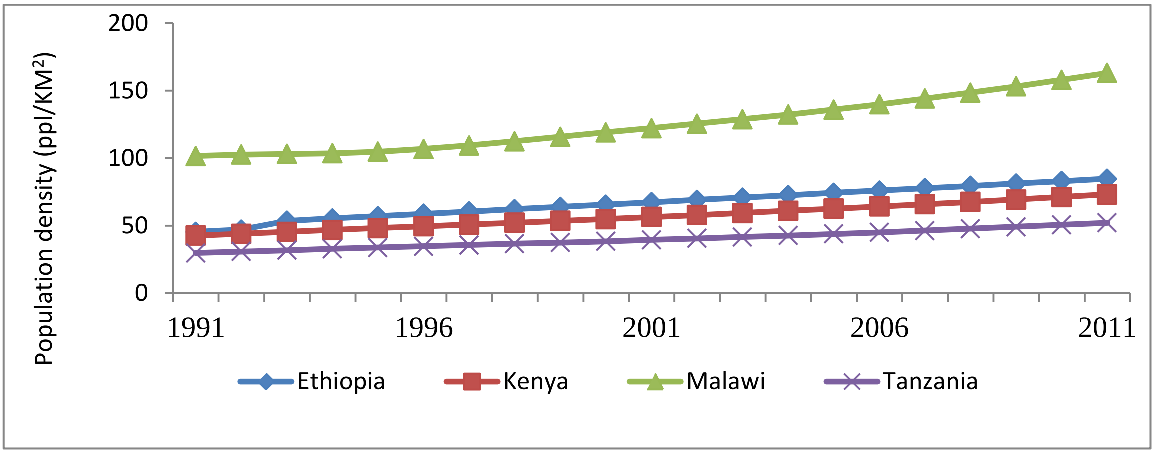
The recent estimates show that that SSA population is growing at about 2% annually and it is projected that SSA will be home to at least 750 million people by 2020 – an increase of about 33% extra people (UNDP, 2005). More specifically, the annual population growth rates in the last two decades for Ethiopia, Kenya, Malawi and Tanzania have been between 2-3% (Figure 4). For example in 2011 Malawi and Tanzania experienced a population growth rate of 3.2% and 3.1% respectively. During the same period, Kenya and Ethiopia reported population growth rates of 2.7% and 2.1% respectively (Figure 4). An increasing population exerts more pressure on the available resources, especially land. The recent statistics also point to an increase in population density per unit of land in the region. In all the case study countries, the population density has doubled in the last 2 decades alone (Figure 5).

Figure 4: Population growth rate in Eastern Africa



Source: Authors' compilation – data from FAOSTAT

Figure 5: Population density in Eastern Africa (people/KM^2)

