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Understanding determinants of farmers' investments in sustainable land management practices in Ethiopia: review and synthesis

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Abstract Although there has been several efforts made to reduce land degradation and improve land productivity in Ethiopia, farmers' investments in sustainable land management (SLM) remain limited. Nevertheless, the results regarding determinants of farmers' investments in SLM have been inconsistent and scattered. Moreover, these factors have not been reviewed and synthesized. Hence this paper reviews and synthesizes past research in order to identify determinants that affect farmers' investments in SLM practices and thereby facilitate policy prescriptions to enhance adoption in Ethiopia, East Africa and potentially wider afield. The review identifies several determinants that affect farmers' investments in SLM practices. These determinants are generally categorized into three groups. The first group is those factors that are related to farmers' capacity to invest in SLM practices. The results show that farmers' investments in SLM practices are limited by their limited capacity to invest in SLM. The second groups of factors are related to farmers' incentives for investments in SLM practices. Farmers' investments in SLM are limited due to restricted incentives from their investments related to land improvement. The third groups of factors are external factors beyond the control of farmers. The review also shows that farmers' capacities to invest in SLM and their incentives from investments have been influenced by external factors such as institutional support and policies. This suggests that creating enabling conditions for enhancing farmers' investment capacities in SLM and increasing the range of incentives from their investment is crucial to encourage wide-scale adoption of SLM practices.

Keywords Sustainable land management · Capacity to invest · Incentives to invest · Determinants · External factors · Motivation

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1 Introduction

Land degradation in the form of soil erosion and nutrient depletion has been major a national agenda and remains an important issues in Ethiopia because of its adverse impact on crop productivity, the environment, food security and the quality of life in general (Hurni 1996; Bewket and Sterk 2002; Kassie et al. 2009). Productivity impacts of soil erosion and nutrient depletion are due to a decline in soil fertility and moisture availability on-site where soil erosion and nutrient depletion occur (Stroosnijder 2009) and off-site where sediments are deposited (Pender and Gebremedhin 2007). As a result, vast areas of fertile lands in Ethiopia have become unproductive (Bewket and Sterk 2002; Kassie et al. 2009). As a response to these severe soil erosion and nutrient depletion, huge investments in sustainable land management (SLM) have been implemented since the 1980s in the country in collaboration with several donors (Berhe 1996; Shiferaw and Holden 1998; Admassie 2000; Beshah 2003). In this review we take SLM to mean a comprehensive set of land management practices, with the potential of making significant and lasting differences in the near future and over the long term in terms of reducing land degradation and improving land productivity (after Liniger et al. 2011).

In Ethiopia (the focus of this review), farmers' investments in SLM remain limited (Adimassu et al. 2012; Bewket 2007). An analysis of the determinants that influence farmers' investments in SLM would help to understand why farmers often refrain from investing in their land and to develop strategies to improve their investments in SLM. In order to identify determinants that affect farmers' investments in SLM, researchers typically select a number of potential independent variables for inclusion in their analysis based on prior theorization and test. Usually, logit, probit or tobit regression model was used to determine factors that affect farmers' investments in SLM practices (Adimassu et al. 2012; Amsalu and De Graaff 2007; Pender and Gebremedhin 2007). Many studies indicated that SLM investments were influenced by several socioeconomic characteristics of the household, biophysical characteristics of farm plots (Gebremedhin and Swinton 2003; Kessler 2006; Requier-Desjardins et al. 2011) and institutional factors (Shiferaw and Holden 2000; Shiferaw et al. 2009). At the household level, differences between farm households concerning social, economic and cultural characteristics lead to differences in how much households invest in SLM (Adimassu et al. 2012; Amsalu and De Graaff 2007). Similarly, differences in biophysical conditions between the study plots such as slope, soil fertility status and size of plots influenced farmers' choice of where to invest (Adimassu et al. 2012; Amsalu and De Graaff 2007). However, it is clear that the empirical records regarding these factors contain many ambiguities and inconsistent results. So, it is crucial to review and synthesize these inconsistent results and to ascertain whether there is a more discernible pattern among the variables typically included in a site-specific analysis of investments in SLM in Ethiopia.

Therefore, the main objective of this study is to investigate the major determinants of farmers' investments in SLM in Ethiopia based on a comprehensive review and further synthesis of previous research results.

2 Methodology

Sustainable land management (SLM) practices comprise of both technologies and approaches (Liniger et al. 2011). In this paper only SLM technologies are considered. The most important SLM technologies considered include stone bunds (level/graded), soil

bunds (level/graded), fanya juu (level/graded), tree planting, compost, farmyard manure (FYM), minimum tillage and contour plowing. Physical SLM practices such as stone and soil bunds were considered as practices with long-term economic benefits, while agronomic SLM practices such as application of compost and FYM were considered as practices with short-term economic benefits (Liniger et al. 2011). This is because physical SLM practices occupy and essentially remove considerable areas from the cultivable land which reduce the economic benefit (Adimassu et al. 2014). Electronic and hard copy literature sources were used to collect data on determinants of farmers' investments in SLM technologies. Several key words were used in searching electronic literatures. These include investments, adoption, determinants, factors, willingness to pay, acceptability, constraints, challenges, soil and water conservation, SLM, land management, stone bunds, soil bunds, fanya juu, rehabilitation, trees, Ethiopian highlands, food-for-work, productive safety net (PSN), effects, impacts, economics of SLM, Ethiopia, etc. Moreover, publications in hard copies were obtained from libraries of different institutions such as Ministry of Agriculture (MoA), World Food Programme (WFP), Water and Land Resource Center (WLRC) and Ethiopian Institute of Agricultural Research (EIAR).

