Chapter 9
Economics of Land Degradation in Sub-Saharan Africa

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Abstract Sub-Saharan Africa (SSA) has experienced the most severe land degradation in the world. Given that livelihoods of the majority of the rural poor heavily depend on natural resources, countries in the region have designed a number of policies and strategies to address land degradation and to enhance productivity. However investment from both countries and their development partners has remained low, especially for livestock, which accounts for the largest area degraded. Our results show that conversion of grassland to cropland and deforestation are the major factors driving land use/cover change (LUCC). One of the major reasons leading farmers to convert grassland to cropland is the low livestock productivity. The increasing demand for livestock products provides an ample opportunity to the value of grasslands and in turn livestock productivity. Given that donor funding accounts for the largest share of expenditure on agriculture and natural resource management in most SSA countries, econometric analysis showed that donor funding reduces the cost of land degradation. This positions donors in a position of influencing efforts to combat land degradation in SSA. The fact that SSA has poor marketing infrastructure suggests that its improvement will enhance efforts to address low productivity and land degradation. Econometric analysis showed that access to market leads to a reduction of the cost of land degradation related to LUCC. Improvement of market infrastructure will achieve a win-win benefit as it will improve natural resources and reduce poverty. Consistent with results from other regions, improvement of government effectiveness reduces cost of land degradation and cropland expansion. This illustrates the key role played by governance in mediating the drivers of land degradation. Efforts to increase adoption of integrated soil fertility management will require improvement of access to markets, advisory services and retraining of agricultural extension services. There is also need to find practical and amenable strategies for incentivizing farmers to use ISFM. For example, conditional fertilizer subsidy could provide incentives for farmers to adopt nitrogen fixing agroforestry trees and

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improve significantly the current subsidy programs in several SSA countries. Overall, our results show that SSA has the potential to become the breadbasket of the world but it has to significantly improve its market access and government effectiveness to create incentives for land holders to invest in land improvement. The increasing demand for land, urbanization, and other global regional changes are creating a conducive condition for taking action against land degradation. These opportunities should be exploited effectively as they lead to win-win outcomes—reducing poverty and achieving sustainable land management.

Keywords Sub-Sahara Africa · Land degradation · Sustainable land management · Land tenure · Access to markets · Government effectiveness

Introduction

Sub-Saharan Africa (SSA) has ample opportunities to become the future breadbasket of the world. While crop yield gaps—the difference between potential and actual yield (Lobell et al. 2009)—in other regions are narrow and closing, SSA has the widest yield gap of maize, rice, and wheat in the world (Nkonya et al. 2013). For example, average maize yield in the tropical lowlands in SSA is only 16 % of its potential (Lobell et al. 2009). Closing such a yield gap will provide food for both the SSA population and the rest of the world. About 90 % of the remaining 1.8 billion ha of global arable land in developing countries is in Latin America (LAC) and SSA (Bruinsma 2009) and it is estimated that about 50 % of the land to be converted to agricultural use by 2050 will come from SSA (Alexandratos and Bruinsma 2012). Three of the seven countries, which account for half of the remaining suitable land in the world, are in SSA (Angola, Democratic Republic of Congo, and Sudan) (Ibid).[1]

In the past two decades (1995 and 2013), SSA's average economic growth was 4.5 % per year in real terms—a level that is about twice the economic growth of the rest of the world during the same period (World Bank 2014; Andersen and Jensen 2014). Such growth has been driven by increasing consumer spending, investment in extraction of natural resources and infrastructure, a rapidly growing services sector, and increased agricultural productivity (World Bank 2014). SSA agricultural productivity has increased in the past few decades, thanks to farmer investments which has led to increased use of improved seeds and inorganic fertilizer (Sheahan and Barrett 2014). For example, Sheahan and Barrett (2014) found that in three of the six countries with a nationally representative household survey, farmers used an average of 57 kg/ha of fertilizer—a level which is much higher than the 13 kg/ha

[1]But as it will be discussed in the cost of land degradation section, conversion of forest, grassland, and other forms of land use/cover change (LUCC) leads to land degradation.

widely cited level, which is based on Food and Agriculture organization (FAO) data. A recent study showed that SSA GDP growth originating from agriculture accounted for income growth of the 40 % poorest population—a level about three times larger than the growth originating from other sectors (De Janvry and Sadoulet 2010).

Despite these potential and economic achievements, SSA faces daunting challenges. About 28 % of the 924.7 million people in SSA (UN 2014) live in areas that have experienced degradation since the 1980s (Le et al. 2014). The most severe land degradation occurred on grasslands, 40 % of which experienced degradation (Le et al. 2014). About 26 % of forestland and 12 % of cropland also experienced land degradation (Ibid). The high land degradation rate coupled with economic development reflect the tradeoffs involved in clearing forest or other high value biomes for crop production. The two processes also suggest an environmental Kuznet curve process—i.e., initial phases of economic development are done at the expense of the environment. Even though land degradation is reducing SSA's agricultural potential, the increasing use of fertilizer and other inputs on cropland has led to greater productivity and it masks the land degradation in the region. Additionally, closing the wide agricultural yield gap requires significant investment to address constraints which lead to low agricultural productivity. One of such constraints is poor market infrastructure which increases the cost of external inputs. SSA has the lowest logistics performance index (LPI)—an index that reflects perceptions on efficiency of customs clearance process, quality of trade and transport-related infrastructure, and other marketing logistics (Arvis et al. 2012). The cost of transporting a ton for 1 km ranges from 0.04 to 0.14 USD in Africa compared to only 0.01–0.04 USD in other developing countries (Foster and Briceno-Garmendia 2010).

Government investment in natural resource development is generally low and has been declining in the past two decades (FAO 2010). Total SSA's public expenditure on agriculture, forestry, wildlife, and fisheries is only about 4 % of the total government budget even though these sectors account for about 25 % of the GDP (FAOSTAT 2012). Official development assistance (ODA) accounts for the largest share of forest investment in most SSA countries (Gondo 2010). SSA's investment in agricultural research and development (R&D) is the lowest in the world and is declining. Intensity of investment in agricultural research—investment in agricultural R&D as share of agricultural GDP—has steadily declined, from 0.59 % in 2006 to 0.51 % in 2011. The intensity is well below the recommended target of 5 % set by the United Nations' Sustainable Development (Beintema and Stads 2014). This shortcoming affects SSA's rural development since countries which invest in agricultural R&D achieve greater land productivity and are more likely to achieve sustainable land management (SLM) than those which spend less (Lobell et al. 2009).

SSA countries have been implementing a number of policies to address land degradation in line with their broad objective of poverty reduction through enhancement of productivity of natural resources upon which majority of the poor depend. These include; establishing protected area, R&D, input subsidies, agricultural water management, land tenure, and others. This chapter analyzes the cost of land degradation in SSA and identifies the drivers of cost of land use/cover change (LUCC)-related land degradation and change of cropland. Given the large amount of donor contribution to land-based development, donor support on cropland expansion and the cost of land degradation will be included in the analysis of drivers of cost of land degradation and cropland expansion. The results of this analysis will help SSA countries to design policies and strategies for taking action against land degradation. To lay ground for the analysis, the chapter first discusses the major land and natural resource management policies and the corresponding public investment. This is followed by a brief discussion of methodological approaches for analyzing the severity and cost of LUCC-related land degradation in SSA—which are discussed in detail in Chaps. 4 (extent of land degradation) and 6 (cost of land degradation). Given that cropland expansion is the major driver of land degradation (Chap. 6), we explore the drivers of cropland expansion. The last section draws policy implications on action to be taken to address land degradation.

Sustainable Land Management (SLM) Policies in SSA

We focus our discussion on policies with direct impacts on SLM—i.e., policies that have direct impacts on land management. For example, although trade policies may have large impacts on land management via their impacts on prices, these impacts are indirect and likely have mixed (positive or negative) impacts, depending on the local contexts (such as whether farmers are net buyers or sellers of tradable commodities). We also focus on policies that are amenable to change. For example, although broader monetary, fiscal, financial, and exchange rate policies may have large impacts on land management, these are unlikely to be changed in order to improve land management, although it may be important to take steps to ameliorate any negative consequences that such policies may have. The review focuses on SSA governments' commitment to achieve sustainable development enshrined in the Rio summits three major conventions (climate change, biological diversity, and land degradation). However, focus of the discussion is on land policies. Country level policies are also reviewed but summarized at regional level to reflect the countries' commitment to sustainable development. Other policies with strong potential impact on land management are also reviewed. These include input subsidies, agricultural water management, land tenure, government effectiveness, market access, and population. To determine the government commitment to implementing their SLM policies, the last section analyzes the SSA government investment in land-based sectors.

Sustainable Development Policies

On conservation of biodiversity, 46 out of 51 (90 %) of SSA countries have ratified the convention on biological diversity (CBD).[2] Accordingly, protected area has been increasing in all sub-regions (Fig. 9.1). Protected areas provide both local and international benefits—especially when policies and strategies involve communities surrounding the protected areas in managing them (Wilkie et al. 2006). For example, Mugisha and Jacobson (2004) observed that seven community-based protected areas (CBPA) management in Uganda had significantly lower bush burning, logging, and encroachment than nine other protected areas without local community involvement.

All SSA countries have ratified the United Nations Framework Convention on Climate Change (UNFCCC) and two thirds of the 51 countries have submitted their national adaptation program of action (NAPA) and 22 countries have submitted the Nationally Appropriate Mitigation Actions (NAMA) to the UNFCCC (2014a, b). Accordingly, many SSA countries are reducing their CO_2 emissions and use of ozone-depleting substances (UNECA 2014). Additionally, forest policies in SSA have increasingly incorporated sustainable forest management (SFM) and have embraced community-based forest management (FAO 2012)—an aspect which has enhanced SFM (Seymour et al. 2014). However, SSA still experiences high deforestation. Deforestation and other forms of land use accounts for 43 % of CO_2 emission in SSA (TerrAfrica 2009). Unfortunately, public investment for forest development and the environment in general remains low in SSA.

All 51 SSA countries have ratified the United Convention to Combat Desertification (UNCCD)[3] and prepared the national action plan (NAPs). Implementation of NAPs follow a bottom-up approach, an aspect regarded as one of the success stories of UNCCD (Bruyninckx 2004). According to Kellner et al. (2011) however, institutional uptake of bottom-up approach has been limited. Additionally, the NAP projects have lacked monitoring and evaluation systems (Ibid). Limited funding for combatting land degradation has generally been common across SSA countries and NAPs have been largely funded by donors. Limited funding from national governments to finance implementation of the three Rio summit conventions is a common problem across all countries.

Input Subsidies

A number of countries—including Burkina Faso, Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, Rwanda, Senegal, Tanzania, and Zambia—have subsidized fertilizer and/or improved seeds in efforts to increase farm crop yield level fertilizer

[2]Source: http://www.cbd.int/information/parties.shtml.

[3]Source:http://www.unccd.int/Lists/SiteDocumentLibrary/convention/Ratification%20list%20May2014.pdf.