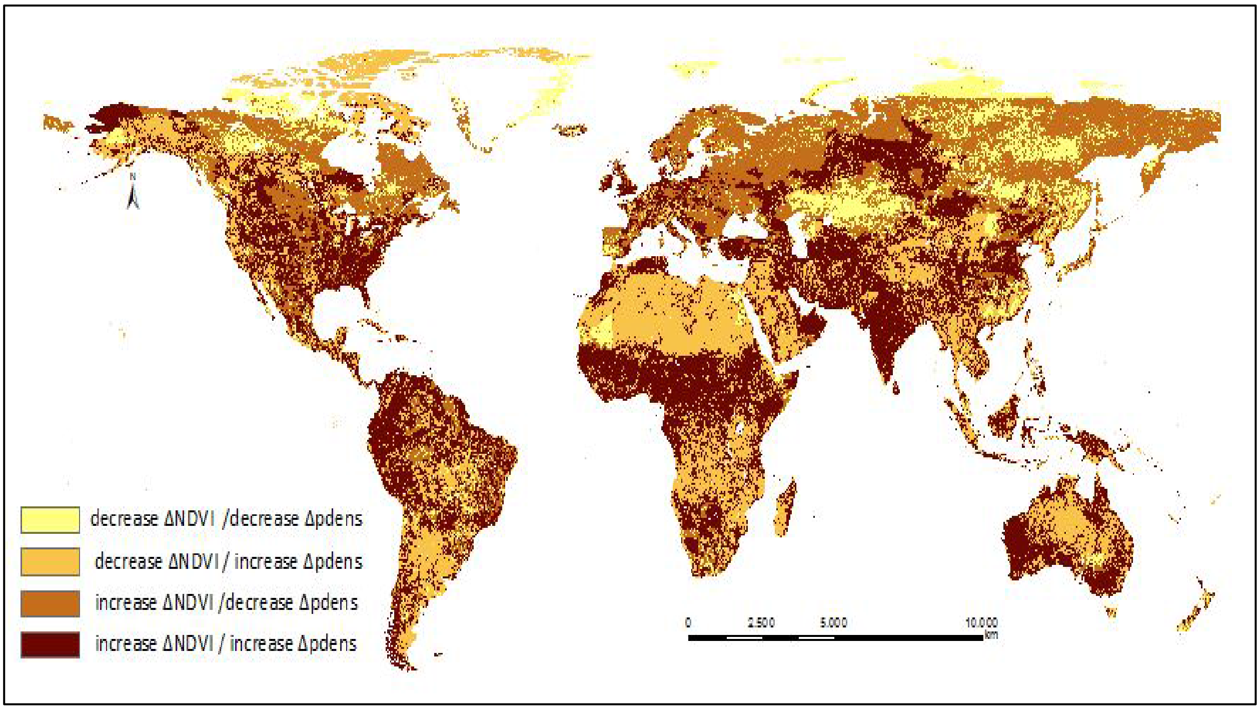


Source: Authors' compilation – data from FAOSTAT

Poverty – also referred to as 'the low equilibrium trap'- is another important underlying driver of land degradation in Eastern Africa (Lambin, 2001). There exist a poverty-land degradation vicious cycle; though poverty can be argued as an outcome of degrading land, it is also seen as a cause of land degradation (Reardon and Vosti 1995). Land degradation contributes to low and declining agricultural productivity, and this in turn contributes to worsening poverty. Land degradation can contribute directly to poverty, separately from its impact on agricultural productivity, by reducing the availability of other important goods and services to poor households and by increasing the demands on labor needed to seek for such goods.

Poverty in turn is posited to contribute to land degradation as a result of poor households' inability to invest in natural resource conservation and improvement (ibid). However, it is also argued that the poor depend heavily on land; therefore, they have a strong incentive to invest their resources into preventing or mitigating land degradation in efficiently working market conditions (de Janvry et al., 1991; Nkonya *et al.,* 2008). More recent studies maps areas with increasing population density and severe poverty but recording land improvements (Nkonya *et al.,* 2011; 2013). A map by Nkonya *et al.* (2011) shows positively correlation between NDVI (proxy for land degradation) and population density in SSA (Figure 6). These relationship may however be misleading because they are simplistic and do not account for omitted variables and serious endogeneity issues. The data utilized also is similar to that used by Bai et al., which need to be corrected for other factors such as the rainfall factor, the atmospheric fertilization and intensive use of fertilizer, and also need to account for seasonal variations in vegetation phenology.

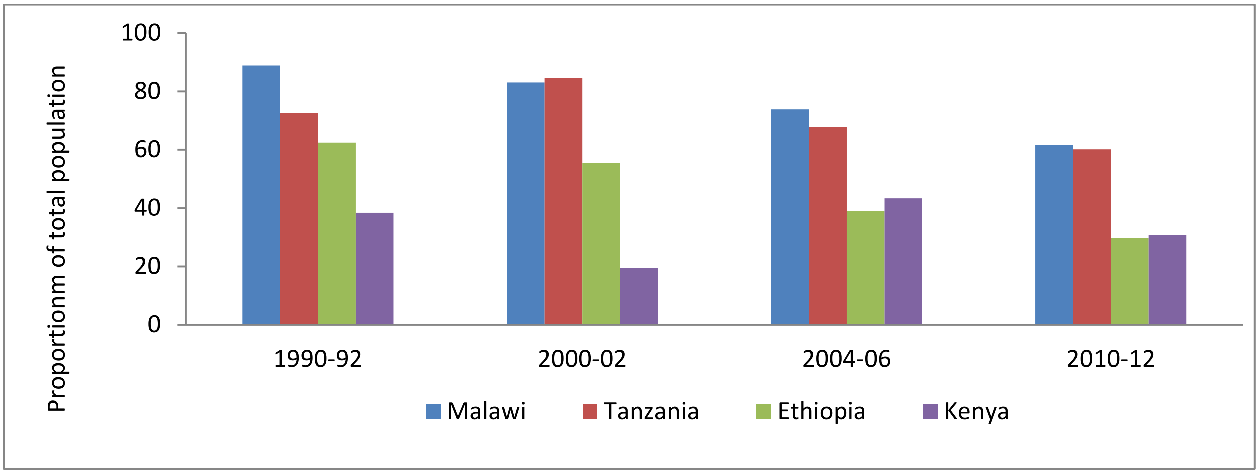
Figure 6: Relationship between change in NDVI and population density



Source: Nkonya *et al.,* 2011.

Available statistics show that poverty is rampant in the Eastern Africa region, especially among the rural agricultural households. The proportion of poverty headcount ratio at $1.25 a day (PPP) for the case study countries is presented in Figure 7. There is a slight reduction in the proportion of poor people in all the countries over the last two decades. About 60% of the Tanzanian and Malawian population were living on less than USD 1.25 per day in 2012 compared to about 30% of Kenyan and Ethiopia populations.