To carry out the synthesis on the determinants of farmers' investments in SLM, a database was created containing 30 variables used in more than 90 peer reviewed articles using Microsoft Excel and SPSS. For each of the variables, the number of incidences where its coefficient was significantly negative or positive was recorded. All significant coefficients at 10, 5, and 1 % were considered as significant for this synthesis. Before summarizing and analyzing the explanatory variables that affect farmers' investments in SLM practices, it is necessary to present the description of each explanatory variable (Table 1). Of the variables, twenty-five were household characteristics, whereas only five were plot characteristics. The effects of these explanatory variables on farmers' investments in SLM were summarized and further grouped into similar categories.

3 Results and discussion

3.1 Characteristics of published results

This section presents the highlights of characteristics of the studies reviewed regarding determinants of SLM practices in Ethiopia. The average sample size in these published articles was 399 with a standard deviation of 455 (Table 2). The sample size ranged from 94 respondents to 2900 respondents.

Probit, logit and tobit models were the most important econometric techniques applied in most of the adoption literature (Table 2). Accordingly, 46, 30 and 21 % of the studies employed were probit, logit and Tobit regressions, respectively. Only 4 % of the studies applied other techniques such as Ordinary Least Square (OLS) regression and factor analysis (FA). In the studies reviewed, farmers' investments in land management were considered as a binary choice in logit and probit models. This means logit and probit models are more conservative than the other tobit models in identifying the factors that affects farmers' investments in land management. Logit and probit models are similar except in the distribution of the error term in which logit model assumes logistic distribution, while the probit model assumes standard normal distribution. Logit and probit models do not consider how much farmers actually invest on their land, and results from these models are similar. However, tobit model considers not only whether farmers invest

Table 1 Description of dependent and explanatory variables used in different studies to identify determinants of farmers' investments in SLM

Variables	Description
Dependent variable	
SLM investments	Investments in SLM practices by farmers (1 if he/she applied one or more of SLM practices in his/her plot (s) and 0 otherwise. In tobit models, how much do farmers invest could be included
Household-level explanatory variables	
AGE	Age of household head (years)
EDUC	Education of the household head (1 if the household head is educated and 0 otherwise)
EXPERI	Farming experience of the household head (years)
SEX	Sex of the household head (1 if the household head is male and 0 otherwise)
MARITAL	Marital status of the household head (1 if the household head is married and 0 otherwise
LANDSIZE	Total land size of the household (ha)
LAND/LAB	Land per economically active family member
LAND/CAPIT	Land per household members
FAMSIZE	The total number of family members in the family
ECOACT	The number of economically active family in the household
OFFFARMI	Access of the household head for off-farm income (1 if she/he had access and 0 otherwise)
CREDIT	Access to credit services (1 if perceived access to credit services and 0 otherwise)
TLU	The total livestock size in Tropical Livestock Unit (TLU)
TLU/ha	The total livestock size in Tropical Livestock Unit (TLU) per total land size of the family
OXEN	The number of oxen of a household in
MEMBSHIP	Membership in local institutions (1 and 0 otherwise)
RELATIVE	Number of relatives in nearby areas like in the Kebele
RADIO	Access of household head to information through radio (1 if she/he had a radio and 0 otherwise)
Aware-EROS	Perception of household head on soil erosion (1 if he/she perceived soil erosion as a problem and 0 otherwise
Aware-SLM	Awareness of household head on the importance of SLM practices (1 if he/she perceived that SLM practices are important and 0 otherwise
TENURE	Perceived land security of household head (1 if secured and 0 otherwise)
EXTENSI	Access to extension services (1 if perceived access to extension services and 0 otherwise)
ROADIS	Distance from home to main road in walking minutes
MARKDIS	Distance to nearby market in walking minute
TRAINING	Access of household head to training services (1 if she/he got training on SLM practices and 0 otherwise)
Plot-level explanatory variables	
PLOSIZ	The size of a plot (ha or timad): 1 ha = 4 timad
SLOP	Slope of plots (1 if a plot is perceived on steep slope and 0 otherwise)
FERTILIT	Fertility of plots (1 a plot is perceived as fertile and 0 otherwise)
PLODIS	The distance from home of household head to each plot (walking minutes)
PLOTNo.	Number of plots per household

Table 2 Characteristics of published studies regarding determinants of farmers' investments in sustainable land management in Ethiopia

Characteristics of studies	Quantity
Sample size, mean (SD)	399 (455)
Method of analysis (%)	
Probit regressions	45.6
Logit regressions	29.8
Tobit regressions	21.1
Others (OLS, FA)	3.5
Study regions (%)	
Tigray	36.8
Amhara	24.6
Oromia	19.3
SNNP	3.5
Mixed	15.9

or not on their plots but also how much do farmers invest on their land. Therefore, tobit models are more important to identify factors that affect how much do farmers invest in SLM on their plots. In terms of adoption of SLM practices by farmers, the logit and probit models identify factors that affect whether or not farmers invest in SLM practice on their plots, while tobit model identifies factors that affect farmers on how much farmers invest.

