Climate-Smart Agriculture

Enhancing Resilient Agricultural Systems, Landscapes, and Livelihoods in Ethiopia and Beyond

Kiros Meles Hadgu, Badege Bishaw, Miyuki Iiyama, Emiru Birhane, Aklilu Negussie, Caryn M. Davis, and Bryan Bernart, *Editors*

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ISBN: 978-9966-108-24-1

Published by:
World Agroforestry (ICRAF)
United Nations Avenue
PO Box 30677, GPO 00100
Nairobi, Kenya

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Internet: http://worldagroforestry.org/

Suggested citation:
Climate-Smart Agriculture: Enhancing Resilient Agricultural Systems, Landscapes, and Livelihoods in Ethiopia and Beyond. 2019. Kiros Meles Hadgu, Badege Bishaw, Miyuki Iiyama, Emiru Birhane, Aklilu Negussie, Caryn M. Davis, and Bryan Bernart, Editors. World Agroforestry (ICRAF), Nairobi, Kenya.

World Agroforestry (ICRAF) encourages climate-smart production systems and resilient and green environments. This book is printed on 100% recycled paper with vegetable-based inks. It is also available for download online at http://worldagroforestry.org/our-publications.

Cover photo: Central Tigray region landscape, Northern Ethiopia. Photo credit: Aklilu Negussie Mekuria.

Graphic design: Caryn M. Davis, Cascadia Editing, Philomath, Oregon, USA. Email: cascadia.editing@gmail.com

16. Constraining the Constraints: Factors Affecting Farmers' Investment in Climate-Smart Land Management

Zenebe Adimassu*

Summary

Increased agricultural productivity and food security in Ethiopia are highly dependent on the status of the natural resource base and how natural resources are managed. Available evidence suggests that climate change coupled with land degradation expressed in the forms of soil erosion and nutrient depletion, among others, present threats to food security and the sustainability of agricultural production in Ethiopia. Reversing land degradation on one hand while improving land productivity on the other lies at the heart of the broader imperative for sustainable agricultural production under smallholder agriculture. Despite decreasing land productivity, increasing land degradation, and climatic and socioeconomic changes (e.g., population growth), farmers' widespread adoption of climate-smart land management (CSLM) technologies, practices, and investments is limited. This chapter discusses several key biophysical, social, economic, and policy constraints that affect farmers' investments in the adoption of CSLM technologies and practices. These constraints are classified into three broad categories: capacity to invest (e.g., landholding, labor, finance, and physical capital); incentives to invest (e.g., net and relative returns, risks, discount rate, and biophysical factors); and external factors (e.g., technology, extension services, land policy, political instability, and infrastructure programs) to better contribute to guiding and facilitating a design of informed policies. Finally, the chapter concludes that there is a need for co-investments from multilevel stakeholders in order to achieve the objectives of CSLM in Ethiopia. These actions will, therefore, enhance agricultural production and food security of smallholders while contributing to the climate change adaptation and mitigation agenda.

Keywords: constraints, land management, investments, stakeholders, determinants

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16.1 Introduction

Most countries of Sub-Saharan Africa (SSA) depend on the natural resources base for their food, social, and environmental security (Shiferaw and Holden 2001). Because of different human-caused and natural disasters, many countries in SSA are increasingly experiencing the impacts of climate change, which severely affect agricultural production, and consequently, food and nutrition security (Reij and Smaling 2008). Available evidence further suggests that land degradation in the form of soil erosion and nutrient depletion presents an increasing threat to the productivity and sustainability of agricultural production in SSA (Lal 1985, Lal and Singh 1995, Reij and Smaling 2008).

The impacts of land degradation, coupled with climate change, on agricultural production and livelihoods are especially severe in Ethiopia, whose agriculture sector is dominated by rainfed, resource-constrained smallholder systems (Shiferaw and Holden 2000, Descheemaeker et al. 2006, Kassie et al. 2008). Smallholder farmers in Ethiopia are, therefore, urged to take immediate actions to reverse the threats of land degradation and adapt to climate change in order to improve land productivity, which lies at the heart of the broader imperative for sustainable agricultural production (Barrett et al. 2006). In addressing land degradation and climate change challenges, governmental and non-governmental agencies have so far invested substantial resources in promoting sustainable land management practices (Adimassu et al. 2018). These practices, considered climate-smart land management (CSLM) practices, have been expected to contribute to rehabilitating degraded lands; ensuring sustainable and increased agricultural production (Nyssen et al. 2000);

mitigating climate change impacts; ensuring economic growth; and reducing poverty (Deininger and Ali 2008). Unfortunately, however, the capacity of Ethiopia's farmers to adopt CSLM has been generally limited over the past decades (Reardon and Vosti 1995, Reardon et al. 1996, Adimassu et al. 2012).

There are many complex and interrelated issues that contribute to the current limited investment in CSLM in Ethiopia (Pender and Kerr 1998, Deressa et al. 2008, Bryan et al. 2009, Reardon and Vosti 1995, Reardon et al. 1996). There have been several studies which attempted to identify major factors affecting farmers' capacity for investments in CSLM (e.g., Adimassu et al. 2015, Adimassu et al. 2012, Amsalu and De Graaff 2006, De Graaff et al. 2008, Kassie et al. 2008, Shiferaw and Holden 2000). The identified factors included the characteristics of households (e.g., gender, education, experience, etc.), characteristics of plots (e.g., size, slope, fertility condition, etc.), and policies and institutional support (e.g., land tenure, access to training, etc.). However, the results were often inconsistent, while much evidence remains undocumented.

Concrete evidence is needed to guide and facilitate a design of informed policies. This chapter attempts to present a comprehensive synthesis of evidence on the factors that affect farmers' investments in CSLM practices in Ethiopia by reviewing study reports and other sources. This chapter proposes to classify these factors into three major categories: incentive to invest, capacity to invest, and external factors (Figure 16.1), which could enhance adoption of CSLM technologies and practices in Ethiopia.

16.2 Incentives to Invest in Climate-Smart Land Management

For farm households to invest in CSLM, they need to have incentives, such as economic benefits from the investment. Incentives, specific to the households' investment, depend on net returns/profitability of investments, relative returns, riskiness, the households-specific discount rate, and the biophysical environment (Reardon and Vosti 1995, Reardon et al. 1996, Clay et al. 1998), which will be reviewed and discussed respectively.