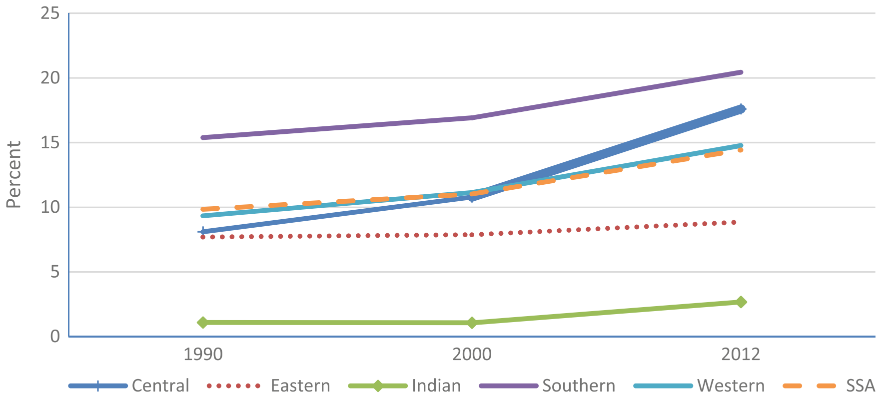

Fig. 9.1 Protected terrestrial and marine area as percent of sub-regional territorial area of SSA

application (Tables 9.1 and 9.2). In five countries (Kenya, Malawi, Rwanda, Tanzania, and Zambia), subsidies were targeted to either the poor or priority crops and reached a large proportion of farmers. For example, about 65 % of farm households in Malawi benefited from the subsidy program (Druilhe and Barreiro-Hurlé 2012). Likewise, about 95 % of the 2.7 million rural households in Kenya benefited from the subsidy program that targeted the universally grown maize crop (KNBS 2014). The number of farmers reached in the subsidies that were not targeted is unknown in most countries reported in Table 9.2. However, in cases where the number of farmers reached was known, beneficiaries of the universal subsidies was significantly smaller than the case of targeted subsidy programs (Tables 9.1 and 9.2).

Investment in input subsidies as share of agricultural budget ranged from 11 % in Burkina Faso to as high as 59 % in Malawi (Tables 9.1 and 9.2). In most cases, government budget covered the entire or largest share of subsidy budget (Druilhe and Barreiro-Hurlé 2012) due to the previous donor's negative perception towards subsidies (Kelly et al. 2011). As shown in Fig. 9.5, the large share of agricultural budget on subsidies has crowded out investment into other essential rural services—such as market infrastructure, extension services, and development of private input markets (Ricker-Gilbert et al. 2013). Jayne and Rashid (2013) also show that the cost of input subsidy is greater than its benefits and that investment into R&D and rural infrastructure would provide higher returns to agricultural growth and poverty reduction.

Agricultural Water Management Policies

Agricultural water management (AWM) includes water conservation practices, water harvesting, supplemental irrigation, ground water irrigation, surface water irrigation, and drainage (CAADP 2013). Given that water supports all forms of life,

Table 9.1 Investment in targeted subsidies and number of beneficiaries

Country	Kenya	Malawi	Rwanda	Tanzania	Zambia
Name and date[a]	NAAIP	AISP	CIP	NAIVS	FISP (ex-FSP)
	2007-on	2005-on	2007–10	2008-on	2002-on
Amount (US$ million)	54.5	171.8	–	121.8	113.2
Subsidy as % of ag budget	19.0	58.9	–	46.0	29.3
Number of beneficiaries (million)	2.5	1.5	0.7	2.5	0.5
Targeted crops	Staples	Maize and tobacco	Maize, wheat, potato	Maize, rice	Maize
Targeted farmers	Poor	Poor	Poor land >0.5 ha	Land poor (<1 ha) in high potential areas	Less poor land 1–5 ha
Allocation criteria		Farm size and need5		Female-headed HH in priority	
% subsidy and ration	100 % on 1 acre or for 2 bags	64–91 % on 1 acre or for 2 bags	75, 50 and 25 % up to 3 bags	50 % on 1 acre or for 2 bags	50–60 % on 2 acres (1 ha bef. 2009) or for 4 bags
Distribution system	Vouchers	Vouchers	Vouchers	Vouchers	Physical distribution

Notes: *NAAIP* National Accelerated Agricultural Input Programme; *AISP* Agricultural Input Subsidy Programme; *CIP* Crop intensification programme; *NAIVS* National Agricultural Input Voucher System; *FSP* Fertilizer Support Programme
Sources Druilhe and Barreiro-Hurlé (2012) and Jayne and Rashid (2013)

AWM is a major determinant of quality and quantity of ecosystem and biodiversity services (Barron 2009). This means AWM is an important component in land degradation and improvement. Of key importance is the high level of water wastage that could lead to salinity and other forms of land degradation. About 50 % of urban water in SSA is unaccounted for and about 70 % of irrigation water is lost (ECA 2014). The major driver of such loss is the poor or lack of water infrastructure which is compounded by weak local institutions and limited investment in water development, all of which significantly contribute to efficient water use efficiency (Ibid).

AWM policies include water law, rights, pricing and subsidy or taxation, allocation, user participation, and decentralization of irrigation infrastructure management or Irrigation Management Transfer (IMT) (Kuriakose and Ahlers 2008). At the regional level, the African Union has adopted the African Water Vision 2025 as

Table 9.2 Investment in universal subsidies

Country	Burkina Faso	Ghana	Mali	Nigeria	Senegal
Name and date	2008-on	2008-on	Rice initiative 2008-on	FMSP 1999-on	GOANA 2008-on
Cost of subsidy (US$ million)	21.1	73.2	21.5	152.3	40.3
# of beneficiaries (million)	0.5	0.9	Unknown	Unknown	Unknown
Targeted crops	Rice, maize, cowpea + cotton (credit)	Staples + cash crops	Rice, maize, wheat + cotton	Staples	Staples
% subsidy	≤50 % (15–30 % actual)	50 % (30–50 % actual)	25 %	25 % (federal) + 0–60 % (state)	50 %
Distribution system	Physical	Physical (vouchers piloted)	Physical (vouchers may be piloted)	Physical (vouchers piloted)	Physical local committees
Participation of agrodealers	None	Very limited	Very limited	None	Unknown

Notes: *GOANA* Grande Offensive Agricole pour la Nourriture et l'Abondance; *FMSP* Federal Market Stabilization Programme
Source Druilhe and Barreiro-Hurlé (2012)

the policy instrument for achieving sustainable water resource management and use (WWAP 2015). Africa's Water Vision 2025 is "Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socioeconomic development, regional cooperation, and the environment" (Ibid). To achieve this, Water Vision 2025 sets ten targets and strategies that broadly aim to sustainably provide adequate potable and agricultural water to ensure food and energy security for all while also ensuring that there is enough quantity and quality of water for sustaining the ecosystems and biodiversity. Enabling environment needed to achieve this vision includes creation of strong and effective water resource management institutions, policies, financial and technical support, all of which will ensure integrated water management and cooperation at local, national, and transboundary water basin levels (Ibid).

Faced with the increasing water demand, climate change, renewed effort to achieving food security, sharp increase in food prices, and other challenges, African countries in the past 10 years have increasingly been receptive of the Water Vision 2025 and to investment in irrigation (Pinstrup-Andersen 2014; Lankford 2009). Among new directions in achieving the vision include an increasing commitment to water-policy reform, decentralization of water institutions, IMT, building water financial sustainability through treating water as an economic good rather than a free resource, and providing a safety net for the poor (Ibid).

Situation Analysis of AWM in SSA

SSA has the smallest irrigated area compared to other regions—despite its above average need for irrigation compared to other regions. Irrigated area as share of cultivated area is only 6 %—a level far lower than the corresponding share of 37 % in Asia and 14 % in Latin America (AQUASTAT 2014). Additionally only 5 % of the region's potential water resources are developed and the per capita water storage is only 200 m^3 compared to 6000 m^3 in North America (WWAP 2015). The Gulf of Guinea (coastal West Africa) and the Sudano-Sahelian zone respectively exploit only 1.3 and 35 % of their Internal Renewable Water Resources (IRWR) (Frenken 2005). The gross volume of SSA's harvestable water runoff is about 5195 km^3 and if only 15 % of the rainwater were harvested, it would be more than enough to meet all of the water needs of the region (Malesu et al. 2006). In fact, and Hatibu et al. (2000) note that rainfall variability, frequent droughts, and high intensity storms create more challenges to potential water quantities.

The rainfall variability and frequent droughts and storms renders SSA's agriculture to highly unreliable rainfed production—especially in the arid and semi-arid areas which contain 54 % of total land area (Jahnke 1982). Frequent events of drought have led to famine and loss of livestock in the region. This has prompted SSA countries to invest in mainly large-scale irrigation in the 1960s to late 1980s (AGRA 2014; Inocencio 2007; Turral et al. 2010). The need for investing in both irrigation infrastructure and local institutions cannot be emphasized enough given SSA's great irrigation potential. In fact, the amount of water in SSA is not the key limiting factor even in the semi-arid areas (Hatibu et al. 2000).

The large-scale irrigation schemes were largely centrally managed with a top-down approach as involvement of local institutions and communities in investment planning and water management was limited (Turral et al. 2010). The policies and investments in the 1990s to present have been directed towards development of smallscale irrigation (AGRA 2014). Empirical evidence shows that there is strong justification for the new direction toward small-scale irrigation. You et al. (2011) showed that the internal rate of return for small-scale irrigation investment was 28 % compared to only 7 % for large scale irrigation. Involvement of local communities and their institutions have also shown much more effective and sustainable water and natural resource management (Pahl-Wostl et al. 2008). However, recent work has shown that even small-scale irrigation in SSA is not a panacea as they fail if their local institutions are weak (Burney and Naylor 2012).

The AWM investment will lead to greater yields and reduced soil erosion. For example, it is estimated that rainfed grain yield is 1.5 metric tons per ha, compared with 3.1 metric tons per ha for irrigated yields (Rosegrant et al. 2002). AWM will also enhance adoption of new crops and varieties that may not be produced under rainfed conditions or during rainy seasons. For example, Smith et al. (2010) observe that AWM investment enhances production of much needed nutritious vegetable and horticultural crops and other high value crop production which simultaneously improves nutrition and income. Unfortunately current policies and investment strategies have not been commensurate to the region's water challenges. As stated above however, new interest in AWM gives promise that governments are getting serious to address the water challenges.

Land Tenure

Studies have shown that secure land rights and presence of land titles are often associated with greater long-term land investment and market transactions (de Soto 2000; Besley 1995; Place and Otsuka 2002; Gavian and Fafchamps 1996). Customary land tenure dominates ownership in SSA as formal tenure covers only between 2 and 10 % of the land (Deininger 2003). Conventional wisdom has postulated that customary land tenure is insecure because it does not involve legal documents. Additionally, customary land tenure puts women at a disadvantage since land is normally bequeathed to sons (Doss et al. 2013). Accordingly, concerted land registration efforts have been made in many SSA countries (Deininger 2003). However, Deininger (2003) and Otsuka and Place (2014) observed that formal tenure systems have also resulted in increased tenure insecurity in many SSA countries, because of the weak enforcement of the formal laws and the stronger customary institutions which still dominate rural communities. Additionally, claims that customary land tenure has an inherent insecurity have been challenged by research. Empirical evidence has demonstrated that customary land tenure is resilient and provides security that has led to comparable or greater long-term investment than land held under formal tenure security (Cotula 2006; Nkonya et al. 2008).

Given the recent land grabbing and interest in large-scale land investments in SSA, there is need of designing tenure systems and land policies to protect the vulnerable groups and enhance security of customary tenure that will provide incentive for land investments by farmers. Place (2009) summarizes key points on policy reforms that need to be taken into account to address the tenure security challenges related to the predominantly customary tenure:

- Tenure security needs to be well-understood and secure—especially for women and other vulnerable groups.
- Tenure security of customary land tenure is a problem—especially for women farmers. Changing customary tenure systems requires long-term strategies to

address cultural biases against women land ownership. In the short-term, improvement of land market is one approach for increasing women's access to land (Nkonya et al. 2008).

