How farmers' characteristics influence spontaneous spreading of stone bunds in the highlands of Ethiopia: a case study in the Girar Jarso *woreda*

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Abstract

This study aims to identify key differences between farmers who spontaneously implement stone bunds (i.e. farmers implementing stone bunds by their own initiative) and farmers who do not. Data were collected in the Girar Jarso *woreda* in the central highlands of Ethiopia, through a household survey with 80 farmers: 40 with spontaneously implemented stone bunds and 40 without. Independent samples *t* test, principal component analysis and regression analysis were used to analyse the data. Results show that five key-factors explain differences between the two groups of farmers: (1) readiness to change, (2) available resources, (3) social capital, (4) type of family, and (5) commitment. These factors together explain 73% of the variance in the data set and show that particularly characteristics related to the farmer's intrinsic motivation play a crucial role to spontaneously implement and integrate stone bunds into the farming system. Furthermore, results show that young farmers are most committed to soil conservation: they are often intrinsically motivated dynamic farmers who are ready to change their future and improve productivity and food security. The study suggests that government extension programmes should therefore focus more on these young and dynamic farmers and foster their readiness to change. This implies that extension workers and government officials should better understand the crucial role of farmers' intrinsic motivation when dealing with sustainable land management, and also reformulate extension strategies and messages. This is particularly important when developing a scaling-up strategy that helps to sustainably increase agricultural production and achieve food security of small-holder farmers in Ethiopia.

Keywords Sustainable land management · Readiness to change · Intrinsic motivation · Social capital · Extension strategies

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1 Introduction

Increasing agricultural productivity and food security, while sustaining the production potential of available natural resources, is a real challenge in Ethiopia. Subsistence agricultural production is the main economic activity for the majority of the population living in the country (Amsalu and de Graaff 2006). However, land degradation in the form of soil erosion and soil nutrient decline is severely threatening agricultural production in the densely populated Ethiopian highlands (Sonneveld and Keyzer 2003; Amsalu et al. 2007; Adimassu and Kessler 2015). Soil erosion triggers loss of fertile top soil during heavy rainfall, especially on bare and unprotected farmlands and results in a long-term decline and seasonal shortages in household food production (Gebremichael et al. 2005; Haileslassie et al. 2005). However, there is evidence that improved production and productivity in the Ethiopian highlands is possible when sustainable land management (SLM) measures are applied to address soil erosion and soil loss (Kassie et al. 2010; Yimer 2015).

Over the last three decades, the Ethiopian government has been promoting and implementing SLM measures in collaboration with a consortia of donors to address soil erosion and to achieve food security (Kassie et al. 2010). These SLM measures, especially the larger (infra-) structural ones, have been promoted and implemented mainly through project and government extension programmes, based on community mass mobilization campaigns (Bewket 2007; Wolka 2014; Teshome et al. 2016a). Nevertheless, despite these considerable efforts made by the Ethiopian government to promote SLM, only a limited number of continued users have been reported (Amsalu and de Graaff 2007; Shiferaw et al. 2009; Kassie et al. 2010). Also, spontaneous implementation of structural SLM measures (e.g. through farmer-to-farmer learning) was only sparsely found in Ethiopia (Shiferaw et al. 2009).

However, in a study conducted in the central highlands of Ethiopia, Abi et al. (2018) found that some SLM measures, particularly stone bunds, were spontaneously implemented on some farmlands. Farmers doing this used their own family labour and knowledge, which was often obtained during their participation in the governmental mass mobilization campaigns. An interesting finding of this study was that such stone bunds were often constructed where they were most needed, for instance on erosion-prone farmlands and close to the farmer's homestead where more frequent monitoring and supervision are possible. Furthermore, these spontaneously implemented stone bunds were often well integrated with other measures to achieve visible results within a short-term period of time. This enhanced integration of the stone bunds evidences that these farmers are experimenting with SLM measures to make them more effective in controlling erosion and improving productivity (Amede et al. 2006). Moreover, following Napier (1991), the fact that such farmers are interested and willing to spontaneously implement stone bunds and integrate them into their farming system, will also motivate them to continue using these practices.