16.2.1 Net returns

Net return is one of the most important factors governing investments in land management technologies (Pampel and van Es 1977, Ervin and Ervin 1982). If the costs of land management practices exceed the short- and long-term benefits, then farmers have no incentive to adopt the technologies (Camboni and Napier 1994, Cary 1994). Net return of a given investment depends on the yield and input requirements per unit of output and the prices of inputs and outputs. Leaving aside the question of capacity constraints, the better the net return of a potential investment in land management technology, the greater the probability of farmers to invest in the technology (Adimassu et al. 2018, Adimassu et al. 2012). As farmers in Ethiopia are sensitive to net returns, they implicitly compare the expected costs and benefits and then invest in options that offer the highest net returns, either in terms of income or reduced risk (Shiferaw et al. 2007, Zainab and Folmer 2000). Moreover, farmers' decisions to invest in land management are affected by the (perceived) profitability of a technology (Napier 1991, Napier et al. 1998, Kelly et al. 2003, Langyintuo and Dogbe 2005, Crook and Decker 2006, Diagana 2007, Getnet 2008). This is substantiated by studies in Tanzania and Ethiopia on adoption and continuous use of stone terraces, which revealed that farmers' investments are highly influenced by the (perceived) profitability of the technologies (Tenge et al. 2004, Amsalu and De Graaff 2006, De Graaff et al. 2008).

16.2.2 Relative returns

Farmers may consider investing in a technology (relative to alternative farm and non-farm investments) when the investment is likely to be profitable, although it may not be sufficiently attractive to motivate them to invest. Some studies reported that the availability of off-farm income has negative impacts on farmers' investments in land management technologies (Pender and Kerr 1998, Shiferaw and Holden 1998, Mbaga-Semgalawe and Folmer 2000, Gebremedhin and Swinton 2003, Holden et al. 2004, Tenge et al. 2004, Amsalu and De Graaff 2006, Mduma 2007). The studies argued that the negative impacts of off-farm activities on investment in land management technologies are because of two reasons. The first reason is that available off-farm activities provide opportunities for household workers to choose to allocate their family labor toward off-farm activities, where it fetches higher returns than on-farm land management. The second reason is that off-farm employment often directly overlaps with the slack season, when land-management activities are undertaken, and this reduces the labor available for land-management practices. However, the result of this variable (relative return) is not consistent. For example, there are conditions in which off-farm earnings are reinvested in land management technologies (Reardon and Kelly 1989, Clay and Reardon 1995, Clay et al. 1995, Kelly et al. 1995). The cash generated from off-farm income can be used to

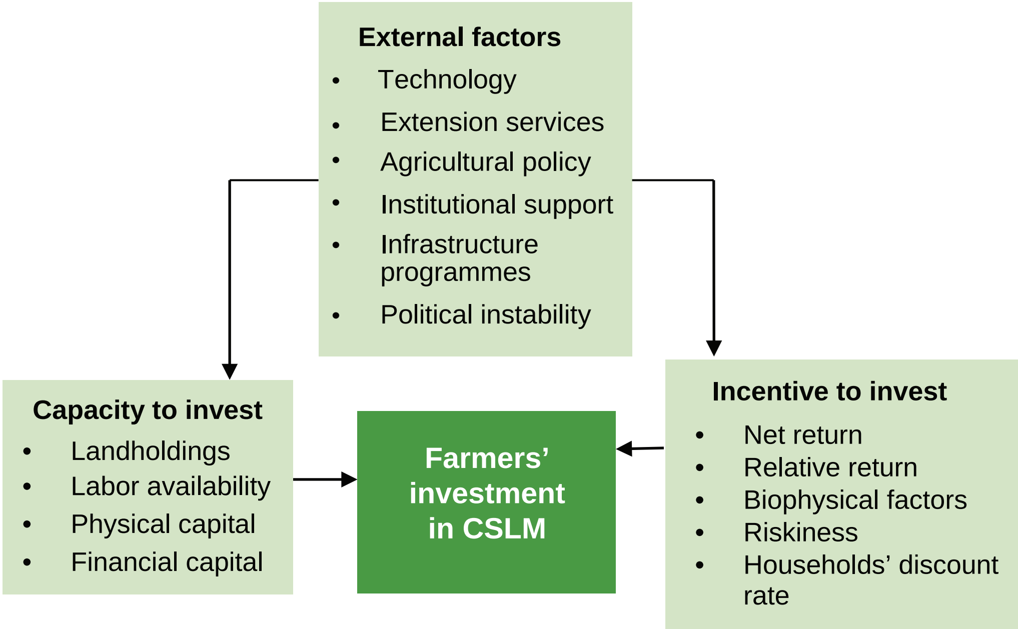

Figure 16.1 Schematic presentation of the key factors affecting farmers' investment in climate-smart land management (CSLM). (Adapted from Reardon et al. 1996.)

purchase chemical fertilizer and improved seeds as well as agricultural tools, which could be used for land preparation and other land management practices.

16.2.3 Riskiness

Another important factor affecting farmers' incentives to invest in land management is risk. Agricultural production under smallholder farming systems involves risk and uncertainty in SSA in general, and in Ethiopia in particular. . Investments in CSLM become risky and incentives decline if farmers are not sure that they will be able to get full benefits by recovering their investment costs. Some studies showed that investment in CSLM can significantly reduce production risks caused, for example, by rainfall variability in SSA (Reijntjes et al. 1992, Alfoldi et al. 2002, Scialabba and Hattam 2002, Mäder et al. 2002) and in Ethiopia (Hengsdijk et al. 2005, Shiferaw and Holden 1998). However, there are circumstances in which some interventions may increase risks (Shiferaw and Holden 1998). Such risks may arise from price and yield variability and land tenure security (Scialabba and Hattam 2002, Shiferaw et al. 2007).

(i) Price variability

The market for agricultural inputs and outputs in Ethiopia is poorly developed and contributes to an unfavorable relationship between input and output prices in the country (Aune and Bationo 2008). As the prices of agricultural products are unknown at the time of planning, they create uncertainties in the price and availability of inputs. Uncertainty in output market outlets also plagued several promising technologies in Africa (Kelly et al. 1995, Abdoulaye and Sanders 2006). Moreover, prices of inputs and outputs are influenced by demand and supply of inputs and outputs (Hill et al. 2006) as well as by limited access to market and market information (Markelova et al. 2009, Tang 2009).

(ii) Yield variability

Crop yields in Ethiopia are generally low and highly variable (Harris and Kennedy 1999). Studies have clearly demonstrated that rainfall is the predominant factor influencing yield variability in the region (Singh and Byerlee 1990, Howard et al. 2003). The increase in extreme weather events, such as spells of high temperatures and droughts, also increases yield variability and reduces average yield (Tittonell et al. 2008, Sinebo 2005). Yield variability also affects the technology choices of farmers due to risk aversion (Graves et al. 2004). Because of this uncertainty, farmers in Ethiopia show logical reluctance to invest in potentially more productive and economically rewarding practices when the outcomes and returns seem so uncertain from year to year (Howard et al. 2003).