Empirical evidence shows that customary land tenure provides adequate investment security. This means efforts to protect customary tenure systems against arbitrary expropriation that occurred during the land grabbing by government or wealthy individuals requires immediate policy action. However the lack of formal titles is a constraint for farmers who need to access credit. This means the current land titling efforts should be targeted to areas where there is demand for land titling. Heterogeneity in land policies is also required to reflect the different socio-economic environments prevailing in rural SSA communities. Currently almost all land policies in SSA recognize the customary land rights and give rights to groups or communities to reflect the common communal land ownership and management. Additionally, restrictions on land markets are being relaxed in many countries but selling and buying land in countries where land belongs to the state is illegal (e.g. Rwanda).

Our study will analyze the impact of land tenure on land degradation and improvement. The study will especially look at the influence of land tenure security on change of cropland and LUCC-related cost of land degradation.

Government Effectiveness and Governance

As noted by Nkonya and Anderson (2015), government effectiveness—defined as the quality of public & civil services and their degree of independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies—has a positive impact on SLM. Government effectiveness index (GEI) scale ranges from −2.5 (weak) to 2.5 (strong). Using the average GEI in 2005–07, we divided countries in three groups, weak government effectiveness, whose GEI was lower than −1.0; medium ($-1.0 < \text{GEI} < 0.0$), and Strong ($\text{GEI} \geq 0$). SSA has the lowest government effectiveness in the world as a third of the 48 SSA countries reporting have a GEI index below −1—the world's largest share in this group (Table 9.3).

There has been significant improvement in democracies in some SSA countries and setbacks in democratization in other countries (Lynch and Crawford 2011). About 35 % of the SSA countries experienced improvement in government effectiveness in the 2007–12 period compared to the 1997–2000 period (Table 9.4). Nine of the 16 countries that experienced GEI improvement fall in the medium GEI category and two in the best GEI (Mauritius and Réunion). The remaining five fall in the worst case group (GEI smaller than −1). This suggests the difficulty in government effectiveness improvement for countries with weak GEI. Accordingly, most of the countries which experienced weakening of government effectiveness are grouped in the worst case group, i.e., a GEI smaller than average GEI.

Table 9.3 Government effectiveness index of all regions, across groups

	Weak		Medium		Strong	
	Percent[a]	$\overline{GEI}$[b]	Percent[a]	$\overline{GEI}$[b]	Percent[a]	$\overline{GEI}$[b]
SSA	31.3	−1.4	47.8	−0.5	20.9	0.5
LAC	4.9	−1.3	39.0	−0.4	56.1	0.7
NAM	0.0	–	0.0	–	100.0	1.5
East Asia	22.2	−2.0	11.1	−0.6	66.7	1.1
Oceania	6.3	−1.5	68.8	−0.7	25.0	1.0
South Asia	0.0		87.5	−0.4	12.5	0.5
SE Asia	20.0	−1.4	30.0	−0.7	50.0	0.9
East Europe	4.2	−1.1	41.7	−0.3	54.2	0.8
West Europe	0.0	–	0.0	–	100.0	1.5
Central Asia	16.7	−1.5	83.3	−0.7	0.0	–
NENA	17.4	−1.2	34.8	−0.4	47.8	0.7
World	14.8	−1.4	40.6	−0.5	44.5	0.9

Notes [a]Percent of countries in the region belonging to corresponding group
[b]$\overline{GEI}$ = Average GEI in corresponding group. GEI Scale: −2.5 weak to 2.5 Strong
Source Compiled from Kaufmann et al. (2012)

Table 9.4 SSA government effectiveness index, 1997–2012

Group	Percent of SSA countries (%)	Countries
Countries which GEI improved: Average GEI1997–2000 < GEI2007–12	35	Angola, Burkina Faso, Burundi, DRC, Congo, Djibouti, Ethiopia, Ghana, Guinea-Bissau, Liberia, Mauritius, Niger, Réunion, Rwanda, Sierra Leone, Swaziland and Zambia
Worst (GEI ≤ −1)	40	Burundi, Central African Republic, Chad, Comoros, DRC, Congo, Côte D'Ivoire, Equatorial Guinea, Eritrea, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone, Somalia, South Sudan, Sudan, Togo, and Zimbabwe
Medium: −1 < GEI < 0	45	Angola, Benin, Burkina Faso, Cameroon, Djibouti, Ethiopia, Gabon, Gambia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mauritania, Mozambique, Niger, Rwanda, Senegal, Swaziland, Tanzania, Uganda and Zambia
Best: GEI ≥ 0	15	Botswana, Cape Verde, Mauritius, Namibia, Réunion, Seychelles and South Africa

Note GEI ranking as worst, medium and best based on average GEI from 2007–2012
Source Compiled from Kaufmann et al. (2012)

Access to Market Infrastructure

SSA has the second lowest LPI—a measure of market services and infrastructure performance (Table 9.5). Though there has been improvement over the past decade, the region faces a daunting challenge in improving its market infrastructure and logistics.

Studies have shown that access to market infrastructure could lead to land improvement or degradation, depending on other mediating factors (Nelson and Hellerstein 1997; Cropper et al. 2001; Laurance et al. 2009). Access to markets could either lead to an increase in land degradation through forest clearing to increase cropland extent (e.g. see Fearnside 2002; Peres 2001) or could lead to agricultural intensification and engagement in non-farm activities, which in turn could lead to a decrease of cropland extent and thus land improvement (e.g. see Haggblade et al. 2007). SSA has the worst access to markets and consequently the highest transaction costs and water and energy tariffs in the world (Table 9.6). Such high transaction costs have led to the limited use of external inputs, which in turn have contributed to SSA's fastest cropland expansion in world.

Though some studies are showing a negative impact of market access to land management, improvement of market infrastructure is necessary to achieve development objectives. However, government effectiveness needs to be improved to mediate the potential negative impact of access to market on land management.

Table 9.5 Logistics performance index

Region	Logistics performance index (LPI)		
	2011–13	2007–10	Change
SSA	2.62	2.69	0.07
LAC	2.77	2.87	0.10
NAM	3.86	3.91	0.06
East Asia	3.38	3.50	0.12
Oceania	3.73	3.68	−0.05
South Asia	2.79	2.93	0.14
SE Asia	2.91	3.02	0.11
East Europe	2.79	2.95	0.16
West Europe	3.81	3.83	0.03
Central Asia	2.42	2.43	0.01
NENA	2.82	2.92	0.10
World	3.13	3.22	0.08

Notes LPI ranges from 1 (low) to 5 (high)
Calculated from World Bank database available at http://lpi.worldbank.org/

Table 9.6 Africa's infrastructure deficit and cost

Characteristics	Africa	Other developing countries
Paved road density (km/km^2 of arable land)[a]	0.34	1.34
Population with access to electricity (%)[a]	14	41
Population with access to improved potable water (%)[a]	61	72
Power tariffs ($/kWh)	0.02–0.46	0.05–0.1
Transportation cost ($/ton/km)	0.04–0.14	0.01–0.04
Tariffs of urban potable water ($/cu m)	0.86–6.56	0.03–0.6

[a]Excludes medium income African countries (South Africa, Kenya, Botswana, Gabon, Namibia, Cape Verde, etc.) and is compared to other low income countries. The rest of the statistics refers to entire Africa and other developing countries
Source Foster and Briceno-Garmendia (2010)

Population

One of the Millennium Development Goals was to provide universal access to reproductive health by 2015. Women with no access to family planning in SSA is 25 %—about twice the level in other regions (Ibid). Given this and other confounding factors, it is not surprising that the SSA region has the fastest growing population—both in terms of number and urbanization. SSA's population growth rate in 2010–15 was 2.7 %—the fastest in the world (UNFPA 2014). About 37 % of the SSA 924.7 million people live in urban areas but by 2050, the urban population will be 55 % of the total population (UN 2014). This trend and pattern poses a concern on land and other natural resources. However, concerns of the pressure the high population puts on natural resources are not emphasized in policy design, rather, in almost all SSA countries, family planning policies to reduce high fertility are formulated and implemented with the emphasis of health and education improvement (Ezeh et al. 2012). However, there has been considerable debate on the impact of human population on land degradation. In the famous publication on population bomb, Ehrlich (1968) predicts that overpopulation and consequent over-exploitation of natural resources will result in human starvation. Ehrlich's conclusions have been heavily criticized and—just as the Malthusian doomsday theory prediction was proven wrong—Ehrlich's prediction of mass starvation in the 1970s–80s didn't happen. The Green Revolution and other improved agricultural technologies have proved wrong Malthusian's and Ehrlich's population doomsday theories (Galor and Weil 2000). Additionally, international trade has also altered the local impacts of population on local biomes and settlement patterns in arable lands (Rudel et al. 2009a; Foley et al. 2011). For example in 2001, Switzerland imported agricultural products equivalent to 150 % of cultivated land area in the country (Wuertenberger et al. 2006).

Recent analyses of overexploitation of resources have focused less on human population and more on natural resource use that lead to depletion and degradation. Concerns on greenhouse gas (GHG) emissions, use of chemicals and other pollutants are simultaneously increasing with the demand for natural resources resulting from increasing income and changing consumption and lifestyles. For example the increasing demand for livestock products in low and medium income countries is due to increasing income (Thornton 2010) and it leads to greater demand for land area and consequently deforestation and loss of biodiversity (Smith et al. 2010).

Accordingly the new measures of land degradation encompass much broader indicators of anthropogenic impacts on ecosystems than focus on population. One such measure is the recent concept of planetary boundaries that needs to be observed to prevent irreversible ecological changes (Rockstrom et al. 2009)—reflects anthropogenic impacts on ecosystems that could result from GHG emission, pollution and depletion of natural resources resulting from changing consumption patterns, demand, and natural resource harvesting and utilization. Another interesting measure of land degradation is the human appropriation of net primary production (HANPP)—which is the aggregate impact of land use on biomass available in a given area (Haberl et al. 2004). HANPP measures the alterations of photosynthetic production in ecosystems and the harvest of products that use photosynthesis. For example SSA harvested only 18 % of its net primary production compared to the global average of 22 and 63 % for Southern Asia (Ibid). This puts SSA in a category of low pressure on natural resource harvesting even though studies focusing on population growth puts the region at much more dire conditions.

The SLM review above shows significant policy commitment to achieve SLM and to improve government effectiveness and market infrastructure. To assess the SSA governments' commitment to its SLM policies, the section below discusses SLM financing.