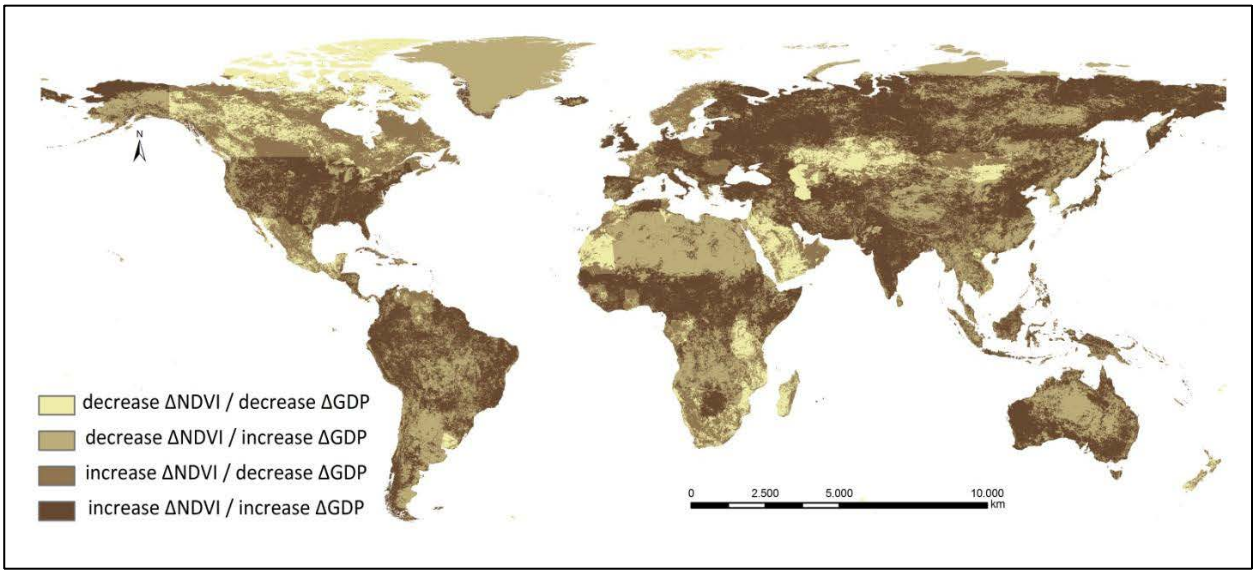
Figure 7: Poverty headcount ratio at $1.25 a day (PPP) (% of population)



Source: Authors' compilation – data from FAOSTAT

With increasing population pressures, absence of proper technologies, lack of appropriate institutional and economic conditions and poverty situation, there are no incentives for sustainable land management among the rural farming communities. What is experienced is rather resource mining. The closest mapping of the relationship between poverty and land degradation is done by Nkonya *et al.* (2011). They use national domestic product (GDP) and NDVI. Figure 8 shows a general increase of both GDP and NDVI in globally (in SSA specifically). However, a closer look to the Eastern Africa shows some areas of decreasing in changes in NDVI and also GDP. This shows a mixed response of land degradation to economic growth and vice versa.

Figure 8: Relationship between GDP and NDVI



Source: Nkonya *et al.,* 2011.

3.3 Costs and Consequences of Land Degradation in Eastern Africa

Land degradation in the Eastern Africa region has substantial environmental, social and economic costs. Land degradation not only reduces the productive capacity of agricultural land, rangelands and forest resources but also significantly impacts on the biodiversity (Davidson & Strout, 2004). The costs and consequences of land degradation can be direct or indirect. Direct costs may include costs such as; costs of nutrients lost by soil erosion, lost production due to nutrient and soil loss, and loss of livestock carrying capacity. On the other hand, indirect costs may include costs such as; loss of environmental services, silting of dams and river beds, reduced groundwater capacity, social and community losses due to malnutrition and poverty. Estimating these costs and the consequences of land degradation continues to be a daunting task (Bojo & Cassells, 1995).

The economic consequences of land degradation are severe in Eastern Africa because about 65% of the population is rural; with the main livelihood of about 90% of these rural populations is agricultural-based. To date, few studies have comprehensively tackled the costs and consequences of land degradation either at the global, regional or national level using different parameters and approaches such as expert opinion, measurement of top soil losses as a result of erosion, rate of deforestation, soil fertility (nutrient balance) and vegetation index (as observed through GIS and remote sensing techniques). A summary of the economic impact of different land degradation process on land productivity and on crop yields are presented in Table 6.

Land degradation has adverse effect on productive capacity of land, and thus, on food security of the farm households (Beinroth *et al.,* 1994; Nkonya *et al.,* 2011; von Braun *et al.,* 2012). Soil fertility degradation is indeed considered the most important food security constraint in SSA (Verchot, *et al.,* 2007). Information on the exact effect of land degradation on productivity for the Eastern African region (and at national level and plot/field level) is very scanty. Previous studies have no consensus on the exact amount of productivity losses due to land degradation in Eastern Africa. Few available country data on the economic costs land degradation show that the direct cost of loss of soil and nutrients in the case study countries are enormous. For example, an earlier study by Lal, (1995) showed up to 50% decline in productivity of some crop lands in SSA due to land degradation processes. Other studies showed yield reduction ranging from 2% to 40% – a mean of 8.2% (Eswaran, 2001). Lal (1995) estimated that past erosion in SSA had caused yield reduction of 2–40% (mean of 6.2 %), and that if present trend continued, the yield reduction would increase to 16.5% by 2020.