The geographical distribution of the studies reviewed is also shown in Table 2. Most of the studies were carried out in Tigray (37 %) and Amhara (25 %) regions of Ethiopia. This shows that the study is skewed to the North and North-western parts of the country where these two regions are located. This is mainly due to the fact that most SLM practices have been implemented in these two regions resulted from relatively severe land degradation (Berhe 1996; Hurni 1996). Moreover, these areas are characterized by rugged topography, highland altitude and relatively torrential rainfall.

3.2 Determinants of farmers' investments in sustainable land management: review

This section presents the review of factors that affect farmers' investments in SLM in Ethiopia at the household and plot levels.

3.2.1 Household-level determinants

Table 3 presents household-level determinants that affect farmers' investments at a household level in SLM. As shown in Table 3, twenty-five household-level factors have been identified as affecting, negatively or positively, farmers' investments in SLM practices. For example, the effect of age and farm experience of a farmer on investment in SLM practices can be either negative or positive, and older farmers (longer farm experience) were expected to have a positive effect on SLM investment because they have longer farming experience (Bekele and Drake 2003; Amsalu and De Graaff 2007). In contrast, younger farmers may have longer planning horizons and, hence, may be more likely to invest in SLM (Tiwari et al. 2008). Similar to age, the effect of education status of a farmer to invest in SLM is either positive or negative. This is because education increases farmers' ability to acquire, process and use information about the negative effect of soil erosion to

Table 3 Details of household-level determinants of farmers' investments in SLM in Ethiopia

SLM practices	Reference	AGE	EDUC	EXPERI	SEX	MARITAL	LANDSIZE	LAND/LAB	LAND/CAPIT	FAMSIZE	ECOACT	OFFFARMI	CREDIT	TLU	TLU/ha	OXEN	MEMBSHIP	RELATIVE	RADIO	Aware–EROS	Aware–SLM	TENURE	EXTENSI	ROADIS	MARKDIS	TRAINING
Stone bunds	Kassie et al. 2008a; Ketema and Bauer 2012	+	+		+		+			+		+		–			–			+			+		+	
Stone bunds	Amsalu and De Graaff 2007; Kassie et al. 2008b	+	+		+		+			–		–		–						+		–	–			
Stone bunds	Deininger and Jin 2006	–	+				–				+	–		+								–	+			
Stone bunds	Hagos and Holden 2006; Benin and Pender 2001; Gebremedhin and Swinton 2003	–	+		+		–			+	+	+	–	+	+					+	+	–	–	–	+	
Stone bunds	Gebremedhin et al. 2003; Beshir 2014	–	+		+		+					+	+	–						+		+	+	–	+	
Soil bunds	Anley et al. 2007; Beshir 2014; Gebremedhin et al. 2003	–	+		+		+	–				+		–						+		+	+	–	–	
Soil bunds	Hagos and Holden 2006	+	–		–		+			+		+	–	–	–					+		+				
Soil bunds	Shiferaw and Holden 1999	–	–				+		+	–		–		+		+				+		+				
Soil bunds	Tadesse and Belay 2004	–	–				+		+	–	+	–		+						+		+	+			
Soil bunds	Gebremedhin and Swinton 2003	–	–		–						+											+	–	–	–	
Soil/stone bunds	Gebregziabher et al. 2013; Birhanu and Meseret 2013; Enki et al. 2001; Tesfaye et al. 2014	–	+		+	+	+	+		+	+	–	+	–	+		+			+	+	+	+			+
Soil/stone bunds	Heyi and Mberengwa 2012; Heyi 2012; Teshome 2014	+	+		+		+			–	+		+	+		+				+		+	+			+
Soil/stone bunds	Mengstie 2009	+	+		–		–	–		–		+		+			–			+					+	–
Drainage ditch	Benin and Pende 2001																					+				
Gully treatment	Gebregziabher et al. 2013	–	+		+	–		–		+		–		+												
Mixed	Bekele and Drake 2003; Deressa et al. 2009	+	+	+	+		+			–	+	–	+	+				+		+			+			