SLM Financing

On average, public expenditure on land-based sectors (agriculture, forestry, and wildlife) and fisheries in SSA countries is only about 4 % of the total government budget even though these sectors account for about 25 % of the GDP (Table 9.7). Dividing the 28 countries reporting the public expenditure into three equal groups (high, medium, and low share of public expenditure on land-based sectors and fisheries—hereafter referred to as agricultural sectors)—shows that countries where the agricultural sector contributed the largest share of GDP, allocated the lowest share of public expenditure to agriculture (Table 9.7). Only six countries—namely Burkina Faso, Guinea, Mali, Niger, Senegal, and Ethiopia have reached the Maputo Declaration target of spending 10 % or more of the government budget on agriculture (Benin et al. 2010), which was reaffirmed and upheld by the recent Malabo Declaration (AU 2014). In fact, the agricultural orientation index—government expenditure on agriculture as share of total budget divided by the agricultural share

Table 9.7 Public expenditure on land-based sectors and fisheries and their contribution to GDP

Country	Public expenditure as percent to total government budget			Contribution to GDP (%)
	2001–05	2006–2012	2001–12	
Zimbabwe		38.4	38.4	17.8
Ethiopia	7.4	18.7	12.4	45.9
Zambia	3.9	8.6	7.7	21.6
Madagascar	7.4	6.4	7	28.1
Swaziland	4.4	6.2	5.4	8.6
Mali		5.4	5.4	37.4
Namibia	5.1	5.2	5.1	9.6
Sao Tome and Principe		4.3	4.3	19.7
Cabo Verde	4.9	4	4.1	
Average, high % of ag expenditure	5.5	10.8	10.0	23.6
Kenya	4.5	3.8	4.1	27.7
Mauritius	4	3.8	3.9	5
Uganda	3.6	3.7	3.6	25
Congo, Republic of	1.2	3.6	2	4.7
Botswana	3.9	3.3	3.6	2.7
Lesotho		3	3	9.2
Tanzania	3.6	3	3.2	30.4
Liberia	1.3	2.6	2.4	62.2
Angola	1.4	2.5	2	8.9
Average, medium % of ag expenditure	2.9	3.3	3.1	19.5
Seychelles		2.4	2.4	2.7
Central African Republic		2	2	54.8
Ghana	1.6	1.8	1.8	33.4
Nigeria	1.1	1.7	1.4	35.1
Cote d'Ivoire		1.5	1.5	24.2
South Africa	1.1	1.5	1.3	3
Benin	3.1	1.4	2.5	32.6
Sierra Leone	1.6	1.4	1.5	53.4
Burkina Faso	0.1	1.1	0.8	36.4
Equatorial Guinea		1.1	1.1	5.2
Average, low % of ag expenditure	1.4	1.6	1.6	28.1
SSA	3.3	5.1	4.8	23.9

Sources Public expenditure as percent of government (FAOSTAT—http://faostat3.fao.org/download/I/IG/E). Contribution of land-based sectors and fisheries to GDP (World Bank http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS)

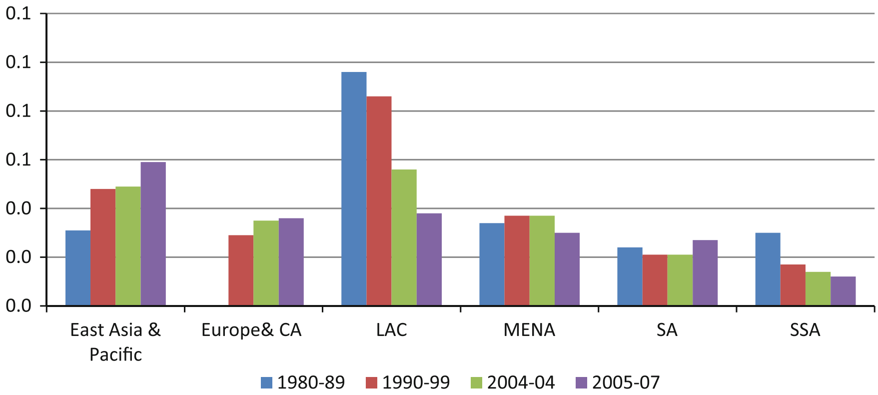

Fig. 9.2 Agricultural orientation index across regions. *Source* Computed from FAO (2012)

of GDP (FAO 2012)—for SSA is the lowest in the world and was falling between the 1980s and 2007 (Fig. 9.2).

As noted above however, the agricultural sector accounted for 40 % of the poorest populations' economic growth—a level about three times larger than the growth originating from other sectors (De Janvry and Sadoulet 2010). This is largely due to private investment resulting from improved land management (Sheahan and Barrett 2014). For example, SSA farmers accounted for 86 % of the total agricultural investment[4] from 2005–07 (Lowder et al. 2012).[5]

Donor contribution to SLM expenditure is large. Many SLM initiatives in the past have tended to be heavily based on donor funded projects. For example, the ODA accounts for the largest share of forest investment in most SSA countries (Gondo 2010). Additionally, Table 9.8 shows that donor-funding accounted for more than 70 % of SLM expenditure in several countries. In fact it is common in many SSA countries to use revenue from forest concessions as a source for financing local and central governments (Ibid). In few countries however—including Nigeria, Ghana, and Kenya—donor funding contributes only a small share of total expenditure.

The large share of donor contribution to SLM expenditure poses a concern about the sustainability of investment in SLM practices and questions the countries' commitment to sustainable development stated in their policies. ODA total support to agriculture, water, and the environment both decreased following the Paris Declaration in 2005, but increased beginning in 2007 (Fig. 9.3). This was largely due to the renewed interest of high income countries and transnational companies to invest in agriculture following the food price spike and increasing demand for bioenergy (HLPE 2011). However, ODA support to agriculture as a share of total

[4]Investment is expenditure to build long-term capital (e.g. agricultural machinery, livestock, tree planting, road construction, etc.). It excludes current expenditure—or short-term expenditure normally consumed in the same year.

[5]The investment in agricultural R&D is excluded because sources of funding were not reported.

Table 9.8 Donor contribution to public expenditure on SLM

Countries	Donor contribution to SLM expenditure (%)	Comments	Source
Nigeria	5		Nkonya et al. (2010)
Mali	70		Nkonya et al. (2010)
Uganda	83	2001–05 period	World Bank (2008)
Ethiopia			
Kenya	45	Development expenditure of total budget	Yu (2014)
Seychelles, Sierra Leone, Namibia	<20	Agricultural budget	Benin and Yu (2012)
Senegal, Madagascar	>80	Agricultural budget	Benin and Yu (2012)

support to all sectors has not fully recovered to the level attained in the 1980s (Fig. 9.3).

Allocation of the public agricultural expenditure (PAE) budget across subsectors and functions also reveals some weaknesses that needs attention. Crops and livestock account for 77 % of the SSA PAE, while forestry and fisheries respectively account for 14 and 9 % (Benin and Yu 2012). Crops take the largest share for the budget allocated to crops and livestock even though about 170 million people in SSA are entirely or partially dependent on production (FAO 2006) and livestock occupies a much larger land area than crops. Kamuanga et al. (2008) also estimates that livestock accounts for more than 50 % of capital held by rural households.[6] Additionally, the demand for livestock products is increasing. Despite the livestock's large potential and opportunities, it receives less than 5 % of the government budget (Fig. 9.4).

Analysis of PAE by function also shows limited investment in developing agricultural marketing. For example, total expenditure on marketing, feeder roads, and regulation as percent of total PAE was highest in Mali at only 32 %—the highest in the countries reporting these data (Fig. 9.5). This clearly shows the production orientation of PAE and apparent neglect of market development, which is key to increasing farmer incentives for land investment (Barrett et al. 2010; Barrett 2008). Schmidhuber et al. (2011) estimate that to achieve food security by 2025, 37 % of the additional US$50.2 billion investment required will be for developing rural infrastructure and market access.

[6]For details of role played by livestock, see Chap. 8.

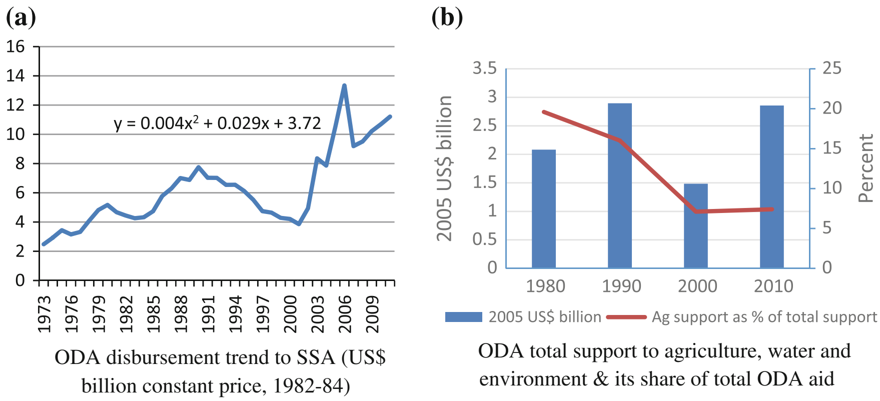

Fig. 9.3 ODA total support trend and allocation to agriculture, water and environment. **a** ODA disbursement trend to SSA (US$ billion constant price, 1982–84). **b** ODA total support to agriculture, water and environment and its share of total ODA aid. *Source* Computed from DAC. http://www.oecd.org/dac/developmentassistancecommitteedac.htm

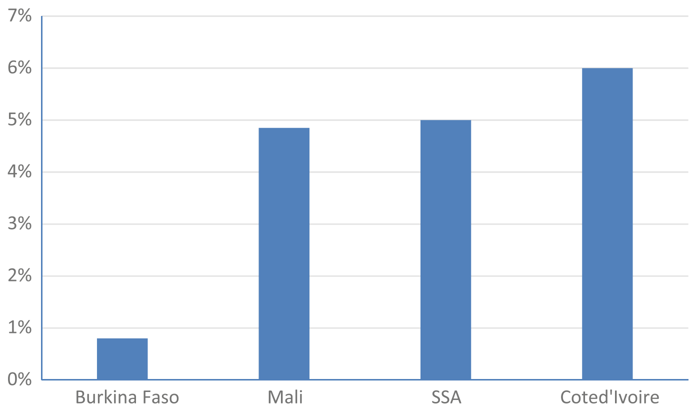

Fig. 9.4 Agricultural budget allocation to livestock as share of total government budget. *Note* Calculated from Kamuanga et al. (2008)

Given the large amount of donor contribution to land-based development, our analysis will examine the impact of donor support on cropland expansion and the cost of land degradation.

Analytical Methods and Data

We analyze the cost of land degradation and drivers of cropland change following the methods discussed in Chaps. 2 (methods) and 6 (cost of land degradation). As discussed in Chap. 6, causes of land degradation are LUCC that replaces high value

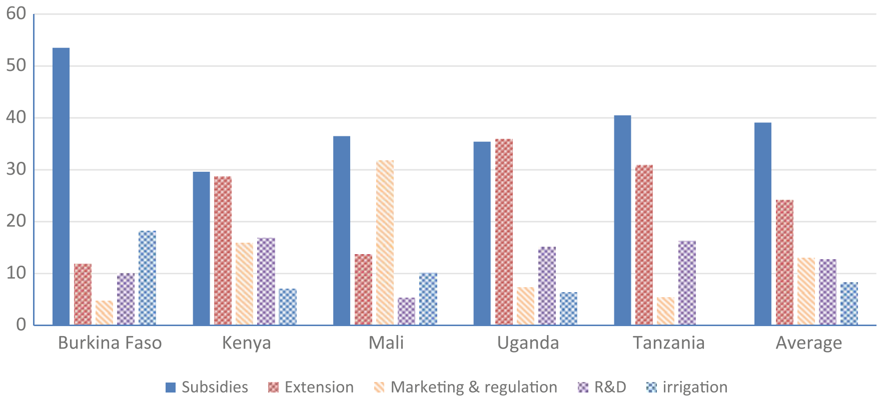

Fig. 9.5 Allocation of agricultural public expenditure by function. *Source* Computed from Benin and Yu (2012)

biomes with low value biomes and use of land degrading management practices on static land use. We cover all biomes when analyzing land degradation due to LUCC and for brevity, we only include cropland and grazing biomes (grassland) for static biomes. Analytical methods that were used without any modification are the same as those for determining the cost of land degradation due to LUCC (Chap. 6) using land degrading management practices on static cropland (Chap. 6) and grazing biomes (Chap. 8). Hereafter, we refer to cost of LUCC-related land degradation as simply cost of land degradation. Methods for drivers of the cost of land degradation and change of cropland were modified. The brief discussion below shows the modifications done to adapt the analysis to biophysical and socio-economic characteristics of SSA.