It is estimated that about 1 billion tons of topsoil is lost annually in Ethiopia due to soil erosion (MoFED 2010). The loss of soil by water erosion in Kenya is estimated at 72 tons per hectare per year (de Graff, 1993) and even higher in Tanzania; 105 tons/ha/year in 1960's and 224 tons/ha/year, 1980's-90's). Further, salinization happened in another 30% of the irrigated land of irrigated land in Kenya and in 27 percent of irrigated land in Tanzania. An earlier study by Dregne (1990) reported permanent reduction (irreversible) soil productivity losses from water erosion in about 20% of Ethiopia and Kenya. This study is however based only on expert opinion on a few areas and extrapolated nationwide; thus they are not representative. Odelmann (1998) estimated that about 25% of cropland and 8-14% of both cropland and pasture were degraded by soil degradation. This study is also older and largely based on expert opinion and smaller areas.

Table 6: Cost and consequences of land degradation in Eastern Africa

Consequence	**Nature and extent of the effect**
Soil nutrient loss and loss of productive land	- Between 4-7% of land area of SSA is severely degraded (GLASOD & TERRASTAT, 2006). - Estimated average annual losses per hectare in 37 SSA countries are 22 kg of N, 2.5 kg of P and 15 kg of K (Sanchez, 2002). For the last 3 decades, replacing these lost nutrients by purchasing fertilizers would cost about US $4 billion.

resources	- Average annual soil nutrient losses of 23 kg/ha from 1980s-1990s increased to 48 kg/ha in 2000 (FAO, 2006). - It is estimated that about 1 billion tons of topsoil is lost annually in Ethiopia (MoFED, 2010). - Loss of soil by water erosion in Kenya estimated at 72 tons per hectare per year; and - Tanzania 105 tons/ha/year in 1960's and 224 tons/ha/year, 1980's- 2000's (de Graff, 1993)
Salinization	- Loss of irrigated lands due to salinization in Kenya (30% of irrigated land), Liniger *et al.,* 2011. - Loss of irrigated lands due to salinization in Tanzania (27% of irrigated land) (ibid)
Loss of Land Productivity	- The productivity loss in Africa from soil degradation estimated at 25% for cropland and 8-14 percent for both cropland and pasture (Odelmann, 1998). - Irreversible soil productivity losses of at least 20 percent due to erosion reported to have occurred over the last century in large parts of Ethiopia and Kenya (Dregne, 1990).
Crop Yield Losses	- Under continuous cropping without nutrient inputs; cereal grain yields declined from 2-4 tons/ha to under 1 ton/ha in SSA (Sanchez *et al.,* 1997). - Crop yield losses due to erosion ranged from 2 to 40% (a mean of 6.2%) for SSA (Lal, 1995). - Annual yield losses for specific crops varied from 4-11% in Malawi (World Bank, 1992 - Field survey in Tanzania: Yields were 30% higher in least eroded areas (Kilasara *et al.,* 1995).
Loss of forest resources	- 3.7 million ha (0.7% of the total SSA land area) lost annually (rising demand for farm land, timber, charcoal). - Forest loss over the period 1990 – 2005 was 12.7% in Malawi. Annual forest losses of 1.1% in Ethiopia, Malawi and Tanzania; and 0.3% in Kenya , chief source of energy (at least 70%) is fuel wood and charcoal in all Eastern Africa countries (UN-Habitat, 2011).
Loss of biodiversity resources	- 126 African animal species have become extinct2 and a further 2,018 are threatened. - Some 125 plant species are recorded as extinct and close to 2,000 more are threatened, of which some 250 are critically endangered in SSA. (IUCN, 2006)
Increased food insecurity, hunger and malnutrition	- In 1990-2000 cereal availability per capita in SSA decreased from 136 to 118 kg/year. - The cereal yields have stagnated over the last 60 years (World Bank, 2007) - At the end of the 1990's; over 20% of the populations in 30 African countries were undernourished, chronic hunger reported in over 35% of the population in18 countries (ibid). - Malnutrition was expected to increase by an average of 32% (UNDP, 2006).
Increased poverty	- 45% of SSA's population lived below the poverty line of less than 1 USD per day; the number of rural people living below the poverty line were more than twice that of those in urban settings (Ravallion *et al.,* 2007). - 73% of the total number of rural poor are currently residing on marginal and degrading lands (Scherr, 2007)