This study investigates farmers' characteristics, particularly those factors that drive individual farmers to spontaneously implement stone bunds integrated with other measures in the Girar Jarso *woreda*. In this *woreda*, we previously conducted research on the characteristics of spontaneous stone bunds (Abi et al. 2018) and analysed the location of farmlands, stone bunds usages and their effects to contribute to understand *where* and *why* the stone bunds spread spontaneously. The present study aims to identify the characteristics of spontaneous farmers, by whom stone bunds spread spontaneously, compared to non-spontaneous farmers to fill the gap. Spontaneous farmers are farmers who adopt and implement stone bunds by their own initiative using their own family labour and knowledge, and

knowledge obtained from somewhere else. Non-spontaneous farmers are farmers who have stone bunds on their farmland but these stone bunds were implemented through the mass mobilization campaign. The main research question is: what are the key-factors in household characteristics that explain why some farmers spontaneously implement stone bunds and other farmers do not? Furthermore, we hypothesize that spontaneous implementation of stone bunds is significantly related with at least one of these key-factors in household/farmer characteristics.

2 Theoretical background

In this study, we used theoretical insights about decision-making processes to help direct the key-factors that drive individual farmers to spontaneously adopt and implement SLM practices. In our case, decision-making is the mental process that leads to a choice of adoption or rejection of stone bunds (Rogers 2002). In his theory of innovation diffusion, Rogers (1995) suggests five stages through which an individual passes during the innovation decision-making process: (1) knowledge; (2) persuasion; (3) decision; (4) implementation; and (5) confirmation. An innovation is conceptualized as a new idea or practice (Meijer et al. 2015), and a new way of resolving problems (Napier 1991); e.g. the use of stone bunds to reduce soil loss.

The decision to adopt and implement technologies such as stone bunds begins with the farmers' perception of erosion as a problem (Ervin and Ervin 1982; Mbaga-Semgalawe and Folmer 2000; de Graaff et al. 2008). These perceptions are shaped by personal, economic, physical and institutional characteristics of farmers (Ervin and Ervin 1982; Meijer et al. 2015). Similarly, Rogers (1983) suggested three characteristics of decision-makers (farmers, in this case) that affect the innovation decision-making process: 1) the socio-economic characteristics, 2) the personality characteristics and (3) the communication behaviour. A wide range of factors therefore influence decisions, such as education, social status, wealth, motivation, behaviour, social bonds, contact with change agents, exposure to information sources (Rogers 1983).

Another theory relating to the decision-making process is the theory of planned behaviour (Ajzen 1991). This theory explains that an individual behaviour towards a technology is driven by the individual attitude, subjective norm and perceived behavioural control. According to Ajzen (1991), farmers tend to adopt a technology towards which they have a positive attitude, which on its turn is related to the farmers' perceived characteristics of a technology such as its relative advantage, compatibility and observability (Rogers 1995). Besides, the value that farmers give to farming also affects their attitude towards a new technology. For instance, a farmer who positively values farming as a way of life may be more willing to conserve the soil by using new technologies (Willock et al. 1999). Furthermore, perceived usefulness of a technology, social capital and perceived ease of implementation influence farmers' intention to adopt and implement a technology (Werner et al. 2017; Zeweld et al. 2017).

A final theory used in this paper is the theory of self-determination (Deci and Ryan 1985; Ryan and Deci 2017). In this theory, two types of motivations are considered: intrinsic motivation and extrinsic motivation (Ryan and Deci 2000a, b). The *intrinsic motivation* refers to doing an activity for the inherent satisfaction of the activity itself (internal self or self-determined), whereas *extrinsic motivation* refers to doing an activity driven by external coercions such as rewards, incentives or even punishments. The theory of

self-determination further suggests that extrinsically motivated actions can become self-determined once individuals identify with the value of an activity and acknowledge the importance of a behaviour; this is particularly important to willingly adopt the behaviour (Ryan and Deci 2000b; Gagné and Deci 2005). Hence, this theory has also important implications for this study that focuses on spontaneous adoption of SLM technologies which were initially promoted through a project or government support.

3 Methodology

3.1 Study area

This study was undertaken in the Girar Jarso *woreda* in the central Ethiopian highlands. The *woreda* is found in the North Shewa Zone of Oromia region at a distance of 112 km from Addis Ababa, the capital city of Ethiopia. The total area of the *woreda* is about 495 km². Elevation ranges between 1300 and 3400 m.a.s.l. The *woreda* encompasses 17 rural *kebele* and has a total population of 80,000 people (CSA 2013). Annual rainfall ranges between 800 mm and 1200 mm according to Fiche Station meteorological data. The main soil types found in the *woreda* are Vertisols (dominant soil types), Nitosols and Cambisols. Rain-fed mixed farming (crop production combined with livestock raising) is the main means of living for more than 90% of the population in the *woreda*. Farming in the *woreda* is characterized by low productivity due to severe erosion and poor soil fertility. Moreover, off-farm activities including petty trade and wage labour are important practices to supplement farmers' income in the *woreda*.