(iii) Land tenure security

Secure and transferable land rights have long been identified as key elements to bringing about higher levels of long-term investments (Gebremedhin and Swinton 2003, Deininger and Jin 2006). Most empirical studies indicated that security of tenure is important for long-term investment and is positively correlated with long-term land management practices (Roth et al. 1994, Besley 1995, Gavian and Fafchamps 1996, Shiferaw and Holden 1998, Gebremedhin and Swinton 2001, Place and Otsuka 2002, Gebremedhin and Swinton 2003, Otsuka et al. 2003, Asrat et al. 2004, Kabubo-Mariara 2007, Nyangena 2008). Although insecurity in land tenure would be a disincentive for investment, paradoxically, it actually increases incentive because investment by itself can increase land security. In other words, investment is necessary to facilitate land security (Sjaastad and Bromley 1997). However, the role of land tenure security in SSA in providing incentives for land-related investment is inconsistent and complicated (Sjaastad and Bromley 1997, Place and Swallow 2000, Deininger and Jin 2006). Accordingly, land tenure security has no significant effect on investment in land management (e.g., Migot-Adholla et al. 1994, Migot-Adholla et al. 1991, Place and Hazell 1993, Pinckney and Kimuyu 1994, Place and Otsuka 2002, Gavian and Fafchamps 1996, Sjaastad and Bromley 1997, Brasselle et al. 2002). The mixed reports on land tenure security on investments in land management could be caused because of inconsistencies in methodologies and definitions of land tenure security used in the different studies (Kabubo-Mariara 2007).

16.2.4 The household-specific "discount rate"

The household-specific "discount rate" is the time value of money, and it reflects how future costs and benefits are weighed, relative to immediate costs and benefits (Pender 1996). Most land-management investments require heavy initial investments (either in cash or in-kind) although the benefits are delivered in many years in the future (Shiferaw et al. 2007). Investments in land management, for example, in agroforestry and terracing, typically have delayed payoffs, and a household with a high discount rate might be less inclined to make this type of investment (Gardner and Barrows 1985, Reardon et al. 1996). The capital budgeting analysis in Ethiopia suggests that returns from investment in stone terraces are highly sensitive to discount rate (Barrett et al. 2002). It is generally accepted that an individual's discount rate is influenced by a number of personal factors, such as wealth and income profiles, level of education, age, and state of health. Wealthier, healthier, younger and well-educated individuals have lower discount rates than their poorer, older, less healthy, and less educated counterparts (Lumley 1997, Shiferaw et al. 2007).

16.2.5 Biophysical environment

Through their effect on profitability and riskiness, biophysical factors, such as natural fertility of soils, rainfall, topography, temperature, diseases, and pests determine the technical feasibility of investments. Among the biophysical factors, rainfall variability is the most important cause for year-to-year variability of crop production, and the high insecurity it produces may consequently affect farmers' willingness to invest in rain-fed agricultural activities (Shiferaw et al. 2007).

Studies in Ethiopia indicated that farmers with steep slope plots invest in land management techniques such as stone terraces (Pender and Kerr 1998, Shiferaw and Holden 1998, Bekele and Drake 2003, Asrat et al. 2004, Amsalu and De Graaff 2006). This can be attributed to the positive relationship between slope and levels of soil erosion severity. Plots perceived to have greater erosion severity receive more investment in land management. The soil fertility status of plots is also an important factor in land management investment. Farmers invest more in fertile plots than infertile ones (Bekele and Drake 2003). This could be attributed to marginal productivity loss due to erosion from plots with fertile topsoil, which is higher than that of plots with less fertile topsoil, and such plots are expected to yield a greater return as compared to infertile plots. Generally, areas with good soil fertility and relatively abundant rainfall may have good agricultural profits, which farmers then reinvest in land management (Gebremedhin and Swinton 2003, Joshi et al. 2005). In spite of this, some studies indicated that farmers invest more in infertile plots than in fertile ones (Amsalu and De Graaff 2006, Benin and Pender 2001) due to a lack of perception on the effects of soil erosion and soil nutrient depletion.

16.3 Capacities to Invest in Climate-Smart Land Management

Farmers' capacity to invest in land management depends on the household's landholdings, labor availability, and physical and financial capital (Reardon et al. 1996).

16.3.1 Landholdings

Land is the major source of wealth and livelihood in SSA. Quantity and quality of land affect the types and intensity of investments that are technically feasible and profitable. Mostly, it is hypothesized that farmers with large plots and farms are more capable of undertaking investments because they can spare part of their land for terracing, fallow, and trees, while still keeping large portions under cultivation (Hayes et al. 1997, Asrat et al. 2004, Smith 2004). In spite of this, empirical studies in Ethiopia showed mixed results. For example, small farms may have strong incentives for intensification and land-enhancing investments because their owners depend more on these small landholdings (Kassie et al. 2008, Byiringiro and Reardon 1996). However, small farmers often face stiff constraints, for example, in obtaining credit and physical capital which could enhance investment in land management (Clay et al. 1995).

On the other hand, some empirical studies in Ethiopia suggest that farmers who hold large farms are more likely to invest in land management (Hayes et al. 1997, Asrat et al. 2004, Smith 2004, Tenge et al. 2004, Amsalu and De Graaff 2006, De Graaff et al. 2008). This could be attributed to farmers with large landholdings who take the risk of investing in land management, which then may help them survive crop failures due to drought, pests, hailstones, or excess rainfall (Nowak 1987, Reardon et al. 1996).

16.3.2 Labor availability

Labor availability, in terms of quantity and quality, is critically important in land management. The quantity aspect of labor is important when labor is considered as an input in labor-intensive land management activities, such as construction of stone terraces. Empirical studies in SSA, including in Ethiopia, showed that large family size and an economically active population have positive and significant effects on labor-intensive investments in land management practices (Pender and Kerr 1998, Mbaga-Semgalawe and Folmer 2000, Gebremedhin and Swinton 2003, Bewket 2007).

16.3.3 Education/knowledge level and capability

The quality of labor, which includes the worker's education level and technical knowledge, is also important to the farmer's ability to make appropriate investment decisions (Smith 2004). Education level of households is also considered as a proxy influencing household head's capacity for understanding technical aspects related to land management (Jumbe and Angelsen 2007). Most studies indicated that higher education levels are associated with more access to information on land degradation problems and improved land management measures (Adimassu et al. 2015, Hagos and Holden 2006). Similarly, education of a household head leads to an increased ability to assess information, better understanding of new technologies, and strengthening of his/her analytical capabilities with new technologies (Swinton and Quiroz 2003). Studies also reported that education has a positive impact on investments in improved land-management technologies in SSA (McDowell and Sparts 1989, Abeygunawardena 1990, Mbaga-Semgalawe and Folmer 2000).

16.3.4 Physical capital

Physical capital to invest in land-management practices includes infrastructure and other physical characteristics of plots. To adopt less erosive forms of land use in steeper plots, which are more susceptible to erosion, there is high incentive to invest in land management practices (Clay et al. 1998). The greater the land degradation in a village, the more likely resident farmers are to invest in land management (Clay et al. 1998, Gebremedhin and Swinton 2003). Empirical studies in Ethiopia also revealed that distance from homesteads to farmers' fields affects the type and intensity of land-management investment (Pender and Gebremedhin 2007, Pender et al. 2004, Gebremedhin and Swinton 2003). Because transportation options for transporting inputs to distant plots were lacking or limited, farmers were more likely to invest in land management practices (e.g., application of compost/farm yard manure) on plots closer to their residence (Clay et al. 1998, Nkonya et al. 2004, Nkonya et al. 2005).