Source: own compilation

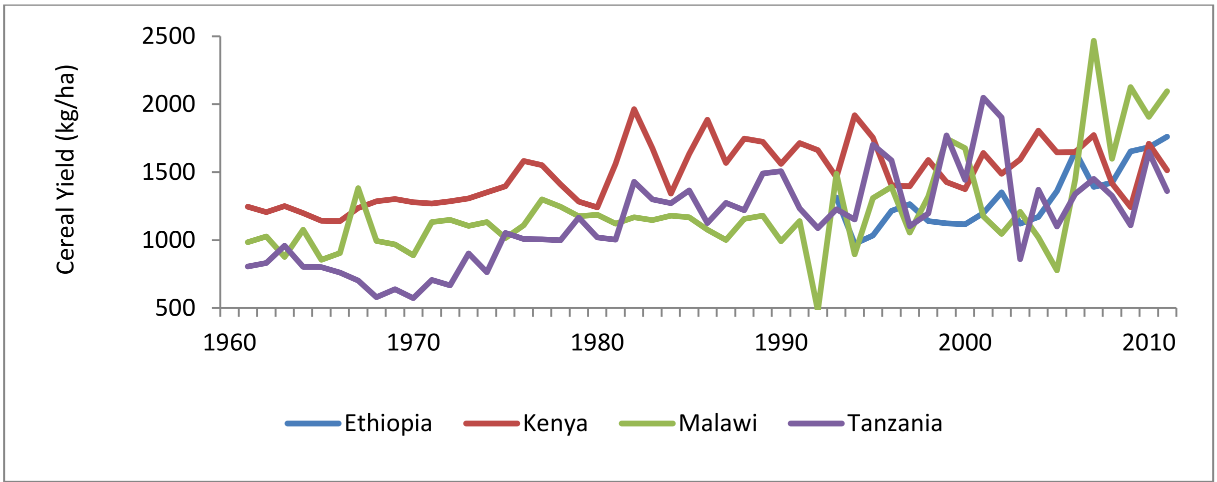
In Ethiopia the annual costs of land degradation relate to soil erosion and nutrients loss from agricultural and grazing lands is estimated at about $106 million (about 3% of agricultural GDP) from a combination of soil and nutrient loss (Bojo & Cossells, 1995; Yesuf *et al.,* 2008). It is further estimated that other annual losses included $23 million forest losses via deforestation and $10 million loss of livestock capacity (Yesuf *et al.,* 2008). All these translated to an annually total loss of about $139 million (about 4% of GDP). In Malawi, the losses are even higher; 9.5–11% of GDP in (FAO, 2007). In Kenya, it is reported that irreversible land productivity losses due to soil erosion occurred in about 20% over the last century (Dregne 1990). Further, a high percentage 30% and 27% of high value irrigated land was lost due to salinization over the last century in Kenya and Tanzania respectively (Tiffen *et al.,* 1994).

World Bank (1992) estimated the annual yield losses for specific crops to be 4–11% in Malawi. Sonneveld (2002) modeled the impact of water erosion on food production in Ethiopia in which he concludes that the potential reduction in production would range from 10% –30% by 2030. However, other non-quantified losses in all these studies include human capital costs of drought and malnutrition, rural poverty and environmental services costs due to the impact of sedimentation of streams and rivers. The other core effect of land degradation is on food supply. Davidson and Strout (2004) show that there is continuously decreasing cereal availability per capita in the Eastern Africa region (from 136 kg/year in the 1980s to 118 kg/year in 2000s) due to land degradation. This translates to annual economic loss from soil erosion in SSA of about USD 1.6 to 5 billion (ibid).

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. The indirect effects which are more difficult to quantify include; conflicts between different land users (such as farmer and herders) as a result of forced expansion of the agricultural frontier and the migration of households and communities towards pastoral land and economic losses arising from land degradation which constrain the development of services in rural areas.

Statistics from FAOSTAT show that the agricultural productivity in the case study countries has remained almost constant for the last five decades (Figure 9) as opposed to the argument by Sanchez *et al.* (1997) that cereal grain yields declined from 2-4 tons/ha to under 1 ton/ha.

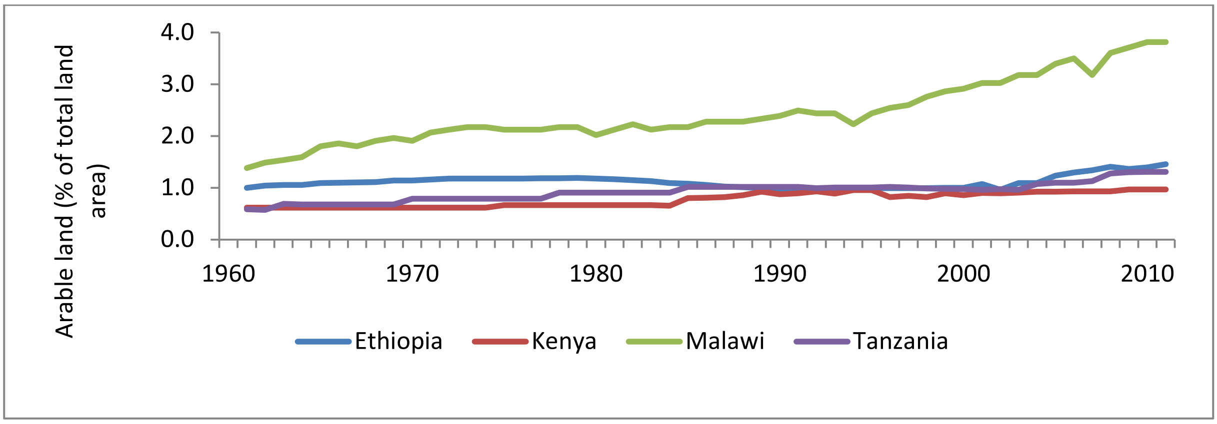
Figure 9: Cereal yield (kg per hectare)