3.2 Method of data collection and sampling design

Data for this research were obtained from a survey conducted in three watersheds in Girar Jarso *woreda*: Gur watershed, Dhaka-Bora watershed and Tulu-Dimtu watershed (Fig. 1). The respective watersheds are 990 hectares, 570 hectares and 600 hectares in size. These watersheds were purposely selected, based on availability of stone bunds on the farmlands. Similarly, purposive sampling was used to select the study farmers. A household survey was conducted on 80 farmers to investigate the process of spontaneous spreading of stone bunds in these watersheds (see Abi et al. 2018). Of these 80 farmers, 40 are spontaneous farmers (SF) and 40 are non-spontaneous farmers (NSF). The distinction between SF and NSF was based on the way in which the stone bunds were implemented on the farmlands over a 5-year period (2010–2014). SF are farmers that have implemented stone bunds on their own initiative (i.e. intrinsic motivation), whereas NSF are farmers have only stone bunds that are implemented through mass mobilization campaigns (i.e. extrinsic motivation). The survey was carried out in November and December 2015 by using a structured questionnaire.

3.3 Description of variables

In the questionnaire, 32 possible factors that explain differences in farmers characteristics were included. These were obtained based on open interviews with farmers and cover factors such as “source of motivation to implement stone bunds”, “opinion concerning the

Fig. 1 Map of Ethiopia, Girar Jarso woreda and study watersheds

implemented stone bunds”, “ownership of stone bunds”, “responsibility to maintain implemented stone bunds”, “opinion about soil productivity and crop yields”, and “perception on Integrated Farm Management (IFM)”.

Table 1 presents a description of variables included in the study, which are related to the socio-cultural, economic and institutional characteristics of farmers. Among the variables included in the analysis, some of the more qualitative variables (“experience in IFM”, “social relations”, “motivation for stone bunds”, “perception of stone bunds”, “ownership of stone bunds”, “drive to improve” and “empowerment”) were measured using a 10 items for Likert-type scale. Farmers level of agreement or disagreement concerning the stated items was rated on a five-point scale basis (ranging from 1 = strongly disagree to 5 = strongly agree). Later, these factors were computed by averaging responses across the items. Also, for ease of statistical analysis, we grouped the five-point scale rating into a three-point scale (1 = disagree, 2 = neutral/undecided and 3 = agree). The remaining—often more quantitative—variables were measured based on the values as indicated in Table 1.

3.4 Data analysis

SPSS was used to process the collected data. First, an independent samples *t* test was performed to test whether there is a statistical significant difference between SF and NSF in relation to the different farmer/household characteristics included in the study. Statistical significance was tested at 1 and 5% probability levels. Then, a principal component analysis (PCA) was carried out to reduce the 32 factors into a smaller set of components. PCA is a statistical data reduction technique that helps to reduce a data set consisting of a large number of interrelated variables into a smaller set of components (Abdi and Williams

Table 1 Description of farmer/household characteristics

No.	Factors	Description	Values
<i>Socio-cultural characteristics</i>			
1.	Age	Age of the household head	(# of years)
2.	Education	Education level of the household head	(1 = illiterate, 2 = basic read and write, 3 = literate)
3.	Family size	Average number of family members in the household	(# of persons)
4.	Family labour	Available family labour for farming activities	(# of persons)
5.	Social position	Current social responsibility of the farmer in the community (e.g. development group leader)	(1 = no social position, 2 = have social position)
6.	Wealth status	Wealth status in the community	(1 = poor, 2 = intermediate, 3 = better-off)
7.	Knowledge about IFM	Farmers are well informed about Integrated Farm Management and soil management practices	(1 = no, 2 = yes)
8.	Experience in IFM	Farmers are practicing Integrated Farm Management on the farmland	(1 = disagree, 2 = neutral, 3 = agree)
9.	Planning	Farmers have an annual farm planning (including implementing/maintaining stone bunds)	(1 = no, 2 = yes)
10.	Field visit to check erosion	Number of farmland visits to recognize erosion problem and loss of soil	(1 = rarely, 2 = sometimes, 3 = often)
11.	Future prospects	Future prospects on improving agricultural productivity, food security and living condition	(1 = negative, 2 = do not know, 3 = positive)
12.	Social relations	Farmers have good relations of trust with farmers, extension workers and government officials	(1 = disagree, 2 = neutral, 3 = agree)
13.	Perception of stone bunds	Farmers have a positive perception towards stone bunds (their suitability, importance, profitability, and effects on productivity)	(1 = disagree, 2 = neutral, 3 = agree)
14.	Ownership of stone bunds	Farmers feel a responsibility to protect and maintain stone bunds implemented on their farmland	(1 = disagree, 2 = neutral, 3 = agree)
15.	Motivation for stone bunds	Farmers are motivated to implement stone bunds on their farmland (work motivation)	(1 = disagree, 2 = neutral, 3 = agree)
16.	Drive to improve	Farmers have interest to use improved technologies, seek technical advice, and teach other farmers	(1 = disagree, 2 = neutral, 3 = agree)
<i>Economic characteristics</i>			
17.	Farmland	Size of the cropland cultivated	(Hectare)
18.	Crop yield	Annual crop yield produced	(Quintal/year)