Table 3 continued

SLM practices	Reference	AGE	EDUC	EXPERI	SEX	MARITAL	LANDSIZE	LAND/LAB	LAND/CAPIT	FAMSIZE	ECOACT	OFFFARMI	CREDIT	TLU	TLU/ha	OXEN	MEMBSHIP	RELATIVE	RADIO	Aware–EROS	Aware–SLM	TENURE	EXTENSI	ROADIS	MARKDIS	TRAINING
Mixed	Schmidt and Tadesse 2012;																									
	Wossen et al. 2013;																									
	Adimassu et al. 2012	–	+	+	–		+	+	+	+	+	–	+	+		+	–			+		–	+			+
Mixed	Asrat at al. 2004;																									
	Gebremariam and Edriss 2012;																									
	Yesuf and Kohlin 2009	–	+		+		+			+	+	+	+	+						+		+	+		+	
Compost/FYM	Pender and Gebremedhin 2007																									
	Pender et al 2007	–	+		+		–			–		–	+	+		+	+		+				–	–		
Compost/FYM	Pender and Gebremedhin 2006;																									
	Kassie et al. 2009;																									
	Bacha et al. 2001	–	+	+	–		–			–	+			+		+	+		–	+		+	+		+	
FYM	Heyi and Mberengwa 2012;																									
	Gebremedhin et al. 2003	+	+		+		+				+		+	+						+		+	+		–	+
FYM	Benin 2006	–	+		+		–			–	+		–	+		–										
FYM	Teklewold et al 2013	+	–		–								+	+			–						+		–	
Tree planting	Gebregziabher et al. 2013;																									
	Holden and Yohannes 2002;																									
	Mengstie 2009;																									
	Deininger and Jin 2006	–	+		+	–	+	+		+	+	+		+		+						+	+			
Tree planting	Benin and Pende 2001	+	+		+		+	+		+		+		+			–			+					+	+
Tree planting	Gebremedhin et al 2003		–				+															+			+	
Minimum tillage	Pender and Gebremedhin 2007	+	–		–		+			–		–	+	+					+				–			
Minimum tillage	Kassie et al. 2009	–	+		+		+				–			+			+			+		+	+		+	
Minimum tillage	Benin 2006	–	–		–		+			+	+		+	–		–										
Intercropping	Pender and Gebremedhin 2007	+	–		–		–			+		+	–	+					+				+			
Contour plowing	Pender and Gebremedhin 2007	+	–		+		–			+		–	+	+					–				+			

have a positive role in the decision to invest in SLM (Pender and Kerr 1998; Lapar and Ehui 2004; Pender and Gebremedhin 2007; Tiwari, et al. 2008). However, the negative effect is largely due to the fact that education increases a farmers' analytical capacity to calculate the costs and benefits of SLM investments and they do not invest if they think that it is not profitable. Moreover, education can create better access to off-farm employment that makes them reluctant to land related investments such as SLM.

Land holdings including total land size of households, land per economically active family members and land per capita can have either positive or negative effect on famers' investments in SLM practices. The positive effect is because of the fact that these factors are often correlated with the wealth that may help ease the needed financial constraint and the potential loss of land for conservation measures may not discourage investments on large farms (Kassie et al. 2008a, 2010; Beshir 2014). On the contrary, these factors are negatively correlated with farmers' investments in SLM practices. The negative correlation between land holdings and farmers' investments in SLM is because when land is more available farmers may not worry about land degradation and consequently may reduce their investment in land. Negative correlations between landholding and farmers' investments in SLM practices have been reported by previous research findings in Ethiopia (Gebremedhin and Swinton 2003; Hagos and Holden 2006; Pender and Gebremedhin 2006). In most of the studies, family size and economically active family members influenced farmers' investment in SLM practices positively (Clay et al. 1998; Gebremedhin and Swinton 2003; Pender and Gebremedhin 2007; Asrat et al. 2004). This is because most SLM practices (e.g., construction of bunds) are labor intensive to construct/maintain and hence households with large family labor can invest more in SLM practices (Pender and Gebremedhin 2007; Asrat et al. 2004). Moreover, the larger the family, the higher the probability that future generations will farm the land and use the future benefits of investment in SLM (Featherstone and Goodwin 1993).

Livestock holding such as livestock number per household, livestock number per hectare and number of oxen is generally considered to be an asset that could be used either in the production process or be exchanged for cash or other productive assets that help farmers' to invest in SLM practices. However, the effects of livestock holding on farmers' investments in SLM practices are inconsistent. This is because there are some farmers whose livelihoods depend on livestock production and do not want to invest in land improvement activities such as SLM.

3.2.2 Plot-level factors that affect farmers' investments in SLM

Table 4 presents the results of the review of plot-level determinants of farmers' investments in SLM. Only five major determinants affected farmers' investments in SLM practices in Ethiopia. Like household-level determinants, the effects of plot-level determinants on farmers' investments were inconsistent. The results show that plot size had positive correlation with farmers' investment in SLM. This is partly because most physical SLM practices take proportionally more space on small plots and the benefit from conservation on such plots may not be enough to compensate for the decline in production due to the loss in area devoted to conservation structures. Similarly, the result show that farmers invest more in physical SLM practices on plots with steep slopes, which have higher, more obvious erosion risks and rates of loss as compared to plots with gentle slope (Ervin and Ervin 1982; Shiferaw and Holden 1998; Mbaga-Semgalawe and Folmer 2000). Effects of fertility condition of plots, plot distance and number of plots on farmers' investments in SLM practices reviewed were inconsistent.