Drivers of Cropland Change and Cost of Land Degradation

We modify the analytical methods discussed in Chap. 2 by including international aid, which—as seen above contributes the largest source of SLM investment in most countries. We use the following parametric multivariate regression approach to identify the effects of each of the of cropland change and cost of land degradation.

$$\Delta a = \beta_0 \Delta x_1 + \beta_1 \Delta x_1^2 + \beta_2 \Delta x_2 + \beta_3 \Delta x_3 + \beta_4 D + e_i \quad (9.1)$$

where a = cropland area in pixel i, x_1 = vector of variables with quadratic relationship with Δa, which reflect the environmental Kuznet curve (Dinda et al. 2004a, b). These include GDP, which represents economic development and population density, which reflect the Boserupian intensification theory (Boserup 1965); x_2 = a vector of variables with linear relationship with cropland area, namely agricultural export index, access to markets, and government effectiveness and international aid; D a vector of dummy variables representing land tenure; βi = coefficients associated with the corresponding covariate i.

We correct for heteroskedasticity by estimating robust standard errors using White-Huber estimators. To ensure that quadratic terms are validly included in the model and that they are not highly correlated with the error term, we conducted the Wald tests and found that they were valid. However, the quadratic terms lead to serious multicollinearity bias. Given that the quadratic forms are valid and consistent with theory, dropping them to avoid multicollinearity could lead to more biased and inconsistent estimates of parameters than the bias due to multicollinearity (Berry and Feldman 1985). However, to check for robustness of our results, we include the linear model, whose variance inflation factor of all covariates was less than 10 and therefore did not have serious multicollinearity bias (Mukherjee et al. 1998). The discussion however will focus on the model with quadratic terms for reasons discussed above.

Household level characteristics—such as change in livelihoods, level of education, access to credit, etc.—also affect change in cropland extent. However, due to lack of household level panel data for the entire region, our empirical model does not include them. This is a weakness that needs to be taken into account when interpreting our results. Additionally, the country-level case studies used household level data to analyze the drivers of land degradation (Chaps. 11–21).

The same model and data are used to analyze the drivers of the cost of land degradation. So the discussion above and the following discussion on data will refer to cropland only but the same discussion is relevant to the drivers of the cost of land degradation.

Data

LUCC We use MODIS data discussed in Chap. 6 for analyzing the cost of land degradation due to LUCC. Similarly we use the MODIS data to analyze the drivers of the change of cropland.

Road connectivity: We use travel time to the nearest urban area with a population of 50,000 or more. We used UNEP road data (Nelson 2007) and the Global Rural-Urban Mapping Project (GRUMP) population data from the Center for International Earth Science Information Network (CIESIN) to identify the urban areas with 50,000 or more population.[7] A 1 h delay is added for travel across international borders.

[7] http://sedac.ciesin.columbia.edu/plue/gpw.

Land tenure We use tenure security, which is threat or absence of likelihood of land expropriation by government or elites. USAID and ARD (2008) used country-level land policies and past history of land expropriation to give a country level tenure security. The land tenure security is divided into three major groups—(i) Moderately serious concern. This group includes countries where land users/owners have the least concern about expropriation. Examples of such countries include: Mali, Senegal, Tanzania, and Zambia. (ii) Serious concern, which is medium threat of expropriation, examples of which include DRC, Ethiopia, Kenya, and Nigeria. (iii) Extremely serious concern of expropriation. This is the group with the worst land tenure security and includes such countries as Zimbabwe and Sudan. Surprisingly even South Africa and Namibia are included in this group.

Government effectiveness We use the World Bank measure of government effectiveness index, which measures the quality of public services, civil service, and the degree of its independence from political pressures.

Poverty We use infant mortality rate (IMR) to represent poverty. The IMR is a good indicator of poverty and has been used in many poverty studies (e.g. see Dasgupta 2010). We use the IMR to represent the impact of poverty on cropland extent and cost of land degradation. IMR data are at half degree resolution and are obtained from CISIEN.

Table 9.9 summarizes the data used, their sources and baseline and endline periods. As far as possible, the baseline and endline periods of all the covariates were matched with the corresponding periods for cropland area and cost of land degradation. For some variables, data for the baseline period (2001) were not available. Hence, an alternative period which is as close as possible to the 2001 periods was used. These include GEI and population density at half degree resolution.

Extent of Land Degradation in SSA

According to Le et al. (2014) who used Normalized Difference Vegetation Index (NDVI) to determine land degradation in 1982–2006, SSA accounts for 17 % of the global 3.623 billion ha that experienced land degradation in the same period. The Eastern, Central, and Southern African sub-regions experienced the most widespread degradation (Fig. 9.6). However, Western Africa—especially southern Ghana and northern Nigeria—also experienced severe deforestation (Fig. 9.7). At the same time, there was significant land improvement through conversion of low value biomes to forest along the Sahelian zone—an aspect consistent with the regreening of the Sahel (Anyamba et al. 2014). Cropland expansion also occurred throughout the SSA region but was more intense in Western Africa and central Africa (Fig. 9.7). Conversion to grassland also occurred in all sub-regions but was more significant in drier areas (Fig. 9.8). About 40 % of the grasslands experienced degradation—a level that is the highest among the major biomes (Fig. 9.9). The second most

Table 9.9 Summary of data sources, resolution and baseline and endline periods

Data type	Resolution	Baseline and endline periods	Source
Biophysical data: total annual precipitation (mm)	0.540 × 0.540	Baseline: 2001–03	Climate Research Unit (CRU), University of East Anglia www.cru.uea.ac.uk/cru/
		Endline: 2009–11	
Cropland expansion	1 km × 1 km	Baseline: 2001	MODIS data
		Endline: 2009	
Socio-economic data			
Total bilateral aid disbursement to all sectors	Country-level	Baseline: 1973–83	http://www.oecd.org/dac/stats/
		Endline: 1997–2007	
Cattle density	Subnational	Fixed: 2005	FAO http://www.fao.org/ag/aga/glipha/index.jsp. Data exclude land unsuitable for livestock
Road density	0.50 × 0.50	Fixed	Nelson (2007)
IMR (infant mortality rate)	0.50 × 0.50	Single period: 2005	CISIEN (2010) http://sedac.ciesin.columbia.edu/povmap/
Government effectivenessa	Country-level	Baseline: 1996–98	http://info.worldbank.org/governance/wgi/index.asp
		Endline: 2005–12	
Population density	0.50 × 0.50	Baseline: 1990	http://sedac.ciesin.columbia.edu/plue/gpw
		Endline: 2007	
GDP	Country-level	Baseline: 2001–3	IMF: www.imf.org/external/pubs/ft/weo/2010/02/
		Endline: 2009–11	
Agricultural R&D expenditure	Country-level	Baseline: 1973–83	ASTI: http://www.asti.cgiar.org
		Endline: 1997–2007	
Agricultural export quantity index	Country-level	Baseline: 2001–3b	FAOSTAT
		Endline: 2009–11	

Notes A Government effectiveness index (GEI) is based on 17 component sources, measures the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. The index values range from −2.5 (very poor performance) to +2.5 (excellent performance) (Kaufmann et al. 2010)

Source See last column of table

The section below discusses land degradation and improvement in SSA by first examining the land use/cover change (LUCC) and particularly cropland change and their association with land degradation

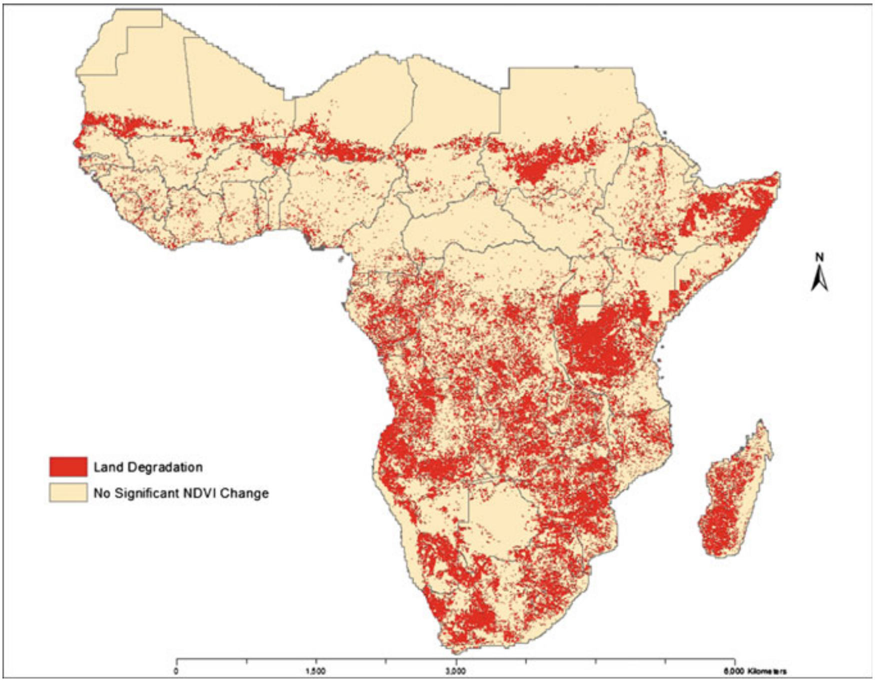

Fig. 9.6 Extent of land degradation in SSA. Note: *Red color* indicates degradation after correction for rainfall variability and carbon fertilization. *Gray color* indicates areas that did not experience degradation after correction for rainfall variability and carbon fertilization. *Source* Le et al. (2014)

degraded area is forest as 26 % of its area from 1982 to 2006 experienced degradation as measured by NDVI (Fig. 9.9).[8]

We overlaid the degraded areas with the major drivers of land degradation, namely, change in population density, government effectiveness, access to markets, and IMR. A significant area in Western Africa with high market access experienced land improvement (Fig. 9.10). This is the area along the Guinea Savanna agroecological zone, where there is active crop and livestock production. The areas of high market access that experienced land degradation are in Eastern and Southern Africa as well as the Sahelian belt in Western Africa.

As shown in Fig. 9.11, a large area experienced land degradation even though population change was only moderate. Conversely and as expected, a large area experienced both land degradation and increase in population. The interesting

[8]It should be noted that NDVI is derived from Advanced Very High Resolution Radiometer (AVHRR) to determine land degradation and the time period is from 1982 to 2006. Figures 9.7 and 9.8 use Moderate Resolution Imaging Spectroradiometer (MODIS) land cover data from 2001 to 2009 to approximate land-cover changes 2001–09 occurring. The differences in data source and time could lead to inconsistent results.

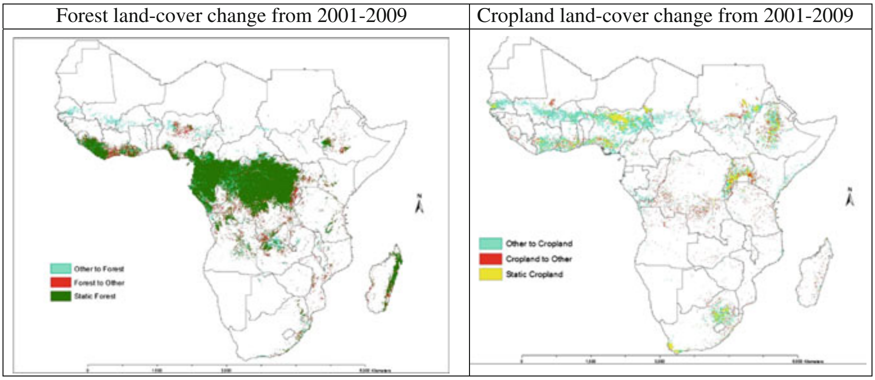

Fig. 9.7 LUCC on forest and cropland biomes. *Sources* Derived from MODIS land cover data

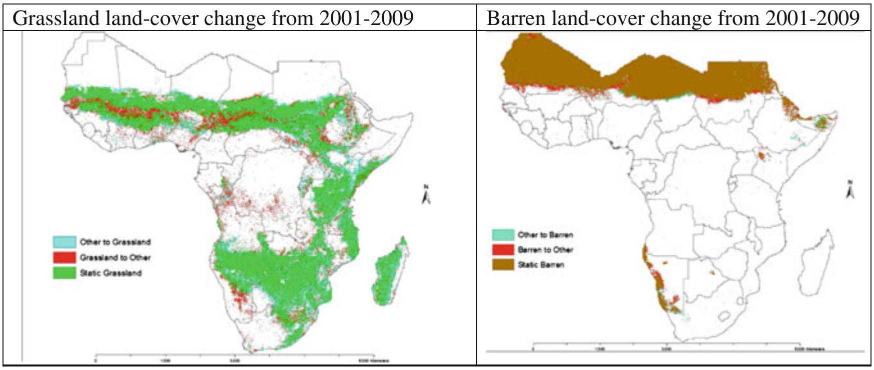

Fig. 9.8 LUCC on grasslands and barren land biomes

results are in Western Africa where there was high population increase but land improvement. As discussed below, improvement of government effectiveness in the area could be the major driver of this favorable pattern.