Table 1 (continued)

No.	Factors	Description	Values
19.	Income from crop products	Total amount of income obtained from sale of crop products per year	(Birr/year)
20.	Farm oxen	Number of farm oxen owned	(Number)
21.	Livestock size	Livestock size owned	(TLU)
22.	Income from livestock	Total amount of income obtained from sale of livestock and products	(Birr/year)
23.	Income from off-farm	Total amount of income obtained from off-farm activities	(Birr/year)
24.	Tools owned	Number of farm tools owned	(Number)
<i>Institutional characteristics</i>			
25.	Extension category	Category or classification of the farmer in terms of extension service uses	(1 = non-model farmer, 2 = model)
26.	Extension contacts	Number of contacts with Development Agents (DA)	(1 = rarely, 2 = sometimes, 3 = often)
27.	Participation	Farmer's active participation in local community organizations and SWC training programs	(1 = low, 2 = medium, 3 = high)
28.	Empowerment	Farmer feels to have the ability to make decision on his/her own farmland during the campaign works	(1 = disagree, 2 = neutral, 3 = agree)
29.	Support/assistance	Farmer obtained technical assistance and material support to execute soil conservation practices	(1 = no, 2 = yes)
30.	Land tenure security	Farmer feels secured to use and transfer farm plots	(1 = not secured, 2 = feel secured)
31.	Credit	Access to credit for soil management	(1 = no, 2 = yes)
32.	Market	Access to local market to sell crop products produced	(1 = no, 2 = yes)
TLU tropical livestock unit			

2010; O'Rourke and Hatcher 2013). It is also used for transforming a set of related variables into a set of unrelated variables that account for decreasing proportions of the variation of the original observations (Everitt 2004; Field 2009).

A varimax orthogonal rotation was used to obtain a rotated component matrix that facilitates the interpretation of the factors. In this rotated component matrix, factor loadings for each of the variables were obtained. Variables with factor loadings less than 0.40 were omitted to improve the clarity of factors in the new components, i.e. variables with factors loadings 0.4 and more were retained for analysis. Kaiser's criterion (the eigenvalue rule) was used to determine the number of factors retained. Based on this rule, factors with an eigenvalue of 1.0 and more were retained to run the final analysis. In addition, the eigenvalue helped to determine the amount of the total variance explained by that factor. Bartlett's test of sphericity was also used to determine whether the relations between the variables were large enough for PCA. Factor scores were generated by the PCA and new factors extracted which were denominated "farmer factors" according to the set of variables they encompassed.

Finally, a multiple linear regression analysis was applied to test the strength of the relationship between the spontaneous implementation (dependent variable) and the "farmer factors" (independent variables). Key-factors among the "farmer factors" are those that show a significant correlation at 1 and 5% probability level. In addition, following Field (2009) and Ashoori et al. (2016), beta values are used to determine the relative importance of these key-factors in explaining the spontaneous implementation of stone bunds.

4 Results and discussion

4.1 Farmer socio-cultural characteristics

Descriptive statistics was used firstly to determine differences between spontaneous farmers (SF) and non-spontaneous farmers (NSF) in relation to the socio-cultural characteristics included in the study. The mean comparison between the two groups of farmers showed a statistically significant difference in many factors at 1% probability level as well as some at 5% probability level. The socio-cultural results (Table 2) indicate that SF are generally younger farmers who have a better level of education and a more social responsibility in the community as compared to the NSF. The mean age was 43 years for SF and 55 years for NSF. However, in terms of wealth status, a majority of SF were intermediate, while the majority of NSF was better-off. Similarly, Lalani et al. (2016) found that poor farmers have highest intentions to use conservation agriculture. Similarly, SF have a smaller family size (5 persons) and relatively a lower available family labour for farming activities (4 persons) compared to the NSF.