Table 4 Details of plot-level determinants of farmers' investments in SLM in Ethiopia

SLM practices	References	PLOSIZ	SLOP	FERTILIT	PLODIS	PLOTNo.
Stone bunds	Amsalu and De Graaff (2007)		+	−	+	
Stone bunds	Deininger and Jin (2006)					+
Stone bunds	Kassie et al. (2008a, b)		+	+		
Stone bunds	Beshir (2014), Ketema and Bauer (2012), Gebremedhin and Swinton (2003), Hagos and Holden (2006)	+	+	−	−	−
Soil bunds	Hagos and Holden (2006), Tadesse and Belay (2004), Anley et al. (2007), Gebremedhin and Swinton (2003), Beshir (2014), Shiferaw and Holden (1998)	+	+	−	−	
Soil/stone bunds	Birhanu and Meseret (2013), Teshome (2014), Mengstie (2009), Tesfaye et al. (2014), Enki et al. (2001)	+	+	−	−	
Mixed	Yesuf and Köhlin (2009), Bekele and Drake (2003), Asrat et al. (2004), Wossen et al. (2013), Schmidt and Tadesse (2012)	+	+	+	−	
Mixed	Adimassu et al. (2012)		+	+	+	
Compost/ FYM	Pender and Gebremedhin (2006), Pender and Gebremedhin (2007), Pender and Gebremedhin (2007)				−	
Compost	Kassie et al. (2009)		+	+	+	
FYM	Benin (2006), Teklewold et al. (2013)		−	+	−	
Tree planting	Deininger and Jin (2006)		−		+	+
Tree planting	Mengstie (2009)				−	
Minimum tillage	Pender and Gebremedhin (2007), Kassie et al. (2009), Benin (2006)		+	−	+	
Intercropping	Pender and Gebremedhin (2007)				−	
Contour plowing	Pender and Gebremedhin (2007)				−	

3.3 Determinants of farmers' investments in sustainable land management: synthesis

The review of the determinants of farmers' investments in SLM (Tables 3, 4) revealed that the empirical records contain a number of inconsistent results. To address this, an attempt is made to synthesize these inconsistent results and to ascertain whether there is a more distinct pattern among the variables typically included in a site-specific analysis of determinants of farmers' investments in SLM (Table 5). This was done by grouping all of the variables into categories which are more plausible for policy makers and a wider, non-

academic audience. As stated previously, most physical SLM practices were considered as investments for "long-term return," while agronomic SLM practices were considered as investments for "short-term returns." The rationale for this classification is that farmers' investments in different SLM practices depend on the how quick the return from their investments is (Shiferaw and Holden 2001).

Table 5 presents the frequency analysis of 30 variables that determine farmers' investments in SLM practices. Although the average effect of household and plot-level variables have similar trend for both long-term and short-term returns, there are some inconsistencies. For example, 87 % of the studies showed positive relation between land size and farmers investments in long-term SLM practices. However, 63 % of the studies showed negative relation between land size and farmers' investments for short-term return.

Generally, as opposed to the review in Tables 3 and 4, the results in Table 5 showed clearer pattern of effect of variables on farmers' investments in SLM. For example, the overall effect of variable related to landholding (LANDSIZE, LAND/LAB and LAND/LAB) shows that farmers with higher landholding invest more as compared to farmers with smaller landholding in both short and long-term investments. Similarly, labor availability (FAMSIZE, ECOACT) affects farmers' investments in land management implying that farmers with higher family labor invested more as compared to farmers with lower family labor.

Education and knowledge (EDU, EXPERI, Aware-EROS, Aware-SLM and RADIO) influenced farmers' investments in SLM positively. Similarly, factors related to financial capita (CREDIT, OFFFARMI, TLU, TLU/ha, OXEN) influenced farmers' investments in SLM positively. This implies farmers with higher financial capital invested more in SLM as compared to farmers with lower financial capital. Farmers with better institutional support (EXTENSI, TRAINING, ROADIS, and MARDIS) invest more in SLM practices than farmers with poor institutional services.

Although the results in Table 5 show greater clustering than seen in Tables 3 and 4, further analysis is required for simple presentation of these factors. Accordingly, farmers' investments in SLM are a direct function of two categories of variables: capacity to invest and incentives to invest. Farmers' capacities to invest in SLM and the incentives of investments are, in turn, affected by external factors/conditioners such as lack of institutional support and poor infrastructure. This is shown graphically in Fig. 1 and further discussed below.

3.3.1 Capacity to invest in SLM practices

As shown in Fig. 1, a farmers' capacity to invest in SLM depends on the household's landholdings, labor availability, knowledge and experience, social capital, physical capital and financial capital. Limited investment in SLM by farmers might be due to the fact that farmers' may not have enough landholding, knowledge/experience, social capital, physical capital and financial capital.