16.3.5 Financial capital

Financial capital consists not only of cash, but also liquefiable assets, such as livestock and crop sales that can be used to finance an investment in land management. The main sources of cash for Ethiopian farmers include livestock and crop sales, off-farm activities, and credits (Pender and Gebremedhin 2007). Because it provides cash income, livestock husbandry, for example, is a boon to farm investments (Hayes et al. 1997). Like other factors, the effect of livestock on investment in land management is mixed. For example, some studies in Ethiopia indicated that large livestock size discourages investment in conservation practices (Amsalu and de Graaff 2006, De Graaff et al. 2008). Due to livestock's relative profitability, households may focus more on livestock than on crop production. By contrast, other studies reported that large livestock ownership is associated with greater use of land-management practices, which is likely because income generated from livestock products helps farmers to purchase agricultural inputs (Hayes et al. 1997, Pender and Gebremedhin 2007). Availability of credit is another financial factor that influences farmers' capacity for investing in land management. Research on the adoption of land-management technologies indicates that there is a positive relationship between adoption levels and the availability of credit in the region (Shiferaw and Holden 1998, Benin and Pender 2001, Pattanayak et al. 2003, Yirga 2007).

16.3.6 Collective action

Collective action is crucial for the success of land-management practices in Ethiopia (Adimassu et al. 2011). This can be explained in two ways. First, most physical land-management practices, such as construction of stone bunds, soil bunds, and cut-off drains, require huge amounts of labor and cannot be implemented by individual farmers. Second, spatial interlinkages related to the flow of water and nutrients are inherent in watersheds. While conservation measures in the upstream may benefit downstream use, soil erosion in the upstream may harm downstream uses of both land and water. In both cases, collective action enhances farmers' capacities to invest in land management and enables fair distribution of costs and benefits from land management. Studies in the northern part of Ethiopia showed that collective action-based land management methods, including use of grazing lands, are effective and sustainable (Gebremedhin et al. 2004, Benin and Pender 2006). Similarly, collective actions in the Gununo watershed of the southern part of Ethiopia increased the effectiveness of land-management practices such as *fanya juu* and soil bunds (Mazengia and Mowo 2012). In the highlands of Kenya, collective actions also determined farmers' investments in land-management practices (Nyangena 2008).

16.4 External Factors

External factors are constraints that are beyond the control of farmers and are more relevant to policy and institutions. These factors affect investments in land management through their effect in influencing farmers' incentives and capacities to invest. External factors common to all households in a particular agro-climatic/policy context include lack of (appropriate) technologies, limited extension services, poor agricultural policies, weak institutional collaboration, poor infrastructure programs, and political instability (Reardon and Vosti 1995).

16.4.1 Lack of (appropriate) technologies

Technology development and transfer is essential for increasing productivity and enhancing land resources management (Reilly et al. 2000). Lack of (appropriate) technology on land management may limit farmers' investment in land management by reducing profitability and increasing riskiness of a particular investment (Vallaeys et al. 1987). If it is difficult for farmers to obtain capital and dry season labor, for example, although the available land management technologies require these resources, then the technology may not be appropriate. Studies in Ethiopia reported that available technologies are not appropriate because they often fail to take proper account of biophysical, socioeconomic, and policy factors (Ehui and Poison 1993, Crane and Traore 2005). Lack of access to technologies is also another main constraint in SSA (Nederlof and Dangbegnon 2007).

16.4.2 Limited extension services

Extension services promote technology adoption and may also cut the cost of using new land-management technologies (Reardon 1996). Studies in Ethiopia revealed that farmers who have close access to extension services adopt more land-management technologies than do those with less or no access at all (Wale 2008, Barrett et al. 2002). The numbers of visits to farmers by extension agents also affected farmers' investment in land management positively and significantly (Clay and Reardon 1995, Benin and Pender 2001, Wale 2008). Unfortunately, there is very limited access to extension services and poor research-extension-farmer linkages in most SSA countries (Mowo et al. 2010).

16.4.3 Weak institutional support

The effectiveness of land management practices depends on how efficiently institutions can work together in providing technical support to farmers (Hoffmann et al. 2007). However, imperfect institutional arrangements; lack of transparency, accountability, and capacity; and limited access to information and networking, are the main features of most institutions in SSA countries, including Ethiopia (Ribot 2002).

16.4.4 Poor infrastructure programmes

Mainly due to inadequate physical infrastructure, agricultural growth in SSA has been constrained by a number of factors, including inefficient agricultural output markets and input supply systems (Gunvant et al. 1987, Katungi et al. 2008). Most farmers in SSA have insufficient access to markets because agricultural outputs are either produced in remote areas or access roads are bad or nonexistent (Lindner et al. 1992, Spencer 1996, Neill and Lee 2001). The quality and quantity of roads affect transaction costs, risks, and price fluctuations of farm products and non-farm activities. Transport and communication infrastructure determines the availability of information and access to markets as well as costs and returns of investments. By increasing output-to-input price ratios, better access to roads and markets can increase labor and/or capital intensity of investments on land management practices (Binswanger and McIntire 1987, Osbahr et al. 2008). Better access to roads and markets also promotes higher income per capita by providing greater economic opportunities to rural households who, in turn, invest in land management practices (Tiffen et al. 1994). On the contrary, poor infrastructure raises the price of inputs and reduces agricultural outputs, which further diminishes the profitability of land management technologies (Shiferaw et al. 2007). A price increase in agricultural products may make certain land management interventions profitable or attractive to farmers. Accordingly, some studies reported a positive relationship between increases in prices of agricultural products and the adoption of land-management technologies (Shiferaw and Holden 2000, Lee 2005). Some studies, however, reported that better infrastructure could instead increase non-farm rather than farm opportunities, which may, thus, reduce intensities of land management technologies (Tschirley and Benfica 2001, Grothmanna and Patt 2005).

16.4.5 Political instability

Political instability appears to be the most important obstacle to agricultural development (Muleya et al. 1987, Nwilene et al. 2008). Political instability can, thus, influence investments in land-management technologies in SSA, including in Ethiopia (Blackie 1987). Political instability interrupts input distribution and output marketing, and may lead farmers to keep their savings in liquid assets, such as jewels or livestock, rather than investing them in long-term land improvement activities (Nwilene et al. 2008).

16.4.6 Poor agricultural policies

Policy plays a pivotal role in land management practices by creating an enabling environment for investment in land management. Macro- and micro-policies directly and indirectly affect output and input prices and, therefore, net and relative returns on investments. Price and credit policies in Ethiopia are changing dramatically and frequently, and farmers do not know how to plan; thus, they shy away from on-farm investments (Baye 2017).