As shown in Table 2, the SF also visit their farmlands more frequently than the NSF. This enables SF to recognize erosion problems more easily and hence implement erosion control measures by their own initiative. Moreover, compared with the NSF, SF are farmers with better knowledge as well as experience in IFM. This was also observed in a previous study that showed that spontaneously implemented stone bunds were more integrated with compost and manure use to produce high yields and sufficient crop residues for livestock feeds (Abi et al. 2018). Results also indicate that SF have a better farm planning and more positive future prospects to change and to make improvements in their household food security and living condition and therefore have a longer planning horizon than the

Table 2 Socio-cultural characteristics of study farmers

No.	Factors	SF (N=40)		NSF (N=40)		<i>t</i> test
		Mean	SD	Mean	SD	
1.	Age	43.03	12.53	55.45	12.82	0.000**
2.	Family size	5.33	2.35	8.25	1.78	0.000**
3.	Family labour	3.53	1.69	5.50	1.63	0.000**
4.	Education	2.10	0.84	1.4	0.59	0.000**
5.	Social position	1.63	0.49	1.28	0.45	0.001**
6.	Wealth status	2.03	0.83	2.73	0.51	0.000**
7.	Knowledge about IFM	1.95	0.22	1.78	0.42	0.024*
8.	Experience in IFM	2.73	0.68	2.13	0.88	0.001**
9.	Field visits to check erosion	2.60	0.55	2.23	0.62	0.005**
10.	Planning	1.73	0.45	1.35	0.48	0.001**
11.	Future prospects	2.73	0.45	2.03	0.58	0.000**
12.	Social relations	2.68	0.57	2.05	0.88	0.000**
13.	Motivation for stone bunds	2.60	0.78	1.68	0.79	0.000**
14.	Perception of stone bunds	2.73	0.55	2.30	0.76	0.005**
15.	Ownership of stone bunds	3.00	0.00	2.20	0.76	0.000**
16.	Drive to improve	2.70	0.56	1.98	0.86	0.000**

***p* value significant at 0.01; **p* value significant at 0.05

NSF. This result is in line with findings by Lapar and Pandey (1999), Bekele and Drake (2003) and Adimassu et al. (2012) that young farmers have more long-term visions and are more likely to invest in conservation measures.

Furthermore, compared to the NSF, SF are farmers who have a better drive to improve: who like to use improved technologies to improve production and protect productivity of their farmlands at the same time, and who teach other farmers about new technologies. Accordingly, SF had better relations of trust with neighbouring farmers, extension workers and government officials. Regarding the motivation to implement stone bunds on the farmland, work motivation for stone bunds is higher among SF than among NSF (Table 2). Work motivation is directly related to the perception that farmers have on implemented stone bunds. Results also show that SF have a more positive perception of stone bunds than the NSF, which is of course due to the experienced positive effects of stone bunds on soil erosion, soil productivity and crop yields (Abi et al. 2018). Not surprisingly, results also show that SF have a better sense of ownership and responsibility to protect and maintain implemented stone bunds than NSF.

4.2 Farmer economic characteristics

Table 3 presents the results of descriptive statistics when comparing SF and NSF in relation to the household's economic characteristics. Statistical test (*t* test) shows that there are significant differences between SF and NSF in relation to farm size, crop yield, income from crop products and livestock size at 1% probability level, while in income from off-farm activities a statistical significant difference at 5% probability level was found.

Table 3 Economic characteristics of study farmers

No.	Factors	SF (N=40)		NSF (N=40)		t test
		Mean	SD	Mean	SD	
1.	Farm size	2.19	1.11	3.35	0.94	0.000**
2.	Crop yield	27.65	12.78	46.38	14.72	0.000**
3.	Income from crop products	6097.50	2555.81	14,047.5	4947.31	0.000**
4.	Farm oxen	1.92	0.37	1.95	0.52	0.771
5.	Livestock size	4.13	1.62	5.88	1.38	0.000**
6.	Income from livestock	2445	4305.52	3147.50	2763.64	0.388
7.	Income from off-farm activities	706.73	512.06	428.82	250.69	0.023*
8.	Tools owned	3.46	1.04	2.67	1.79	0.077