Source: Authors' compilation – data from FAOSTAT

Over the same time period, the expansion of agricultural land remained relatively the same all case study countries except in Malawi where it showed a significant increase (Figure 10). The input subsidy program saw expansion of agricultural land in Malawi double (from about 20% in mid-1990s to about 40% in 2011). It is notable that increase in proportion of arable land implies a reduction in forest lands and conversion of marginal land into agricultural plots. The population outburst coupled with the ever increasing demand and value of land sets into play (von Braun *et al.,* 2013).

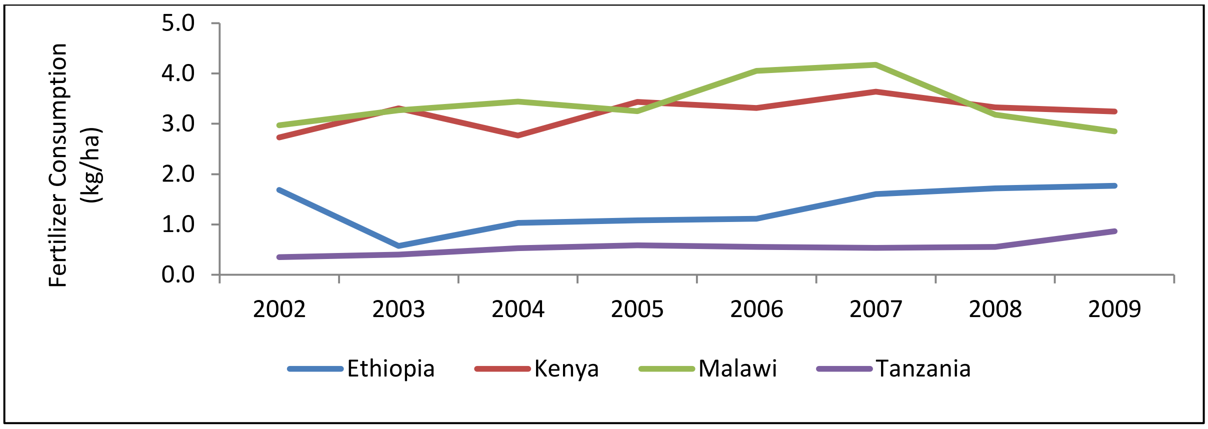
Figure 10: Arable land (% of land area)



Source: own compilation – data from FAOSTAT

Most importantly, the use of fertilizer has not increased to compensate for the loss of soil nutrients and therefore leading to a continuous mining of soil organic matter. Data show that fertilizer use in the case study countries remains very low. While Malawi and Kenya report an average of fertilizer use of about 32 kg/ha and 29 kg/ha of arable land respectively, Ethiopia and Tanzania fertilizer use rates are very low; about 17 kg/ha and 9 kg/ha respectively (Figure 11). Alternative means of maintaining soil fertility, such as crop rotation, green manuring, and agroforestry have also not been sufficiently and effectively adopted to compensate the nutrient loss.

Figure 11: Fertilizer consumption (kilograms per hectare of arable land)



Source: own compilation – data from FAOSTAT

Decreased productivity of land attributed to the resource degradation, contributes directly to reduced livelihoods among the rural and agricultural population of Eastern Africa (UNU/INRA, 1998). With increasing population pressure, agricultural production is characterized by decrease in farm holding sizes and by declining potential. These have a negative implication to food security situation in the region.

3.4 Opportunities for SLM

There is a broad consensus that sustainable land management is critical in reversing the current land degradation trends and in ensuring adequate and sustainable food supply in the future. Estimates show that the adoption of SLM practices in SSA is alarmingly low – just about 3% of total cropland is under SLM practices (WB, 2010). Liniger *et al.* (2011) observe that lack of information and knowledge by farm households in rural areas of low income countries is a major hurdle to the uptake of SLM. The SLM practices discussed in the vast literature can be summarized as shown in Box 1 (For a comprehensive discussion see Liniger (2011)).