16.5 Conclusions

The principal part of this chapter is the documentation of key factors influencing farmers' investments in CSLM. The investment in CSLM by smallholder farmers is constrained by an array of biophysical, social, economic, institutional, and policy factors. In this chapter, the most important factors that affect farmers' investments in CSLM are grouped into three categories: incentives, capacities, and external factors. While we identify these factors that affect farmers' investments in CSLM, there are good lessons to be learned from Ethiopia, where CSLM practices are successful mainly in the Amhara and Tigray regions (Adimassu et al. 2018). Farmers are able to constrain these factors by enhancing their capacities to invest in CSLM and increase incentives for the investments they make. The success behind these case studies is due to the fact that CSLM land practices are implemented using the landscape approach. The landscape approach employs collective action to constrain the three key factors that affect farmers' investments in CSLM. This implies that a landscape approach is crucial for the adoption of CSLM in Ethiopia. Due to differences in social, economic, cultural, and biophysical characteristics, however, the influence of these factors varies from place to place within in the country. This suggests that a blueprint (one-size-fits-all) approach of CSLM practiced in lowland areas of Ethiopia may not be useful in the highland areas. Based on local biophysical, social, cultural, and farmers' contexts, CSLM strategies should be designed and adapted at micro- and macro-levels.

Although this chapter reviews the key determinants of farmers' decisions to invest in CSLM, further meta-analysis and synthesis may be required to better understand the impacts of CSLM practices on farmers' livelihoods and the environment.

Acknowledgement

The author gratefully acknowledges the CGIAR Research Program on Water, Land and Ecosystems (WLE) and the Ethiopian Institute of Agricultural Research for funding this study. The author would also like to extend his thanks to the anonymous reviewers and editors for their invaluable comments and suggestions to improve the quality of this chapter.

16.6 References

Abeygunawardena, P. 1990. Should soil conservation be subsidized? *Journal of Agricultural Engineering of Sri Lanka* 2(1):84–88.

Abdoulaye, T, and JH Sanders. 2006. New technologies, marketing strategies and public policy for traditional food crops: millet in Niger. *Agricultural Systems* 90:272–292.

Adimassu, Z, S Langan, and B Jennie. 2018. *Highlights of soil and water conservation investments in four regions of Ethiopia.* IWMI Working Paper 182. International Water Management Institute (IWMI), Colombo, Sri Lanka. 35 p.

Adimassu, Z, S Langan, and R Johnston. 2015. Understanding determinants of farmers' investments in sustainable land management practices in Ethiopia: Review and Synthesis. *Environment, Development and Sustainability* 18:1005–1023.

Adimassu, Z, A Kessler, and H Hengsdijk. 2012. Exploring determinants of farmers' investments in land management in the Central Rift Valley of Ethiopia. *Applied Geography* 35:191–198.

Adimassu, Z, K Mekonnen, and B Gorfu. 2011. Understanding and managing complexities in integrated natural resources management at watershed scale: lessons from the central Highland of Ethiopia, p. 468 in *Proceedings of the International Conference on Ecosystem Conservation and Sustainable Development (ECOCASD 2011) February 10–12, 2011,* ed. Natarajan et al. Organized by Ambo University, Ambo, Ethiopia.

Alfoldi, T, T Fliessbach, U Geier, L Kilcher, U Niggli, L Pfiffner, M Stolze, and H Willer. 2002. Organic agriculture and the environment. In *Organic Agriculture, Environment and Food Security,* ed. N Scialabba and C Hattam. Environment and Natural Resources Series No. 4, Food and Agriculture Organization of the United Nations (FAO), Rome.

Amsalu, A, and J De Graaff. 2006. Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. *Ecological Economics* 61:294–302.

Asrat, P, K Belay, and D Hamito. 2004. Determinants of farmers' willingness to pay for soil conservation practices in the southeastern highlands of Ethiopia. *Land Degradation and Development* 15:423–438.

Aune, JB, and A Bationo. 2008. Agricultural intensification in the Sahel—the ladder approach. *Agricultural Systems* 98:119–125.

Barrett, CB, MR Carter, and M Ikegmai. 2006. *Threshold-targeted Social Protection to Overcome Poverty Traps and Aid Traps,* University of Wisconsin, Madison, Wisconsin USA.

Barrett, CB, F Place, A Aboud, and DR Brow. 2002. The challenge of stimulating adoption of improved natural resource management practices in African agriculture, in *Natural Resources Management in African Agriculture: Understanding and Improving Current Practices,* ed. CB Barrett, F Place, and A Aboud. CABI, New York.

Baye, TG. 2017. Poverty, peasantry and agriculture in Ethiopia. *Annals of Agrarian Science* 15:420–430.

Bekele, W, and L Drake. 2003. Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. *Ecological Economics* 46:437–451.

Benin, S, and J Pender. 2006. Collective action in community management of grazing lands: the case of the highlands of northern Ethiopia. *Environment and Development Economics* 11:127–149.

Benin, S, and J Pender. 2001. Impact of Land Redistribution on Land management and productivity in the Ethiopian Highlands. *Land Degradation and Development* 12:555–568.

Besley, T. 1995. Property rights and investment incentives: theory and evidence from Ghana. *Journal of Political Economy* 103(5):903–937.

Bewket, W. 2007. Soil and water conservation intervention with conventional technologies in northwestern highlands of Ethiopia: Acceptance and adoption by farmers. *Land Use Policy* 24:404–416.

Binswanger, HP, and J McIntire. 1987. Behavioral and material determinants of production relations in land-abundant tropical agriculture. *Economic Development and Cultural Change* 36(1):73–99.

Blackie, MJ. 1987. Restructuring marketing systems for smallholders: Cases in Zimbabwe, in *Accelerating Food Production in Sub-Saharan Africa*, ed. JW Mellor, CL Delgado, and MJ Blackie. John Hopkins University Press, Baltimore, Maryland USA.

Brasselle, AS, F Gaspart, and JP Platteau. 2002. Land tenure security and investment incentives: puzzling evidence from Burkina Faso. *Journal of Development Economics* 67:373–418.

Bryan, E, T Deressa, AG Gbetibouo, and C Ringler. 2009. Adaptation to climate change in Ethiopia and South Africa: Options and constraints. *Environmental Science Policy* 12(4):413–426.

Byiringiro, F, and T Reardon. 1996. Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments. *Agricultural Economics* 15:127–136.

Camboni, SM, and TL Napier. 1994. Socioeconomic barriers to adoption of soil conservation practices in the United States, pp. 47–59 in *Adopting Conservation on the Farm: An International Perspective on the Socioeconomics of Soil and Water Conservation*, ed. TL Napier, SM Camboni, and SA El-Swaify. Soil and Water Conservation Society, Ankeny, Iowa USA.