***p* value significant at 0.01; **p* value significant at 0.05

As can be seen from Table 3, the mean size of cultivated farmland was 2.19 ha for SF and 3.35 ha for NSF. However, most surprisingly, SF produced on average 21.65 quintal of crop products per year, while NSF produced on average 46.38 quintal. This large difference in yield production is due to the size of farmland and type of crop products produced. Moreover, the mean income obtained from the sale of crop products was lower for the SF than for the NSF. The possible reason for this difference is the fact that SF used most of their produced crop products for their own consumption. According to the Central Statistical Agency (CSA) of Ethiopia, farmers utilize large amounts of their crop products for their own consumption leaving little for selling. CSA (2016) indicates that in general about 66% of cereal crop products produced are used for self-consumption and only about 17% for sale on the market.

The number of farm oxen owned by the farmers in this study was more or less equal among the SF and the NSF. However, the total number of livestock they held, measured in TLU, was 4.13 for SF and 5.88 for NSF. In addition, the SF obtained a smaller income from selling livestock and livestock products than the NSF. On the other hand, the SF obtained a higher income from off-farm activities than the NSF, which helps SF to compensate the limited income they obtain from selling crop and livestock products. A high income from off-farm activities also improves farmers economic status (Enki et al. 2001). Although not significant, the mean number of farm tools owned was 3.46 for SF and 2.67 for NSF.

4.3 Farmer institutional characteristics

Table 4 compares the institutional characteristics of SF and NSF. Except for access to market, descriptive results show significant differences between the two groups of farmers in relation to all the institutional characteristics included in the analysis at 1 and 5% probability level (Table 4). Important, SF often are model farmers who have more frequent contact with extension workers than the NSF. Model farmers are farmers who are using more than 70% of the agricultural technologies provided through the extension services (FDRE 2010; Tefera et al. 2016). Also, a majority of SF actively participate in local community organizations and SWC trainings and obtain more technical support from extension workers more than the NSF. Contrary to the NSF, the majority of SF had access to credit services. SF are, however, less secured to use and transfer their farmland than the NSF, given

Table 4 Institutional characteristics of study farmers

No.	Factors	SF (<i>N</i> =40)		NSF (<i>N</i> =40)		<i>t</i> test
		Mean	SD	Mean	SD	
1.	Extension category	1.63	0.49	1.28	0.45	0.001**
2.	Extension contacts	2.20	0.91	1.30	0.72	0.000**
3.	Participation	2.63	0.63	1.68	0.89	0.000**
4.	Support/assistance	1.83	0.39	1.63	0.49	0.046*
5.	Credit	1.70	0.46	1.38	0.49	0.003**
6.	Land tenure security	1.58	0.50	1.85	0.36	0.006**
7.	Market	1.83	0.39	1.78	0.42	0.582
8.	Empowerment	1.13	0.34	1.00	0.00	0.023*

***p* value significant at 0.01; **p* value significant at 0.05

that SF are younger farmers and therefore rarely obtain their farmlands through formal land distribution.

Another important factor is farmers' decision-making ability (empowerment) on their own farmlands, especially during the campaign works. Empowerment infers that the decision-making process to manage and protect farmlands from erosion is decentralized to the farmer level (Van den Berg and Jiggins 2007). An implication is that farmers participate in the selection of SLM technologies suitable for their farmlands and decide where to implement them, even during the mass mobilization campaign. However, results show that only very few SF take decisions on their farmlands during the campaign works (Table 4). This is in line with findings by Snyder et al. (2014) that farmers decision-making ability in relation to land management intervention is limited in Ethiopia.

Generally, as can be seen from Tables 2, 3 and 4, descriptive statistics showed a significant difference between the SF and NSF in many factors included in the analysis. Based on these factors, it is really difficult to identify the key-factors that explain differences in farmers characteristics. Therefore, in the next section, PCA is applied to reduce the number of factors into a smaller set of principal components to help identify those key-factors.

4.4 Key differences between farmers: PCA

PCA was performed on the 26 of the original 32 variables to identify key differences between farmers who spontaneously implemented stone bunds and those that did not. Six variables were discarded due to factor loadings less than 0.4. The Kaiser–Meyer–Olkin (KMO) measure verified the goodness-of-fit of the variables for the analysis with a KMO equal to 0.843, which is “great”, according to Field (2009). Bartlett's test of sphericity ($\chi^2=1859.933$, $df=325$ and p value=0.000) indicated that relations between variables were sufficiently large for PCA. After PCA, five factors with eigenvalues higher than 1 were extracted. These factors explained about 73% of the variance in farmer's socio-cultural, economic and institutional characteristics (Table 5).