Landholding is the major source of wealth and livelihood in Ethiopia. The quantity and quality of land affect the types and intensity of investments which are technically feasible and profitable. Mostly, it has been hypothesized that farmers with larger plot and farm sizes are more capable of undertaking investments because they can spare land areas for terraces, for fallow, and for trees while putting larger portions of their lands under cultivation (Hayes et al. 1997; Asrat et al. 2004; Smith 2004). There are also empirical studies in other part of the world suggesting 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;

Table 5 The frequency analysis (%) of 30 variables that determine farmers' investments in SLM practices with long-term and short-term benefits in Ethiopia

Determinants of farmers investments in SLM	Long-term return (%)		Short-term return (%)		Mixed (%)		All (%)	
	(+)	(−)	(+)	(−)	(+)	(−)	(+)	(−)
Landholding								
LANDSIZE	87.0	13.0	37.5	62.5	100.0	0.0	78.4	21.6
LAND/LAB	50.0	50.0	–	–	100.0	0.0	55.6	44.4
LAND/CAPIT	100.0	0.0	–	–	100.0	0.0	100.0	0.0
Labor availability								
FAMSIZE	61.5	38.5	85.7	14.3	57.1	42.9	73	26.9
ECOACT	100.0	0.0	75.0	25.0	100.0	0.0	90.5	9.5
Knowledge/experience								
EDUC	80.0	20.0	66.7	33.3	100.0	0.0	80.4	19.6
EXPERI	–	–	66.7	33.3	100.0	0.0	83.3	16.7
AGE	34.6	65.4	40.0	60.0	33.3	66.7	35.6	64.4
SEX	82.4	17.6	63.6	36.4	71.4	28.6	74.3	25.7
Aware-EROS	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
Aware-SLM	100.0	0.0	–	–	–	–	100.0	0.0
RADIO	–	–	60.0	40.0	–	–	60.0	40.0
Social capital								
MARITAL	33.3	66.7	–	–	–	–	33.3	66.7
MEMBSHIP	25.0	75.0	75.0	25.0	0.0		44.4	55.6
RELATIVE	–	–	–	–	100.0	0.0	100.0	0.0
Financial capital								
CREDIT	60.0	40.0	62.5	37.5	100.0	0.0	72.2	27.8
OFFFARMI	54.5	45.5	66.7	33.3	50.0	50.0	55.2	44.8
TLU	57.1	42.9	88.9	11.1	100.0	0.0	72.2	27.8
TLU/ha	66.7	33.3	–	–	–	–	66.7	33.3
OXEN	100.0	0.0	60.0	40.0	100.0	0.0	77.8	22.2
Land tenure (TENURE)	90.0	10.0	100.0	0.0	75.0	75.0	89.7	10.3
Extension services (EXTENSI)	80.0	20.0	100.0	0.0	100.0	0.0	87.5	12.5
Training (TRAINING)	75.0	25.0	100.0	0.0	100.0	0.0	85.7	14.3
Infrastructure								
ROADIS	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
MARKDIS	66.7	33.3	66.7	33.3	33.3	66.7	64.3	35.7
Plot characteristics								
SLOP	92.3	7.7	33.3	66.7	100	0	85.7	14.3
PLODIS	15.4	84.6	42.9	57.1	66.7	33.3	30.4	69.6
PLOSIZ,	100.0	0.0	–	–	100	0	100.0	0.0
PLOTNo	66.7	33.3	–	–	–	–	66.7	33.3
FERTILIT	14.3	85.7	100.0	0.0	100	0	50.0	50.0

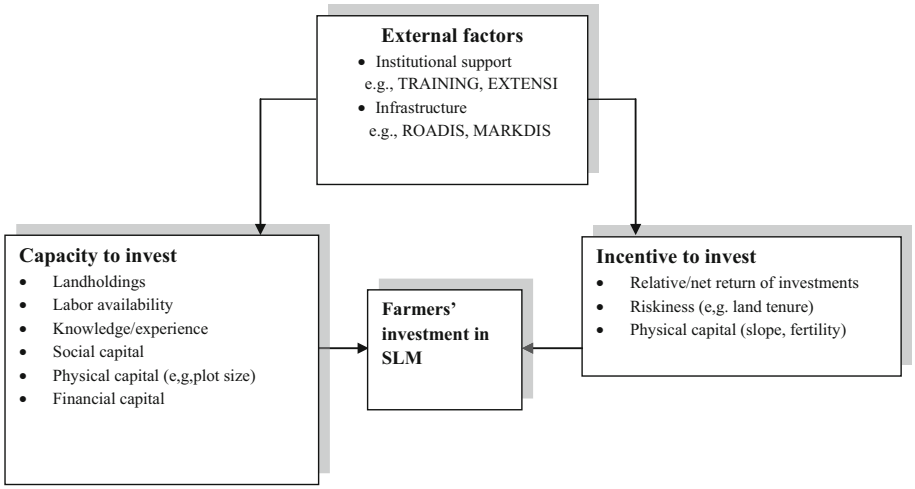

Fig. 1 Factors that affect farmers' investments in SLM in Ethiopia

Amsalu and De Graaff 2007; De Graaff et al. 2008). This is because farmers with more land can take more risks, including relatively high investment, if required, and survive crop failure due to pests, hailstones and excess rainfall (Nowak 1987; Reardon et al. 1996).