Cary, JW. 1994. The adoption of conservation practices in Australia: an exploration of commercial and environmental orientations, pp. 461–474 in *Adopting Conservation on the Farm: An International Perspective on the Socioeconomics of Soil and Water Conservation*, ed. TL Napier, SM Camboni, and SA El-Swaify. Soil and Water Conservation Society, Ankeny, Iowa USA.

Clay, D, F Byiringiro, J Kangasniemi, T Reardon, B Sibomana, L Uwamariya, and D Tardif-Douglin. 1995. *Promoting Food Security in Rwanda through Sustainable Agricultural Productivity: Meeting the Challenges of Population Pressure, Land Degradation, and Poverty*. International Development Paper No. 17. Michigan State University, East Lansing, Michigan USA.

Clay, D, and T Reardon. 1995. Dynamic Linkages among Population, Environment, and Agriculture in the Highlands of East Africa. Department of Agricultural Economics, mimeo. Michigan State University, East Lansing, Michigan USA.

Clay, DC, T Reardon, and J Kangasniemi. 1998. Sustainable Intensification in the Highland Tropics: Rwandan Farmers' Investments in Land Conservation and Soil Fertility. *Economic Development and Cultural Change* 46(2):351–378.

Crane, T, and B Traore. 2005. Farmers' knowledge and perceptions of soil fertility, in *Conflict, Social Capital and Managing Natural Resources: A West African Case Study,* ed. KM Moore. CABI, Cambridge, USA.

Crook, BJ, and E Decker. 2006. Factors affecting community-based natural resource use programs in southern Africa. *Journal of Sustainable Forestry* 22(3):111–133.

De Graaff, J, A, Amsalu, F Bodna, A Kessle, H Posthumus, and A Tenge. 2008. Factors influencing adoption and continued use of long-term soil and water conservation measures in five developing countries. *Applied Geography* 28:271–280.

Deininger, K, and S Jin. 2006. Tenure security and land-related investment: Evidence from Ethiopia. *European Economic Review* 50:1245–1277.

Deininger, K, and DA Ali. 2008. Do Overlapping Land Rights Reduce Agricultural Investment? Evidence from Uganda. *American Journal of Agricultural Economics* 90:869–882.

Deressa, T, RM Hassan, T Alemu, M Yesuf, and C Ringler. 2008. *Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia*. IFPRI Discussion Paper 00798.

Descheemaeker, K, J Nyssen, J Poesen, M Haile, B Muys, D Raes, J Moeyersons, and J Deckers. 2006. Soil and water conservation through forest restoration in exclosures of the Tigray highlands. *Journal of the Drylands* 1(2):118–133.

Diagana, B, J Antle, J Stoorvogel, and K Gray. 2007. Economic potential for soil carbon sequestration in the Nioro region of Senegal's Peanut Basin. *Agricultural Systems* 94:26–37.

Ehui, S, and R Poison. 1993. A review of the economic and ecological constraints on animal draft cultivation in Sub- Saharan Africa. *Soil & Tillage Research* 27:195–210.

Ervin, CA, and DE Ervin. 1982. Factors affecting the use of soil conservation practices: Hypotheses, evidence and policy implications. *Land Economics* 58:277–292.

Gardner, K, and R Barrows. 1985. The Impact of Soil Conservation Investments on Land Prices. *American Agricultural Economics Association* 67(5):943–947.

Gavian, S, and M Fafchamps. 1996. Land tenure and allocative efficiency in Niger. *American Journal of Agricultural Economics* 78:460–471.

Gebremedhin, B, J Pender, and G Tesfay. 2004. Collective action for grazing land management in crop–livestock mixed systems in the highlands of northern Ethiopia. *Agricultural Systems*