The first factor (factor 1) comprises seven socio-cultural factors: drive to improve, farm planning, perception of stone bunds, motivation for stone bunds, education level, social position and ownership of stone bunds. This factor is related to a farmer's personal characteristics and behaviour (especially farmer's willingness and motivation to change and improve) but also to positive experiences with stone bunds. This first

Table 5 Rotated component matrix

Farmer characteristics	Farmer factors				
	Factor 1, readiness to change	Factor 2, available resources	Factor 3, social capital	Factor 4, type of family	Factor 5, commitment
Drive to improve	0.883				
Farm planning	0.847				
Perception of stone bunds	0.843				
Motivation for stone bunds	0.810				
Education level	0.723				
Social position	0.716				
Ownership of stone bunds	0.411				
Crop yield produced		0.909			
Total Farm size		0.850			
Income from crop products		0.837			
Wealth status		0.767			
Livestock size		0.676			
Support and assistance			0.844		
Extension category			0.752		
Participation			0.679		
Credit services			0.622		
Social relations			0.599		
Experience in IFM			0.593		
Extension contacts			0.579		
Family labour				0.779	
Land tenure security				0.755	
Age of HH				0.747	
Family size				0.731	
Field visits to check erosion					0.830
Future prospects					0.720
Knowledge about IFM					0.430
Explained variance (%)	41.43	13.12	7.44	6.20	4.72

Only factor loadings over 0.40 are presented

factor is denominated *Readiness to change*. The PCA indicates that readiness to change explains most of the variance in farmer's characteristics (41%), which is much higher than the other factors.

Factor 2 comprises four economic factors (crop yield produced, farm size, income from crop products and size of livestock owned) and wealth status. These factors are directly related to household resource endowments and asset accumulation, and hence denominated *Available resources*. The third factor (factor 3) comprises five institutional factors (institutional support and assistance, use of extension services, participation in local organizations, use of credit services and number of contacts with extension workers), and two socio-cultural factors (social relations and experience in IFM). These factors relate to farmer's social networks and connectedness with other farmers and extension workers. Therefore, factor 3 is referred to as *Social capital*.

Factor 4 comprises three socio-cultural factors (age of head of household, family size and available family labour) and one institutional factor (land tenure security). This fourth factor relates to the farmer's demographic condition and land tenure rights. This factor is therefore denominated *Type of family*. The final factor (factor 5) comprises three socio-cultural factors: number of field visits to check erosion, future prospects and knowledge about IFM. This factor shows the commitment a farmer has to improve his/her living condition using his/her own knowledge and his/her connectedness with his/her farmlands. Therefore, this component is referred to as *Commitment*.

In order to identify one or more key-factors in household characteristics that explain why some farmers spontaneously implement stone bunds and others do not, a regression analysis was performed with the extracted scores (farmer factors). Table 6 presents the results of the regression analysis for each factor. Spontaneous implementation of stone bunds is significantly related with all five farmer factors included in regression analysis at 1 and 5% probability level. Thus, all these key-factors explain differences between the two groups of farmers (SF vs NSF).

Results show that three key-factors (readiness to change, social capital and commitment) are positively related to spontaneous implementation of stone bunds, whereas the available resources and family type are negatively related. In terms of their relative importance, based on the results of beta values, available resources are the most important factor in explaining the spontaneous implementation of stone bunds followed by social capital, readiness to change and commitment (Table 6). Type of family has relatively low importance. Furthermore, the regression model predicts that 56% ($R^2=0.561$) of the variation in spontaneous implementation of stone bunds is explained by these five key-factors.

The negative relation between the first key-factor (available resources) and the spontaneous implementation of stone bunds implies that farmers with limited resources are more likely to spontaneously implement stone bunds. This is due to the fact that farmers with limited resource endowments and asset accumulation are more likely to invest in land management measures such as stone bunds in order to improve the productivity of their limited soil resources and to cover their food security condition (Adimassu et al. 2012; Nyanga et al. 2016). Consistently, the economic characteristics of the farmers in this study indicate that farmers who spontaneously implement stone bunds were farmers with relatively limited productive resources such as farmland, labour and livestock. These farmers are more enthusiastic to improve their agricultural production and productivity by conserving their soil using stone bunds and integrate them with more compost and manure (Abi et al. 2018).