Labor availability in quantity and quality terms is critically important in land management. The quantity aspect of labor is important when considering labor as an input used in the labor-intensive land management activities such as construction of stone terrace. Empirical studies in Ethiopia and elsewhere have shown that large family size and economically active population have positive and significant effect in investment in labor-intensive land management practices (Pender and Kerr 1998; Mbaga-Semgalawe and Folmer 2000; Gebremedhin and Swinton 2003).

The quality of labor which includes the worker's education and technical knowledge are also important to the farmers' ability to make appropriate investment decisions (Smith 2004). The variable "education" has been included in many studies as a proxy for the capacity of the head of household to understand technical aspects related to land management (Jumbe and Angelsen 2007). In most of the studies, higher education levels are associated with more access to information on land degradation problem and improved land management measures (Swinton and Quiroz 2003; Sheikh et al. 2003). Education of the household head increased their ability to assess information, better understanding of the new technology and strengthened his/her analytical capabilities with new technology (Swinton and Quiroz 2003). Many authors report that education has a positive impact on farmers' investments in improved land management technology in general (Mbaga-Semgalawe and Folmer 2000; Lapar and Ehui 2004).

Physical capital to invest in land management practices includes infrastructure and physical characteristics of plots. Steeper plots are more susceptible to higher rates of erosion and increase the incentive to invest in land management and to adopt less erosive forms of land use (Clay et al. 1998). The greater the land degradation in a village, the more likely the resident farmers will be to invest in land management (Clay et al. 1998; Gebremedhin and Swinton 2003). Empirical studies reveal that distance from homesteads to farmers' fields

affect the type and intensity of land management investment in Ethiopia (Pender and Gebremedhin 2007; Pender et al. 2004; Gebremedhin and Swinton 2003). Studies have shown that farmers are more likely to invest in land management (e.g., application of compost/farm yard manure) on plots closer to their residence is partly due to the difficulty of transporting inputs to distant plots (Clay et al. 1998; Nkonya et al. 2004, 2005).

Financial capital consists of not only cash but also liquid assets such as livestock and crop sales that are used to finance an investment in land management. Livestock and crop sales, off-farm activities and credit are the main sources of cash for Ethiopian farmers (Pender and Gebremedhin 2007). Livestock husbandry is a boon to farm investments as it provides cash income (Hayes et al. 1997). Greater ownership of livestock is associated with greater use of beneficial land management practices, probably because income generated from livestock products helps farmers afford to buy inputs (Hayes et al. 1997; Pender and Gebremedhin 2007). Another financial capital is the availability of credit. Research on adoption of land management technologies indicates that there is a positive relationship between the level of adoption and the availability of credit in sub-Saharan Africa (Shiferaw and Holden 1999; Benin and Pender 2001; Pattanayak et al. 2003; Yirga 2007). Evidence from Zambia shows that farmers' investments in land management are small/minimal due to their limited social capital (Smith 2004; Ngombe et al. 2014).

Generally, this review suggests that farmers with better capacity in terms of landholding, experience, knowledge, social capital, physical capital and financial capital invest more as compared to other farmers with limited capacity in terms of these variables. This suggests that supporting farmers to improve their capacity to invest in SLM is crucial for adoption and sustainability of farmers' investments in SLM in Ethiopia.

3.3.2 Incentives to invest in SLM practices

The factors that affect farmers' incentives to invest in SLM are related to those conditions that affect the net/relative return of investments and riskiness of investments in SLM. Most farmers in Ethiopia are sensitive to net/relative return to their labor or financial investments in land. Usually, net/relative returns from labor and finance can be higher in non-farm business (e.g., casual labor, petty trading) relative to investments in long-term SLM practices.

Net return/profitability is one of the most important factors governing investments in land management (Ervin and Ervin 1982). If the costs of land management practices exceed the short-term and the long-term benefits, farmers have no incentive to adopt them (Napier et al. 1998). Net returns of a given investment depend on the yields 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, the greater the probability of a farmers' investment will be. In general, Ethiopian farmers are sensitive to net returns and implicitly compare the expected costs and benefits and then invest in options that offer highest net returns in terms of either income or reduced risk (Shiferaw et al. 2009). Their decision to invest in land management is affected by the (perceived) profitability of the technology (Kelly et al. 2003; Langyintuo and Dogbe 2005; Crook and Decker 2006). For instance, studies on the adoption and continuous use of stone terrace in Tanzania and Ethiopia revealed that farmers' investments are highly influenced by the (perceived) profitability of the technology (Tenge et al. 2004; Amsalu and De Graaff 2007; De Graaff et al. 2008). Similarly, a given investment may be profitable, yet not sufficiently attractive relative to alternative farm and non-farm investments to motivate farmers to invest. A number of authors have reported that the

availability of off-farm income has a negative impact on farmers' land management investment (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 2007). Two common reasons are given in the literature for the negative outcomes. The first reason is that household workers face higher opportunity costs and prefer to allocate family labor into 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 high season land management activities and reduces the labor available for land management practices.