82(3):273–290.
Gebremedhin, B, and SM Swinton. 2003. Investment in soil conservation in northern Ethiopia: the role of land tenure security and public programs. *Agricultural Economics* 29:69–84.
Gebremedhin, B, and SM Swinton. 2001. Reconciling food-for-work project feasibility with food aid targeting in Tigray, Ethiopia. *Food Policy* 26(1):85–95.
Getnet K. 2008. From market liberalization to market development: The need for market institutions in Ethiopia. *Economic Systems* 32:239–252.
Graves A, R Matthews, and K Waldie. 2004. Low external input technologies for livelihood improvement in subsistence agriculture. *Advances in Agronomy* 82:473–555.
Grothmanna, T, and A Patt. 2005. Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change* 15:199–213.
Gunvant, M, GM Desai, O Abiodun, AO Falusl, M Schluter, and RL Gapare. 1987. Commentaries on Marketing Systems, in *Accelerating Food Production in Sub-Saharan Africa*, ed. JW Mellor, CL Delgado, and MJ Blackie. John Hopkins University Press, Baltimore, Maryland USA.
Hagos, F, and S Holden. 2006. Tenure security, resource poverty, public programs, and household plot-level conservation investments in the highlands of northern Ethiopia. *Agricultural Economics* 34:183–196.
Harris, JM, and S Kennedy. 1999. Carrying capacity in agriculture: global and regional issues. *Ecological Economics* 29:443–461.
Hayes, J, M Roth, and L Zepeda. 1997. Tenure security, investment and productivity in Gambian agriculture: A generalized Probit Analysis. *American Journal of Agricultural Economics* 79:369–382.
Hengsdijk, H, GW Meijerink, and ME Mosugu. 2005. Modeling the effect of three soil and water conservation practices in Tigray, Ethiopia. *Agriculture, Ecosystems and Environment* 105:29–40.
Hill, J, E Nelson, D Tilman, S Polasky, and G Tiffany. 2006. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. *PNAS* 103(30):11206–11210.
Hoffmann, V, K Probst, and A, Christinck. 2007. Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? *Agriculture and Human Values* 24:355–368.
Holden, S, B Shiferaw, and J Pender. 2004. Non-farm income, household welfare and sustainable land management in the less favored area in the Ethiopian highlands. *Food Policy* 29:369–392.
Howard, J, E Crawford, V Kelly, and M Demeke. 2003. Promoting high-input maize technologies in Africa: the Sasakawa-Global 2000 experience in Ethiopia and Mozambique. *Food Policy* 28:335–348.
Joshi, PK, AK Jha, SP Wani, L Joshi, and R Shiyani. 2005. *Meta-analysis to assess impact of watershed programme and people's participation*. Research Report No. 8. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India.
Jumbe, CBL, and A, Angelsen. 2007. Forest dependence and participation in CPR management: Empirical evidence from forest co-management in Malawi. *Ecological Economics* 62:661–672.
Kabubo-Mariara, J. 2007. Land conservation and tenure security in Kenya: Boserup's hypothesis revisited. *Ecological Economics* 64:25–35.
Kassie, M, J Pender, M Yesufa, G Kohlinc, R Bluffstoned, and E Mulugeta. 2008. Estimating returns to soil conservation adoption in the northern Ethiopian Highlands. *Agricultural Economics* 38:213–232.
Katungi, E, S Edmeades, and M Smale. 2008. Gender, social capital and information exchange in rural Uganda. *Journal of International Development* 20:35–52.
Kelly, V, A Adesina, and A Gordon. 2003. Expanding access to agricultural inputs in Africa: a review of recent market development experience. *Food Policy* 28:379–404.
Kelly, V, B Diagana, T Reardon, M Gaye, and E Crawford. 1995. *Cash Crop and Food grain Productivity in Senegal: Historical View, New Survey Evidence, and Policy Implications.* MSU Staff Paper No. 95-05. Michigan State University, East Lansing, Michigan USA.
Lal, R, and BR Singh. 1995. Research priorities in soil management for sustainable land use. *Norwegian Journal of Agricultural Sciences* 21:17–29.
Lal, R. 1985. Soil erosion and sediment transport research in tropical Africa. *Hydrological Sciences Journal* 30:117–134.
Langyintuo, A, and W Dogbe. 2005. Characterizing the constraints for the adoption of a *Callopogonium mucunoides* improved fallow in rice production systems in northern Ghana. *Agriculture, Ecosystem and Environment* 110:78–90.
Lee, DR. 2005. Agricultural Sustainability and technology adoption in developing countries: Issues and policies for developing countries. *American Journal of Agricultural Economics* 87:1325–1334.
Lindner, R, P Pardey, and FG Jarrett. 1992. Distance to information source and the time lag to early adoption of trace element fertilizers. *Australian Journal of Agricultural Economics* 26(2):98–113.
Lumley, S. 1997. The environment and the ethics of discounting: An empirical Analysis. *Ecological Economics* 20:71–82.
Mäder, P, A Fliessbach, D Dubois, L Gunst, P Fried, and U Niggli. 2002. Soil fertility and biodiversity in organic farming. *Science* 296:1694–1697.
Markelova, H, R Meinzen-Dick, J Hellin, and S Dohrn. 2009. Collective action for smallholder market access. *Food Policy* 34(1):1–7.
Mazengia, W, and J Mowo. 2012. Role of collective actions in integrated soil and water conservation: The Case of Gununo Watershed, Southern Ethiopia. *Journal of Development and Agricultural Economics* 4(1):23–36.
Mbaga-Semgalawe, Z, and H Folmer. 2000. Household adoption behaviour of improved soil conservation: the case of the North Pare and West Usambara Mountains of Tanzania. *Land Use Policy* 17(4):321–336.
McDowell, C, and R Sparts. 1989. Multivariate modeling and prediction off farmer's conservation behavior towards natural ecosystems. *Journal of Environmental Management* 28:185–210.
Mduma, JK. 2007. Does rural labour market affect soil conservation? Case study of Kilimanjaro, Tanzania. *Journal of Agronomy* 6(1):228–234.
Migot-Adholla, SE, PBR Hazell, B Blarel, and F Place. 1991. Indigenous land rights systems in sub-Saharan Africa: a constraint on productivity? *World Bank Economic Review* 5:155–175.
Migot-Adholla, SE, F Place, and W Oluoch-Kosura. 1994. Security of tenure and land productivity in Kenya, pp. 119–140 in *Searching for Land Tenure Security in Africa,* ed. JW Bruce and SE Migot-Adholla. Kendall/Hunt Publishing Co., Dubuque, Iowa USA.
Mowo J, O Chris, N Adolf, and Z Adimassu. 2010. Addressing the research-development disconnects: lessons from East and Central African Highlands. *Development in Practice* 20:1001–1013.
Muleya, BK, P Ndegwa, and K Ohkawa. 1987. Commentaries on political considerations, nationalism, and development, in *Accelerating Food Production in Sub-Saharan Africa*, ed. JW Mellor, CL Delgado, and MJ Blackie. John Hopkins University Press, Baltimore, Maryland USA.
Napier, TL, CS Thraen, and SM Camboni. 1998. Willingness of land operators to participate in government-sponsored soil erosion control programs. *Journal of Rural Studies* 4(4):339–347.
Napier, TL.1991. Factors affecting acceptance and continued use of soil conservation practices in developing societies: a diffusion

perspective. *Agriculture, Ecosystems and Environment* 36:127–140.

Nederlof, ES, and C Dangbegnon. 2007. Lessons for farmer-oriented research: Experiences from a West African soil fertility management project. *Agriculture and Human Values* 24:369–387.

Neill, SP, and DR Lee. 2001. Explaining the adoption and disadoption of sustainable agriculture: the case of cover crops in Northern Honduras. *Economic Development and Cultural Change* 49:793–820.

Nkonya, E, J Pender, P Jagger, D Sserunkuuma, CK Kaizzi, and H Ssali. 2004. *Strategies for Sustainable Land Management and Poverty Reduction in Uganda*. Research Report No. 133, International Food Policy Research Institute, Washington, DC.

Nkonya, E, J Pender, C Kaizzi, K Edward, and S Mugarura. 2005. *Policy Options for Increasing Crop Productivity and Reducing Soil Nutrient Depletion and Poverty in Uganda*. Environment and Production Technology Division Discussion Paper No. 134, International Food Policy Research Institute, Washington, DC.

Nowak, PJ. 1987. The adoption of conservation technologies: economic and diffusion explanations. *Rural Sociology* 42:208–220.

Nwilene, FE, KF Nwanze, and A Youdeowei. 2008. Impact of integrated pest management on food and horticultural crops in Africa. *Journal Compilation* 128:355–363.

Nyangena, W. 2008. Social determinants of soil and water conservation in rural Kenya. *Environment, Development and Sustainability* 10:745–767.

Nyssen, J, M Haile, J Moeyersons, J Poesen, and J Deckers. 2000. Soil and water conservation in Tigray (Northern Ethiopia): The traditional technique and its integration with introduced techniques. *Land Degradation and Development* 11:199–208.

Otsuka, K, AR Quisumbing, E Payongayong, and JB Aidoo. 2003. Land tenure and the management of land and trees: the case of customary land tenure areas of Ghana. *Environment and Development Economics* 8:77–104.

Osbahr, H, C Twyman, WN Adger, and DSG Thomas. 2008. Effective livelihood adaptation to climate change disturbance: Scale dimensions of practice in Mozambique. *Geoforum* 39:1951–1964

Pampel, F, and JC van Es. 1977. Environmental quality and issues of adoption research. *Rural Sociology* 42:57–71.

Pattanayak, SK, DE Mercer, E Sills, and Y Jui-Chen. 2003. Taking stock of agroforestry adoption studies. *Agroforestry Systems* 57(3):173–186.

Pender, J, and B Gebremedhin. 2007. Determinants of agricultural and land management practices and impacts on crop production and household Income in the Highlands of Tigray, Ethiopia. *Journal of African Economies* 17(3):395–450.