All possible combinations of weak and strong government effectiveness and land degradation and improvement are observed in Fig. 9.12. Of interest is Western Africa and parts of Southern Sudan, Chad, and Cameroon, where there was improvement in government effectiveness and land—supporting Foster and Rosenzweig (2003) and Esty and Porter (2005) observation of the role played by governance on mediating drivers of land degradation. As expected, a large area experienced land degradation in countries where government effectiveness worsened.

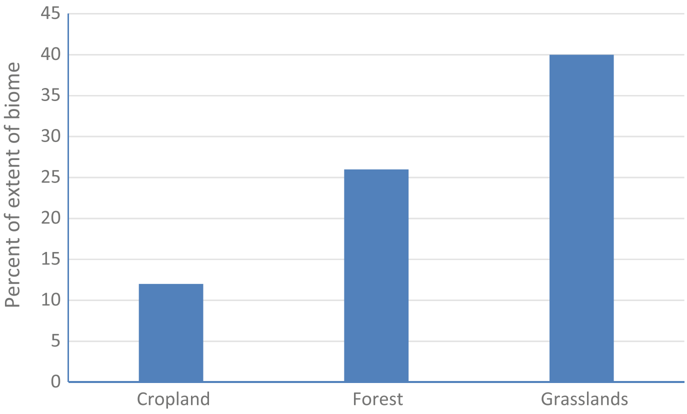

Fig. 9.9 Extent of land degradation for the major biome, 1982–2006. *Source* Computed from Le et al. (2014)

The Western Africa region and Southern Chad again shows a pattern of land improvement combined with high poverty (Fig. 9.13)—an aspect which contradicts the poverty-land degradation spiral (Scherr 2000) and demonstrates that even poor farmers could sustainably use their land resources (Nkonya and Anderson 2015). Swinton et al. (2003) observe both poor and well-off farmers in Latin America degrade their lands and conclude that land policies that provide incentives for environmental stewardship—rather than wealth endowment—are key drivers of land management. Accordingly and consistent with the downward spiral (Scherr 2000), high poverty and degradation are observed in Eastern, Central Africa, Mozambique, and Madagascar—largely due to the weak governance and lack of policies that provide incentives for land improvement.

Cost of Land Degradation Due to LUCC

The annual cost of land degradation is 2007 US$58 billion, which is about 7 % of the region's 2007 GDP of US$879.15 billion (Table 9.10). But if only provisioning services are considered, the annual cost of land degradation is US$29.19 billion or 3.3 % of GDP. As observed in Chap. 6, SSA accounts for 26 % of the global total annual cost of land degradation, though the region's land area and population respectively account for only 18 and 13 % of the global land area and population.[9]

[9]Global and SSA land area is respectively 14.08 and 2.6 billion ha (FAOSTAT). SSA and global population in 2014 was respectively 911 and 7244 million people UNFPA (2014).

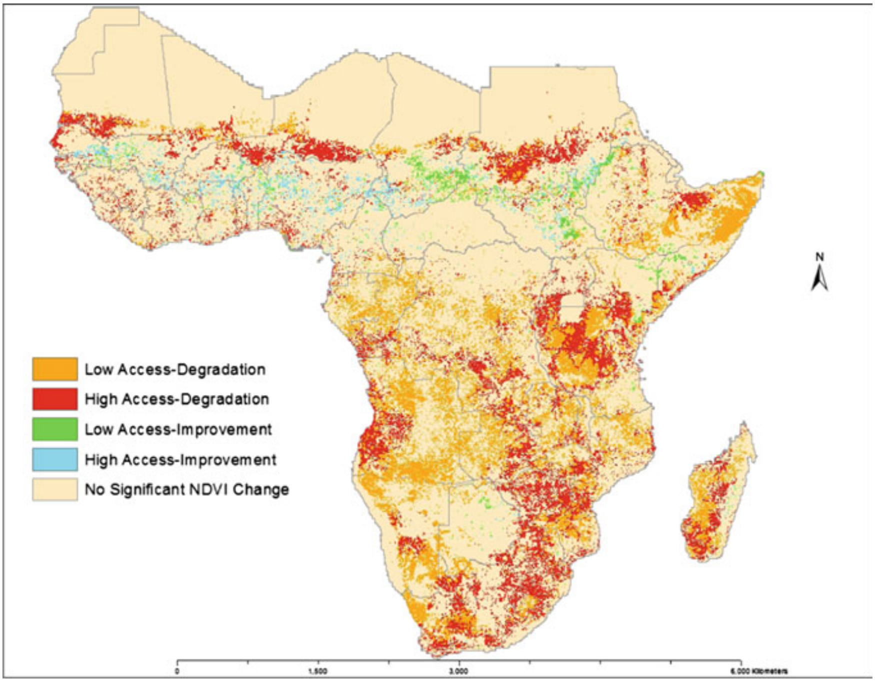

Fig. 9.10 Land degradation and access to market. *Note*

Market access	Minutes to city with population of at least 50,000 people	(%)
High	≤60	12.4
Medium	>60–100	35.6
Low	>100	52.0

The cost of land degradation is highest in Western Africa but commensurate with its area and population. Western Africa accounted for 32 % of the total cost of land degradation and as a sub-region accounts for about a third of SSA's population and land area (Table 9.10). The sub-region that has an unproportionally higher degradation than the corresponding share of its population is Central Africa, whose cost of land degradation is about 20 % of the total cost but its population accounts for only 10 % of SSA's population.

The marginal rate of returns (MRR) for taking action against land degradation is about 4—i.e., land users would receive US$4 for every US$ they invest to address land degradation. Such high returns justifies programs to address land degradation but raises serious questions about the current inaction against land degradation.

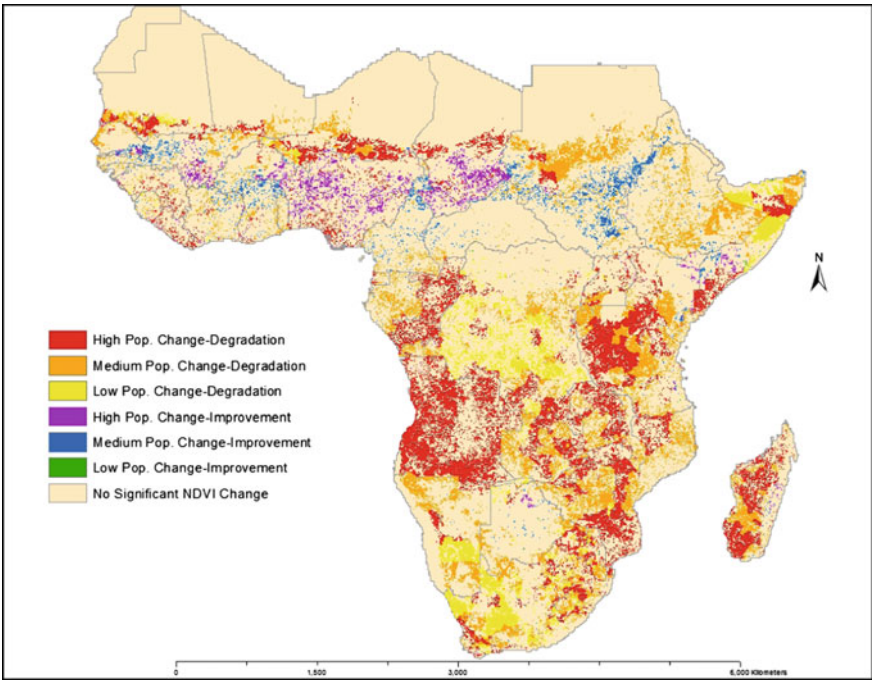

Fig. 9.11 Human population and land degradation

Land Degradation on Static Land—Grazing Biomass

The Eastern Africa sub-region accounts for about 40 % of the livestock population in SSA and it experienced the most severe grazing biomass degradation as 65 % of livestock were grazing on degraded grasslands (Table 9.11). The arid agroecological zone also accounts for the largest livestock population and 65 % of its grazing area experienced degradation.

The cost of land degradation on grazing biomass is about US$1.11 billion (Table 9.12), an amount that is equivalent to about 4 % of the SSA agricultural expenditure of US$20.729 billion in 2010 (Benin and Yu 2012). The Central African region and Eastern sub-regions accounted for more than 60 % of the total cost of land degradation. This is due to the widespread grassland degradation in DRC and Central African Republic (Fig. 9.8).

The high cost of land degradation in the arid areas is a concern given that the majority of the resident people are among the poorest in most of SSA countries (Thornton et al. 2002). Livestock also accounts for the largest wealth endowment and provides security against biophysical and socio-economic shocks. This underscores the need to take action to address land degradation in the grasslands as

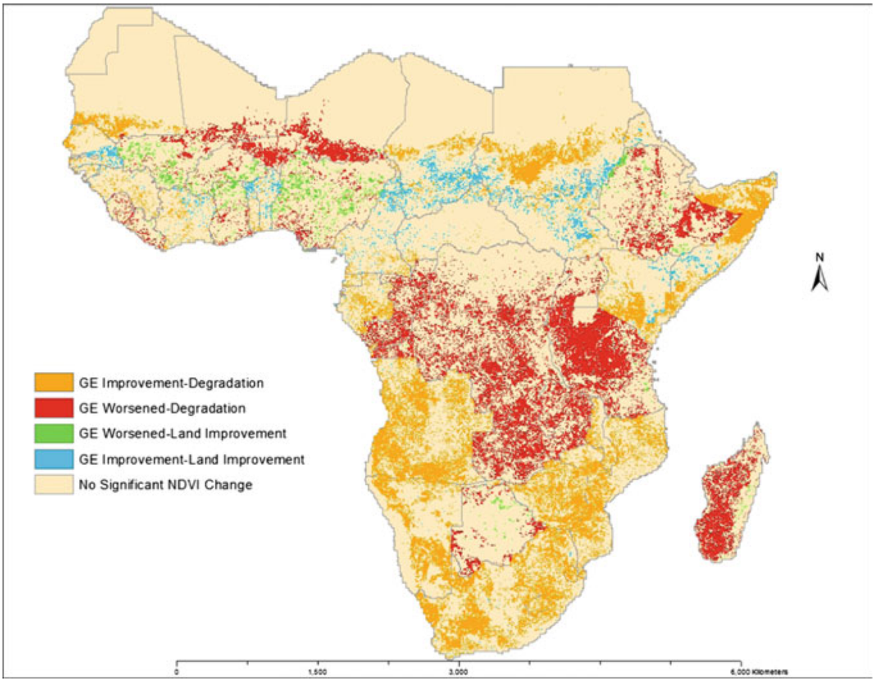

Fig. 9.12 Change in government effectiveness and land degradation

this will have multiplier effects on poverty reduction, food security efforts, and adaptation to climate change (Table 9.13).