Another important factor affecting farmers' incentives to invest in land management is risk. Climatic risk (e.g., rainfall) and risk of losing their property (e.g., land tenure) can affect farmers' investments in land. The importance of secure and transferable land rights has long been identified as a key element to bring about higher levels of long-term investment (Gebremedhin and Swinton 2003; Deininger and Jin 2006). Most empirical studies have shown that security of tenure is important for long-term investment and positively correlated with long-term land management practices (Shiferaw and Holden 1998; Gebremedhin et al. 1999; Gebremedhin and Swinton 2003; Otsuka et al. 2003; Asrat et al. 2004; Kabubo-Mariara 2007; Nyangena 2008). Moreover, the characteristics of physical capital such as the slope and fertility status of plots affect the farmers' investments because it determines the profitability of investments in SLM. For example, farmers' investments in more fertile soils may be profitable as compared to their investments in infertile soils. Farmers invest more in fertile plots than in infertile ones (Bekele and Drake 2003). This is because marginal productivity loss due to erosion from plots with fertile topsoil will be higher than those with less fertile topsoil and expected to give higher return in the short term. Generally, areas with good soil fertility and relatively abundant rainfall may have a good agricultural profit and farmer reinvest this profit in land management (Gebremedhin and Swinton 2003).

3.3.3 External factors/conditioners

External factors affect farmers' investments in SLM indirectly by influencing their capacities to invest in SLM and the incentives of their investments. External factors common to all households in a particular agro-climatic/policy context include institutional support (provisions of trainings, extension services, and technologies), policies (e.g., land tenure) and access to infrastructure (e.g., road, market) (Reardon and Vosti 1995). These factors could affect farmers' investments in SLM by either motivating or discouraging farmers' investments in SLM (Yirga 2007). Most of the factors under this category are beyond the control of farmers, and hence support from governmental and non-governmental institutions is vital for enhancing farmers' capacities to invest in SLM and their incentives from SLM investments.

The effectiveness of land management depends on how institutions can work together most efficiently to provide technical support to the farmers (Hoffmann et al. 2007). However, lack of transparency, accountability, capacity, access to information and networking are the main features of most institutions in sub-Saharan Africa (Ribot 2003). Most farmers in sub-Saharan Africa have insufficient access to markets because they are producing in remote areas and roads are bad or nonexistence (Bryceson 2002). The quality and quantity of roads affect transaction costs, risk and price fluctuations, and non-farm activities. Transport and communication infrastructure determines the availability of information, access to markets, and costs and returns of investments. Better access can

increase the labor and/or capital intensity of investment in land management by increasing output to input price ratios (Binswanger and McIntire 1987; Osbahr et al. 2008). Better access to roads and markets also promote higher income per capita, by providing greater economic opportunities to rural households and in turn investment in land management (Tiffen 2003). Poor infrastructure raises the prices of inputs and reduces the agricultural outputs which further diminish the profitability of the technology (Shiferaw et al. 2009). An increase in the price of agricultural products may make certain land management interventions profitable or attractive to farmers. Accordingly, some studies find a positive relation between the increase in the price of agricultural produce and adoption of land management technologies (Shiferaw and Holden 2000). However, in some cases better infrastructure may increase non-farm opportunities and thus reduce the intensity of land management (Grothmann and Patt 2005).

4 Conclusions and recommendation

This paper reviews and synthesizes past research in order to identify the determinants that affect farmers' investments in SLM practices/technologies in Ethiopia and thereby facilitate further evidence to evolve thinking and policy prescriptions to enhance adoption. The review has identified several determinants that affect farmers' investments in SLM practices. Generally, our review and synthesis identified three major factors for the limited investments in SLM by smallholder farmers in Ethiopia. Firstly, farmers' capacity to invest in SLM is very limited. Secondly, farmers' incentives from their investments in SLM practices are limited. Thirdly, there are insufficient enabling conditions for motivating farmers to invest in SLM practices/technologies.

Our review and synthesis indicates the need for improving farmers' capacity to invest in SLM. Different approaches such as provision of credit and training can be used to enhance farmers' capacities to invest in SLM. When farmers are poor and risk adverse, and SLM investments appear to have only long-term payoffs that are perceived as more uncertain than productivity or income diversification investments, SLM measures may be ranked quite low in the farmers' priorities. Hence increasing farmers' incentives to invest in SLM practices should be an important element for SLM in Ethiopia. One of the most important approaches to increase farmers' incentives to invest in SLM is to reduce risk related to long-term investments in land. Our synthesis has suggested that a proxy variable related to land tenure insecurity reduced farmers' investments in SLM practices with long-term economic benefits. This suggests the need to create stable and secure land tenure system in the country.

The review and synthesis showed that external factors such as policies, institutional support and infrastructure influenced farmers' capacities to invest in SLM and their incentives from SLM investments. This suggests there is a need to create enabling conditions to enhance their investment capacities in SLM practices and increase their economic incentives from SLM investments.

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