Pender, J, P Jagger, E Nkonya, and D Sserunkuuma. 2004. Development pathways and land management in Uganda. *World Development* 32(5):767–792.

Pender, J, and J Kerr. 1998. Determinants of farmers' indigenous soil and water conservation investment in semi-arid India. *Agricultural Economics* 19:113–125.

Pender, JL. 1996. Discount rates and credit markets: Theory and evidence from rural India. *Journal of Development Economics* 50:257–296.

Pinckney, C, and PK Kimuyu. 1994. Land tenure reform in East Africa: good, bad or unimportant? *Journal of African Economies* 3(1):1–28.

Place, F, and K Otsuka. 2002. Land tenure systems and their impacts on productivity in Uganda. *Journal of Development Studies* 38(6):105–128.

Place, F, and B Swallow. 2000. *Assessing the Relationship between Property Rights and Technology Adoption in Smallholder Agriculture: A Review of Issues and Empirical Methods*. CAPRi Working Paper, volume 2. International Food Policy Research Institute, Washington, DC.

Place, F, and P Hazell. 1993. Productivity effects of indigenous land tenure systems in sub-Saharan Africa. *American Journal of Agricultural Economics* 75:10–19.

Reardon, T, and V Kelly. 1989. *Impact of Liquidity Sources on Chemical Fertilizer Use in Semi-Arid West Africa*. IFPRI, Washington, DC.

Reardon, T, and SA Vosti. 1995. Links between rural poverty and environment in developing countries: Asset categories and investment poverty. *World Development* 23:1495–1503.

Reardon, T, E Crawford, V Kelly, and B Diagana. 1996. *Promoting Farm Investment for Sustainable Intensification of African Agriculture*. Technical Paper No. 26, Department of Economics, Michigan State University, East Lansing, Michigan USA.

Reij, CP, and EMA Smaling. 2008. Analyzing successes in agriculture and land management in Sub-Saharan Africa: Is macro-level gloom obscuring positive micro-level change? *Land Use Policy* 25(3):410–420.

Reijntjes, C, B Haverkort, and A, Waters-Bayer. 1992. *Farming for the Future: An Introduction to Low-External Input and Sustainable Agriculture*. MacMillan Press, London.

Reilly, J, D Schimmelpfennig, and J Lewandrowski. 2000. Global, regional and local food production and trade in a changing environment, in *Climate change and Global Crop Productivity,* ed. KR Reddy and HF Hodges. CABI, New York.

Ribot, JC. 2002. *Democratic decentralization of natural resources: Institutionalizing popular practices*. World Resource Institute Report, World Resources Institute, Washington, DC.

Roth, M, J Cochrane J, and W Kisamba-Mugerwa. 1994. Tenure security, credit use, and farm investment in the Rujumbura pilot land registration scheme, Uganda, in, *Searching for Land Tenure Security in Africa*, ed. JW Bruce and S Migot-Adholla. Kendall/Hunt Publishing Co., Dubuque, Iowa USA.

Scialabba, N, and C Hattam. 2002. General concepts and issues in organic agriculture, in *Organic Agriculture, Environment and Food Security,* ed. N Scialabba and C Hattam. Environment and Natural Resources Series No. 4, Food and Agriculture Organization of the United Nations (FAO), Rome.

Shiferaw, B, J Okello, and RV Reddy. 2007. Adoption and adaptation of natural resource management innovations in smallholder agriculture: reflections on key lessons and best practices. *Environment, Development and Sustainability* 11(3):601–619.

Shiferaw, B, and S Holden. 2001. Farm-level benefits to investments for mitigating land degradation: empirical evidence for Ethiopia. *Environment and Development Economics* 6:336–359.

Shiferaw, B, and S Holden. 2000. Policy instruments for sustainable land management: the case of highland smallholders in Ethiopia. *Agricultural Economics* 22:217–232.

Shiferaw, B, and S Holden. 1998. Soil erosion and smallholders' conservation decisions in the Highlands of Ethiopia. *World Development* 27(4):739–752.

Sinebo, W. 2005. Trade off between yield increase and yield stability in three decades of barley breeding in a tropical highland environment. *Field Crops Research* 92:35–52.

Singh, AH, and D Byerlee. 1990. Relative variability in wheat yields across countries and over time. *Journal of Agricultural Economics* 41:23–32.

Sjaastad, SE, and DW Bromley. 1997. Indigenous land rights in sub-Saharan Africa: Appropriation, security and investment demand. *World Development* 25(4):549–562.

Smith, RE. 2004. Land tenure, fixed investment, and farm productivity: Evidence from Zambia's southern province. *World Development* 32(10):641–1661.

Spencer, DS. 1996. Infrastructure and technology constraints to agricultural development in the humid and sub-humid tropics of Africa. *African Development Review* 8(2):68–93.

Swinton, SM, and R Quiroz. 2003. Is poverty to blame for soil, pasture, and forest degradation in Peru Altiplano? *World Development* 31:1903–1919.

Tang, TT. 2009. Information asymmetry and firms' credit market access: Evidence from Moody's credit rating format refinement. *Journal of Financial Economics* 93(2):325–351.

Tenge, A, J De Graaff, and JP Hella. 2004. Social and economic factors affecting the adoption of soil and water conservation in West Usambara highlands, Tanzania. *Land Degradation and Development* 15(2):99–114.

Tiffen, M, M Mortimore, and F Gichuki. 1994. *More People, Less Erosion: Environmental Recovery in Kenya.* Wiley & Sons Ltd., Chichester. 311 p.

Tittonell, P, KD Shepherd, B Vanlauwe, and KE Giller. 2008. Unravelling the effects of soil and crop management on maize productivity in smallholder agricultural systems of western Kenya: An application of classification and regression tree analysis. *Agriculture, Ecosystems and Environment* 123:137–150.

Tschirley, DL, and R Benfica. 2001. Smallholder agriculture, wage labour and rural poverty alleviation in land-abundant areas of Africa: Evidence from Mozambique. *Journal of Modern African Studies* 39(2):333–358.

Vallaeys, G, P Silvestre, MJ Blackle, and CL Delgado. 1987. Development and Extension of Agricultural Production Technology, in *Accelerating Food Production in Sub-Saharan Africa*, ed. JW Mellor, CL Delgado, and MJ Blackie. John Hopkins University Press, Baltimore, Maryland USA.

Wale, E. 2008. A study on financial opportunity costs of growing local varieties of sorghum in Ethiopia: Implications for on-farm conservation policy. *Ecological Economics* 64:603–610.

Yirga, C. 2007. *The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia.* PhD dissertation. Department of Agricultural Economics, Extension, and Rural Development. University of Pretoria, South Africa.

Zainab, MS, and H Folmer. 2000. Household adoption behaviour of improved soil conservation: The case of the North Pare and West Usambara Mountains of Tanzania. *Land Use Policy* 17:321–336.