Box 1: Typology and examples of SLM practices in Eastern Africa

- Integrated Soil Fertility Management: *micro-dosing with inorganic fertilizers, manuring and composting, rock phosphate application, etc.*
- Conservation Agriculture: *minimum soil disturbance, permanent soil cover, and crop rotation*
- Rainwater Harvesting: *In-situ rainwater conservation, micro-catchments, macro-catchments, small dams / ponds, roof catchments*
- Smallholder Irrigation Management: *Efficient water abstraction, storage and distribution and efficient water application in the field*
- Cross-Slope Barriers: *Bench terraces, earth bunds, fanya juu/chini, stone bunds, vegetative strips*
- Agroforestry: *Agroforestry parkland systems, multistorey systems, fodder banks, improved fallows, windbreaks / shelterbelts*
- Integrated Crop-Livestock Management: *Animals stall-feeding (zero-grazing), harvesting and relocating nutrients, dual-purpose crops, haymaking, production of forages, grasses and leguminous trees, enclosures*
- Pastoralism and Rangeland Management: *Nomadism, transhumance, agro pastoralism, mixed systems, enclosed systems and ranching*
- Sustainable Planted Forest Management: *Plantations for industrial purposes, out-grower schemes, plantations for energy production, environmental/protective plantations, farm/home plantations*
- Sustainable Forest Management in Drylands: *Securing forest resources, enhancing biodiversity, alternative livelihoods options*
- Sustainable Rainforest Management: *Good forest governance, land use planning, community forestry, diversification of production, biodiversity conservation*

Source: Authors compilation

Important contributions have been made by previous studies on identifying the determinants of adoption of SLM practices; however, a number of limitations are evident. Despite the fact that a long list of explanatory variables is used, most of the statistical models developed by these studies have low levels of explanatory power (Ghadim & Pannell, 1999). The results from different studies are often contradictory regarding any given variable (ibid). Linder (1997) points out that the inconsistency results in most empirical studies could be explained by four shortcomings, namely; failure to account for the importance of the dynamic learning process in adoption, biases from omitted variables, poorly specified models and failure to relate hypotheses to sound conceptual framework.

Recent studies have tried to overcome these limitations in different ways: model adoption sequentially (Leathers & Smale, 1991), include farmers' personal perceptions, abilities and capabilities and risk preferences to capture the dynamic learning process (Ghadim & Pannell, 1999), use of stochastic production function to capture importance of risk effects of factors inputs on production behavior (Fufa & Hassan, 2003), use a partial observability model to capture the varied access to information and levels of awareness of the new technology (Dimara & Skuras, 2003), use of a double hurdle model to capture the sequential decisions and multiple stages in investing in SLM (Gabremedhin & Swinton, 2003) and determinants of adoption and intensity of adoption of SLM may be different, hence use a tobit model rather than probit or logit (Nakhumwa & Hassan, 2003).

Following Nobel *et al*. (2005), FAO (2012) has developed some general guiding principles for successful formulation and implementation of SLM practices. A summary is presented in Box 2. Successful implementation of SLM practices requires technical, policy, legislative and institutional interventions at different (community, district and national) levels.

Box 2: Success factors and barriers for SLM in Eastern Africa

Essential key elements for the success of Sustainable Land Management:

(i) Quick and tangible benefits *(iv) Aspiration for change* *(vii) Participatory approach*
(ii) Low risk of failure *(v) Social capital* *(xiii) Property rights*
(iii) Market opportunities *(vi) Supportive policies* *(x) Innovation and appropriate technologies*

SLM should offer a choice of practices that are easily adopted and offer tangible benefits. These practices ought to be:

(i) Simple–be readily demonstrated to, understood and implemented by land users;
(ii) Low cost–be within the financial reach of rural households, limited labor needs and no foregone benefits;
(iii) Productive–lead to increased benefits (i.e. higher yields, increased fuel wood, guaranteed fodder supplies);
(iv) Sustainable–require limited effort, or purchased inputs each year to maintain;
(v) Low risk–be non-susceptible to climatic variations (drought or waterlogging) or market fluctuations;
(vi) Flexible–leave scope for future developments; and
(vii) Conservation effective–contribute to the maintenance of land.

The main barriers to widespread adoption of SLM can be grouped as knowledge, technological institutional and policy barriers. They include:

(i) Lack of local-level capacities and experience with SLM (among farmers, extension officers NGOs)
(ii) Knowledge gaps on specific land degradation and SLM issues
(iii) Inadequate monitoring and evaluation of land degradation and its impacts
(iv) Inadequate knowledge transfer and management, and Research and Development
(v) Compartmental approach of many SLM programs and knowledge management systems
(vi) Poverty, lack of financial resources (credit) and general lack of resources and investment opportunities
(vii) Institutional bottlenecks: Lack of good governance and operational capacity, Inapt political agendas
(viii) Policy and legal framework: difficulty and costly enforcement of existing laws that favor SLM
(ix) Market and infrastructure: Insecure prices of agric. products, increasing input costs, inaccessible markets
(x) Inappropriate incentive structure: inappropriate land tenure and user rights, inequitable access to land and water, insecurity about private and communal rights.