On-farm cost of land degradation due to using land degrading management practices on cropland. Based on nationally representative data drawn from agricultural household surveys in six SSA countries only 6 % of households used integrated soil fertility management (ISFM) in SSA. Analysis of profitability of ISFM and selected land degrading management practices show an inverse relationship between adoption and profitability (Fig. 9.14). Given that smallholder farmers respond to price and other market signals (Eriksson 1993; Barrett 2008), the inverse relationship implies that there are constraints which inhibit adoption of profitable land management practices.

Country-level household data from Ethiopia, Kenya, Niger, Senegal, Tanzania, and Malawi (Chaps. 14, 16, 17, 19, and 20) identify such constraints and discuss the factors that affect adoption of ISFM. The discussion below focuses on the cost of land degradation in SSA caused by using land degrading management practices on cropland. As explained in Chap. 6, we focus on maize, rice, and wheat crops which cover only about 19 % of the cropland area in SSA (Table 9.14). Maize is the major staple crop in SSA and it covers about 14 % of the cropland. Its area coverage

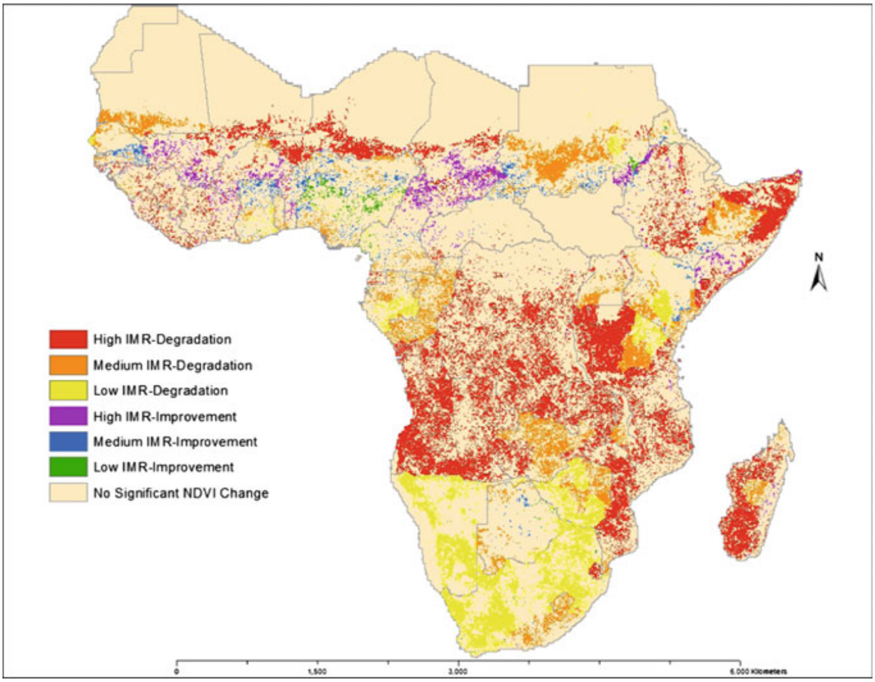

Fig. 9.13 Poverty and land degradation

Table 9.10 Cost of LUCC-related land degradation in SSA

Subregion	Central	Eastern	Indian	Southern	Western	SSA
% of land area	30.5	28.5	2.4	12.5	28.5	
% of population	9.8	33.6	2.5	20.8	33.2	
Cost of land degradation, action and inaction (2007 US$ billion)						
Total cost of land degradation (TEV)	11.09	13.43	1.6	13.38	18.9	58.4
Cost of loss of provisioning services	4.96	7.25	0.8	7.88	8.3	29.19
Cost of action	134.5	182.71	25.62	210.48	205.76	759.07
Opportunity cost	132.34	182.84	25.42	206.92	202.24	749.76
Cost of inaction	552.32	749.83	94.53	828.93	955.84	3181.45
Loss of provisioning services as % of total loss	44.67	54	50.28	58.89	43.91	49.98
MRR of taking action	4.11	4.1	3.69	3.94	4.65	4.19

Sources Population and land area (FAOSTAT). Rest of data (authors)

Table 9.11 Livestock population and percent in degraded grazing lands

Subregion	Hyperarid		Arid		Humid		Temperate		% of total TLU	% in DG
	Thousand in TLU	% in DG	Thousand in TLU	% in DG	Thousand in TLU	% in DG	Thousand in TLU	% in DG		
Central	0		269.8	67	3943.2	43	232.7	26	8.8	44
Eastern	18.1	14	17505.1	65	532.6	64	541.0	85	36.9	65
Indian	24.9	14	2509.3	61	417.7	40	31.6	57	5.9	58
Southern	1.4	97	12415.8	29	1071.4	62	2293.5	41	31.4	33
Western	0.1	62	7261.5	46	1265.9	61	0.1	0	16.9	48
SSA	44.5	16	39961.4	50	7230.9	50	3098.9	48	100.0	50
% of total	0.1	14	79.4	67	14.4	43	6.2	26		

Notes: *DG* livestock in degraded grazing area
Sources Computed from FAO http://www.fao.org/ag/aga/glipha/index.jsp

Table 9.12 On-farm cost of land degradation due to grazing biomass degradation

Sub-region	Milk	Meat	Total	Gross total[a]
	2007 US$ million			
Central Africa	370	14	384	423
East Africa	274	29	303	395
Indian Ocean	28	2	30	49
Southern Africa	161	44	206	289
West Africa	178	16	193	266
Total	1011	98	1110	1422

[a]Includes meat of livestock not sold or slaughtered for home consumption

is largest in Eastern and Southern Africa. Wheat production occupies the smallest area—less than 2 % of total area.

Table 9.15 shows that land degradation due to the most commonly used land management practices is about 2007 US$3.37 billion. Western Africa accounts for the largest cost largely due to the low adoption rate of ISFM. The cost of land degradation due to loss of carbon sequestration accounts for about 76 % of the total cost. This is due to the large soil carbon storage of ISFM (Vanlauwe et al. 2014). Continuous use of ISFM also contributes a large cost of land degradation and is consistent with Nandwa and Bekunda (1998), who used data from a long-term soil fertility experiment in Kenya and observed declining yield even for plots receiving ISFM at recommended rates. This means rotational cropping is necessary even for farmers using ISFM. The results also underscore the large potential of carbon sequestration on agricultural land and the need for finding incentives for using ISFM.

Table 9.13 Adoption and profitability of soil fertility management practices in SSA

Country	ISFM	Fertilizer	Organic inputs	Nothing
	Adoption (%)			
Mali	0	23	11	66
Uganda	0	1	68	31
Kenya	16	17	22	44
Nigeria	1	23	28	47
Malawi	8	52	3	38
Tanzania	1	1	3	95
Mali	18	16	37	27
	Average adoption rate and profit			
Adoption rate (%)	6.2	19.1	24.6	49.8
Profit (US$/ha/year)[a]	36.5	24.6	15.1	10.4

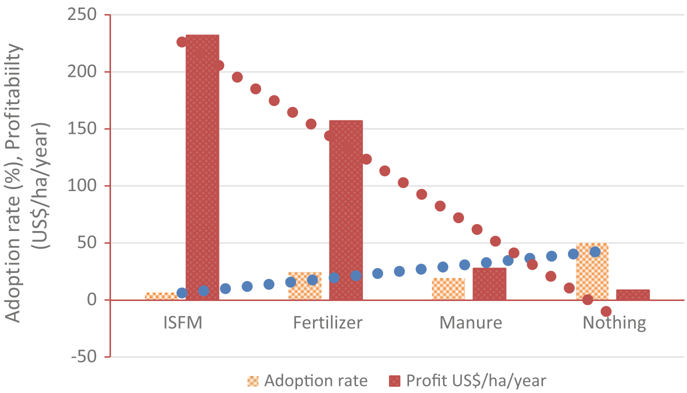

Fig. 9.14 Unholy cross: inverse relationship between adoption rate and profitability. *Sources* Adoption rate of land management practices: Mali (Direction nationale de la Statistique et de l'informatique (DNSI). Recensement general de l'agriculture, 2004/2005); *Uganda* Uganda national panel survey 2009/10 agriculture module; *Kenya* Kenya Agricultural Sector Household Baseline Survey; *Nigeria* Fadama III household survey, 2012; *Malawi* National panel survey, agriculture module, 2010/11. *Note* A returns to maize in Nigeria for the following land management practices: (i) ISFM: 5 tons/ha manure, 80 kgN/ha, 100 % crop residues, (ii) Fertilizer: 80 kgN/ha + 100 % crop residues, (iii) Manure: 5 tons/ha, 100 % crop residues, (iv) Nothing—no manure or fertilizer applied: 100 % crop residues

Econometric Results

Market access and rural population: Controlling for government effectiveness, rural population density, and other covariates, distance to urban areas increases cost of land degradation but reduces cropland expansion (Table 9.16). This suggests greater cropland expansion to meet demand for the urban population. The lower cost of land degradation could be due to stricter enforcement of deforestation in

Table 9.14 Maize, rice, and wheat harvested area and yield across SSA sub-regions

Maize	Eastern Africa	Central Africa	Southern Africa	Western Africa	SSA
Area as % of total cropland area	20.19	13.28	21.81	7.89	13.5
Yield (tons/ha)	1.48	0.97	3.14	1.57	
Rice					
Area as % of total cropland area	3.78	2.40	0.01	5.23	4.0
Yield (tons/ha)	2.23	0.93	2.63	1.76	
Wheat					
Area as % of total cropland area	2.62	0.05	5.29	0.06	1.3
Yield (tons/ha)	1.71	1.34	2.128	1.43	
Total area	26.6	15.7	27.1	13.2	18.8

Source FAOSTAT data

Table 9.15 Cost of land degradation due to using land degrading management practices on cropland

SSA sub-region	Cost of land degradation due to		Cost of loss of CO_2 sequestration due to using		Total cost
	BAU	Continuous ISFM	BAU	Continuous ISFM	
	2007 US$ billion				
Central	0.018	0.002	0.075	0.069	0.164
Eastern	0.127	0.01	0.464	0.053	0.654
Indian Ocean	0.004	0.00	0.021	0.051	0.076
Southern	0.188	0.023	0.741	0.14	1.092
Western	0.352	0.09	0.303	0.635	1.38
Total	0.689	0.126	1.604	0.947	3.367

Notes: *BAU* Business as usual land management practice, i.e., commonly used land management practice in the area. *ISFM* Integrated land management practice—assumed to be sustainable but its yield declines with continuous cultivation

areas closer to cities. For example Banana et al. (2004) found stricter deforestation laws for areas closer to urban areas in Uganda. Rural population density has a U-shaped relationship with cost of land degradation suggesting greater land degradation at high population densities beyond a threshold. Such pattern supports Rockstrom et al. (2009) ecological boundary beyond which an irreversible ecological damage could occur. Cropland expansion has an inverted U-shaped relationship with rural population— implying a potential establishment of non-farm activities or migration to urban area.