Source: Authors compilation

Lack of information and knowledge is considered a major hurdle to reducing land degradation, improving agricultural productivity, and facilitating the uptake of SLM among smallholder farmers (Liniger *et al.,* 2011). Farm households in rural areas of low income countries lack most information (such as; available inputs, input and output prices, weather forecasts, SLM practices) needed to help strategize production, improve yields, negotiate better prices and improve farm competiveness (Low, 2013). However, recent market and technology innovations have transformed the dynamics of gathering and disseminating information. Specifically, the developments in the Information and Communication Technologies (ICTs) provide new opportunities in awareness-raising and knowledge dissemination (Gantt & Cantor, 2010).

The easily accessible mobile phones can now timely, widely and directly deliver useful information such as weather forecasts, farm inputs, market information and also development of SLM practices to the farmers (AfDB, 2009). Recent statistics confirms the rapid growth and penetration of mobile phones across Africa albeit at different speeds– ranging from 78% in Kenya to just about 17% in

Ethiopia (Wireless Intelligence (WI), 2012). This is expected to significantly influence SLM adoption and hence reduction in land degradation. Deeper understanding on the role played by ICTs (penetration of mobile phones) on adoption of SLM practices among farm households is imminent.

4 Conclusions and policy perspectives

Land degradation remains a serious impediment for improving livelihoods in the Eastern Africa region. Recent estimates indicate that about 27 percent of the land area of SSA is subject to land degradation. Water and wind erosion are the most widespread types of land degradation in the region. The land degradation 'hotspots' in the region are located the northern part of Ethiopia, western and central part of the Kenya, southern Tanzania and northern parts of Malawi.

Major proximate causes of land degradation common across borders in Eastern Africa include: climatic conditions, topography, unsuitable land uses and inappropriate land management practices (such as slash and burn agriculture, overgrazing, cutting trees and shrubs, cultivation on steep slopes, bush burning, pollution of land and water sources, and soil nutrient mining).

The critical underlying causes of land degradation include socioeconomic and institutional factors such as land tenure insecurity, poverty, population density and weak policy and regulatory environment in the agricultural and environmental sectors. Insecure land tenure may act as a disincentive to investments in sustainable agricultural practices and technologies. A growing population, without SLM behavior and practice, may exhaust the capacity of land to continue providing ecosystem services. The continued demand for agricultural land, fuel-wood, charcoal, construction materials, large-scale timber logging and resettlement of people in forested areas continue to accelerate land degradation through deforestation. Some studies indicate at a poverty-land degradation vicious cycle: poverty can be an outcome of degrading lands; it is also seen as a cause of land degradation.

The economic implications of land degradation are substantial thus a sustained and strategic action plan for preventing and/or mitigating is needed. Degradation reduces the productive capacity of land though the erosion of top fertile soil, leaching and depletion of nutrients and salinization, among others. There is, therefore, an urgent need to develop policies that encourage sustainable land use and management. In several countries in the region such SLM policies seeking to address the drivers of land degradation identified above do exist, but are often contradicting, so need to be harmonized. Some of the SLM practices already in practice could be scaled up to support the degradation control. Further rigorous studies that comprehensively evaluate drivers of land degradation and fully capture the losses incurred due to land degradation (using the Total Economic Value approach) in Eastern Africa are needed to effectively and successfully expedite actions and investments into SLM. Current debate on land degradation in the Eastern African region is short of consensus because of misunderstanding, misinterpretation and discrepancies of the available information. Future studies could endeavor to mobilize and employ scientific and standard methods in data collection and assessments of land degradation.

National and local policies and programs play a critical role in affecting farmers' decisions with regard to land management. Specific policies and programs that affect many of these socioeconomic and institutional factors include those relating to agricultural research, irrigation, land governance, extension, regulating input and output markets, access to credit, infrastructure development, and farmers' cooperatives and organizations. It would be worthwhile to consider the comparative advantages of customized policy strategies for various regions on SLM, i.e. empowering decentralization. For instance, for areas with high agricultural potential, policies that facilitate development of credit, input, and output marketing systems could have higher private and social returns. Commercial agriculture is feasible and profitable in these areas and thus, there is a strong potential to increase incomes through sustainable land use (through use of purchased inputs and integrated organic soil fertility management practices, for example). Infrastructural development together with adequate provision of inputs and credit in areas closer to urban markets and in areas where there is a high agricultural potential or high irrigation potential could also be prioritized. Similarly, for low agricultural potential areas, the initial priority could be increased investments in irrigation and intensification of livestock production through improved management of grazing lands. Efforts to catalyze development of local institutions to better manage grazing lands through collective action should also be stimulated. Barriers to adoption and uptake of sustainable land management (SLM) ought to be overcome. Farmers need adequate information and capacity building (through trainings) to help improve the use of SLM. Policies and programs with respect to food aid, agricultural extension, education and training in non-farm activities and land tenure are also relevant for these areas to achieve productive agriculture and reduce poverty.

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