Table 9.16 Drivers of cost of land degradation and extent of cropland—robust OLS regression

	Land degradation cost (2007 million US$)		Change of cropland (ha)	
	Structural	Reduced	Structural	Reduced
Market access and population density				
Travel time (minutes) to city with 50 k people	0.01***	0.01***	−19.63***	−15.65***
Δ Rural population (million people)	−0.09***	−0.05***	65.97***	47.98***
(Δ rural population)2	1.49e−5***		−0.01*	
Economic development and international trade and aid				
Δ GDP (2005 million US$)	1.45***	2.20***	4568.98***	1216.77***
Δ GDP2 (2005 million US$)2	0.01***		−42.20***	
Adjusted IMR (of 1000 live births)	−0.49***	−0.38***	−1664.87***	−2181.42***
Δ Ag export index (2004–06 = 100)	0.57***	0.55***	−421.56***	−317.63***
Δ ODA aid (constant price 1982–84 million US$)	−39.78***	−31.81***	27575.18***	−8275.28***
Cattle density 2005	−0.14***	−0.15***	471.42***	471.47***
Governance and land tenure				
Δ Government effectiveness	−32.12***	−34.19***	−217654.10***	−210264.30***
Land Tenure security (cf Secure tenure)				
Moderate concern	212.71***	217.16***	111256.60***	91039.39***
Severe concern	156.51***	162.05***	206836.30***	183099.60***
Extremely severe concern	54.47***	65.97***	−177483.00***	−228307.00***
Precipitation (1982–86)	0.01***	0.01***	−71.21***	−68.44***
Constant	53.97***	37.79***	271117.90***	342259.30***

Note Standard errors are corrected for heteroskedasticity using Huber-White estimators
*, **, and *** respectively mean the corresponding coefficient is significant at $P = 0.10$, 0.05 and 0.01

Economic development, international trade and aid: Change in GDP and cropland is consistent with the environmental Kuznet curve—i.e., a simultaneous increase in cropland and GDP until a GDP threshold is reached, beyond which cropland expansion declines. Some countries have in fact seen decreasing cropland area (e.g. Botswana, Guinea, Senegal, Equatorial Guinea, Congo, and DRC)

(Nkonya et al. 2013). This is consistent with Orubu and Omotor (2011) who observed that African countries are turning the environmental Kuznet curve at a much faster pace and at a lower income level than countries in other regions. The cost of land degradation however has a positive relationship with GDP suggesting increasing degradation beyond the inflection point. This shows the potential for severe degradation even in high incomes that are observed in Chap. 6. Interestingly, severity of poverty, as represented by the infant mortality rate, is negatively related to cost of land degradation and cropland expansion. The results suggest that poor people have the capacity to sustainably manage their land if other mediating factors are taken into account.

Export leads to higher cost of land degradation but reduces cropland expansion. The impact of export on cost of land degradation is consistent with Rudel et al. (2009b) and Foley et al. (2011)—predominantly agricultural export volume. The negative impact of export on cropland expansion is contrary to Lambin and Meyfroidt (2011) and could be explained by the greater intensification of export crops compared to non-export crops (Kelly 2006; Crawford et al. 2003). For example, fertilizer application and use of improved varieties is greater for high-value and export crops than on other crops (Ibid). The contradictory results of higher cost of land degradation and reduced cropland expansion could be explained by the fact that cost of land degradation is a sum of all types of LUCC. It is possible that export crops are planted on a relatively smaller area but are replacing high value biome such as forests. For example, the recent large foreign agricultural investment in SSA with heavy orientation towards meeting food and energy needs of investing countries, rather than for domestic consumption (Anseeuw et al. 2012; World Bank 2011) has triggered cropland expansion into forested areas even when there is intensification (Schoneveld et al. 2011). The expansion into forested area could occupy a smaller but higher value area and could therefore imply reduced cropland expansion but lead to high value LUCC.

As expected, ODA funding reduces cost of land degradation—suggesting a favorable impact of international budget on environmental and agricultural ministries in SSA. Similarly, ODA funding has a negative impact on cropland expansion for the reduced model (Table 9.16). The results suggest that public investment can help efforts to address land degradation.

Cattle density has negative impact on cost of land degradation suggesting that areas with higher cattle density are less degraded than other areas. This supports other findings which have shown that pastoral areas are less degraded than cropland areas in SSA. This is consistent with Nkonya and Anderson (2015) who observed greater propensity to sustainably manage land with greater cattle density and with Bai et al. (2008), who observed greater land improvement in pastureland. The results suggest that there is great potential for rehabilitating the 339.80 million ha of degraded grazing areas (Chap. 8).

Government effectiveness and land tenure: As expected and consistent with Esty and Porter (2005), government effectiveness reduces cost of land degradation and cropland expansion. This further underlines the importance of land management institutions that play key roles in private and collective natural resource management in rural communities (Ostrom 1990). For example, government effectiveness is high in countries which have experienced a decrease in cropland (e.g. Botswana GEI = 0.7). This suggests governance could have also contributed to a decrease in cropland extent by limiting expansion into protected areas. For example, Mbaiwa et al. (2011) observed an effective protection of the Okavango delta using a community-based natural resource management approach.

Consistent with Place and Otsuka (2001), Gavian and Fafchamps (1996), tenure security reduces the cost of land degradation. Similarly, cropland expansion is greater in lands held with moderate to extremely severe security concern compared to lands held with secure tenure. These results imply that in countries with more secure land rights, the cropland expansion is slower. Recent foreign land acquisition in SSA is consistent with these results since such acquisitions have been concentrated in countries with weak tenure security (HLPE 2011). The results further underline the importance of land rights to farmers in SSA. However, land held with extremely severe security concern are less likely to experience cropland expansion than those held with secure tenure. This could be due to the tendency of farmers holding land with secure tenure to do cropland expansion in response to increasing demand for agricultural products.

Summary, Suggested Actions to Address Land Degradation, and Conclusion

LUCC accounts for about 93 % of the total annual cost of land degradation (US$ $62.9 billion) when the total economic value (TEV) of all terrestrial biomes are taken into account and for 94 % when only loss of provisioning services is considered (Fig. 9.15). This means action against land degradation needs to involve more aggressive efforts to address LUCC. What actions could be taken to address LUCC?

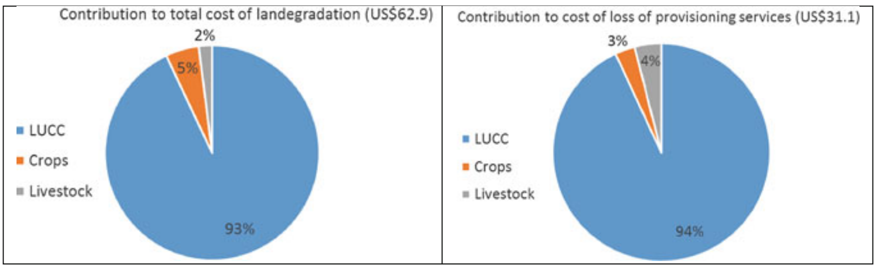

Fig. 9.15 Summary of the annual cost of land degradation

Protection of Grasslands and Forests and Increase Their Productivity

Conversion of grassland to cropland and deforestation are the major factors driving LUCC. One of the major reasons leading farmers to convert grassland to cropland is the low livestock productivity. The increasing demand for livestock products provides an ample opportunity to the value of grasslands and in turn livestock productivity. This will require an increase in the public budget allocation to livestock production, which is currently only about 5 %. Investments in livestock productivity need to be directed to both cost-effective and amenable pasture management practices and breeding programs. There are success stories of livestock systems in SSA which have shown high productivity due to such efforts. The Kenyan dairy programs and Botswana's beef production demonstrate some of the success stories that could be used in other SSA countries (Hazell 2007). The success story for both countries is due to long-term policies for livestock development, which have aimed at; genetic improvement, disease control, strengthening domestic and international markets to allow farmers to address highly seasonal supplies, and health and safety standards (Hazell 2007). Efforts to improve grassland through controlled grazing, planting legumes, and other amenable practices will increase both livestock productivity and carbon sequestration (Henderson et al. 2015).

Our econometric results also show the importance of tenure security and government effectiveness. Such institutional development will help efforts to enforce policies and programs that regulate LUCC. Access to markets will also contribute to reducing the cost of land degradation. Botswana for example has aggressively invested in livestock production and marketing strategies to put the country among the leading exporters of beef in SSA. In Botswana, export policies have been created to establish markets in Europe and other countries (Stevens and Kennan 2005). Sources of land degradation are the most widespread in SSA and this leads to a lower livestock productivity. The major LUCC of SSA involved is the conversion of grassland to other land use types. This is largely a result of the low livestock productivity. Deforestation and conversion of grassland to alternative land uses also means current SSA efforts to strengthen protected areas must increase.

Increase Government and Donor Funding to Support Land-Based Sectors

Econometric analysis showed that donor funding reduces the cost of land degradation. This underscores the role played by investment in land improvement played by donors. It also shows the favorable impact of investment in land improvement. Current public allocation to land based sectors is only about 5 %, a level that is only half of the Maputo declaration of spending 10 % of the government budget on agriculture. This needs to be increased to simultaneously reduce poverty (De Janvry and Sadoulet 2010) and improve natural resources.

Increase Access to Markets

Our econometric analysis also showed that access to market leads to a reduction of the cost of land degradation related to LUCC. This suggests that increasing access to markets could help to create alternative non-farm employment that could reduce pressure on land resources. SSA is currently investing only about 13 % of its agricultural budget on market infrastructure development. Schmidhuber and Bruinsma (2011) have recommended an annual investment of an additional US $50.2 billion of investment to achieve food security by 2025 and 37 % of such investment to be directed to market infrastructure development in developing countries. This is especially high in SSA with the worst market infrastructure in the world. Improvement of market infrastructure will achieve a win-win benefit as it will improve natural resources and reduce poverty. However, improvement of government effectiveness as discussed below is required to mediate the potential degradation that could result from improved market access.

Improve Government Effectiveness and Land Tenure Security

Our econometric analysis showed consistent favorable impact of improvement of government effectiveness on reduction of the cost of land degradation and cropland expansion. This further demonstrates the key role played by governance in mediating the drivers of land degradation (Nkonya and Anderson 2015).

Tenure security also has favorable impact on efforts to prevent land degradation. The recent land grabbing was concentrated on lands held under customary tenure and/or communal lands with no formal tenure (HLPE 2011). Additionally, the prices of land (and shadow prices) are increasing and are expected to increase as the world gets wealthier and more crowded, moving from a population of 7–9 billion in the coming generation. This poses expropriation risks for land held under customary tenure. This means efforts to protect customary tenure systems against arbitrary expropriation requires immediate policy action. Additionally, long-term strategies for enhancing women access to land under customary tenure need to be taken to increase women land acquisition through customary tenure. Short-term strategies for improving women land acquisition include improvement of land markets. It is especially important to legalize land sales in SSA countries where land belongs to the state and where selling and buying land is illegal.

Increase Adoption of ISFM

The current low adoption of ISFM is due to a number of factors discussed above. In addition to these, there is need for enhancing the capacity of agricultural extension services in order to provide ISFM advisory services. This is because studies have shown they have a low capacity to provide advisory services on ISFM and agricultural marketing remains low and weak (AGRA 2014). There is need of retraining agricultural extension service providers on ISFM and agricultural marketing. A pluralistic extension services could be required to achieve this objective since different providers will give complementary advisory services to cover many aspects that the traditional extension services seem to be deficient.

There is also need for finding practical and amenable strategies for incentivizing farmers to use ISFM. For example, conditional fertilizer subsidy could provide incentives for farmers to adopt nitrogen fixing agroforestry trees and improve significantly the current subsidy programs in several SSA countries. Such a strategy will simultaneously reduce the high labor intensity of ISFM and reduce the inorganic fertilizer requirement (Akinnefesi et al. 2010) and thus lower the high cost of subsidies without reducing yield and production. A study conducted in Malawi showed that providing conditional fertilizer subsidies was highly favorable among farmers (Marenya et al. 2014).

Overall, our results show that SSA has the potential to become the breadbasket of the world but it has to significantly improve its market access and government effectiveness to create incentives for land holders to invest in land improvement. The increasing demand for land, urbanization, and other global regional changes are creating a conducive condition for taking action against land degradation. These opportunities should be exploited effectively as they lead to win-win outcomes—reducing poverty and achieving SLM.

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