Table 6 Results of regression analysis of farmer factors with spontaneous implementation

Farmer factors	Unstandardized coefficient		Standardized coefficient	<i>t</i>	<i>p</i> value
	β	SE	β		
Readiness to change	0.130	0.039	0.246	3.110	0.003**
Available resources	-0.279	0.039	-0.533	-6.733	0.000**
Social capital	0.167	0.039	0.317	4.004	0.000**
Type of family	-0.078	0.039	-0.192	-2.423	0.018*
Commitment	0.116	0.039	0.231	2.911	0.005**

Model summary: $R=0.749$; $R^2=0.561$; adjusted $R^2=0.531$; SE of the estimate=0.344

***p* value significant at 0.01; **p* value significant at 0.05

Therefore, in order to convince farmers with higher available resources (farmland, livestock, labour, wealth, etc.) to spontaneously implement and integrate SLM practices into their farming system, the government extension programme must pay more attention to awareness raising and learning from each other. In a previous study, we found that knowledge about stone bunds came from the neighbouring farmers (Abi et al. 2018), implying that the role of farmer-to-farmer learning in spontaneous adoption and implementation was important. Likewise, as the need to implement stone bunds is lower for the better-off farmers, awareness raising focused on sustainability issues and planning with a longer-term vision is essential for this group of farmers.

Social capital is the second most important key-factor that significantly and positively explains spontaneous implementation of stone bunds, suggesting that farmers who have a better social network and connectedness with other farmers and extension workers are more likely to implement stone bunds by their own initiative. This result is in line with findings by Adimassu et al. (2012), Nyanga et al. (2016) and Teshome et al. (2016b) that farmers with more social capital invest more in SLM practices. Interesting from this PCA is that support and assistance score high in the social capital factor. This is due to the fact that a majority of SF are model farmers and had better contacts with extension workers. Model farmers have a greater chance to be involved in practical trainings and often obtained more technical support from extension workers than other farmers. As a result, such farmers are better prepared and interested to implement new agricultural technologies including stone bunds on their farmlands. Adesina and Zinnah (1993) indicated that better contact with extension workers affects the intensity of stone bunds use because this exposes farmers to available information. Particularly, a better contact with extension workers, active participation in extension programme and strong social relation demonstrate how much SF benefitted from bridging social capital. This type of social capital provides a means for farmers to access a wider information network, technical support and resources (Leonard 2004; Cramb 2005; Sanginga et al. 2010). Similarly, farmers with more experience in IFM are more aware to spontaneously implement stone bunds integrated with more fertilizer, compost and manure using knowledge obtained from different sources. Simultaneously, for farmers who cannot afford to buy chemical fertilizer, access to credit service is important. This is the case of the SF with a lower wealth status, who actively seek for access to credit service to buy fertilizer.

The third most important key-factor that significantly and positively explains spontaneous implementation is readiness to change. In this key-factor, a majority of variables explaining the individual motivational characteristics of farmers who spontaneously implement stone bunds are included, such as drive to improve and motivation or willingness to use stone bunds. This implies that farmers who are willing and motivated to change and improve (dynamic farmers) are more likely to spontaneously implement stone bunds. This result is consistent with the findings by Kessler (2006) that dynamic farmers invest more in SWC practices. Following Kessler (2006), Quinn and Burbach (2010), Kessler et al. (2016) and Ryan and Deci (2017), farmers' willingness and interest can be considered as a sign of intrinsic motivation, suggesting that farmers who implement stone bunds by their own initiative are more intrinsically motivated farmers.

According to Napier (1991), when farmers are already intrinsically motivated to implement erosion control measures, such as stone bunds, they are also more willing to continue using it. Equally important is farmers' perception towards implemented stone bunds, particularly when trying to understand whether farmers are prepared to continue using them (de Graaff et al. 2008). Result of this study show a big difference between the two groups of farmers, with SF having a more positive perception towards implemented stone bunds

on their land. This result is in line with findings in other parts of Ethiopia where a more positive perception towards implemented conservation measures has significant effects on its sustainable use (Shiferaw and Holden 1998; Amsalu and de Graaff 2007). Other important characteristics in the key-factor "Readiness to change" are farm planning, motivation for stone bunds and education. Results imply that farmers with a high education level have a better farm planning and motivation to make progress in their farming activities, suggesting the importance of educating farmers to enhance their capacity to plan their farming activities, also to become motivated to implement stone bunds on their farmlands.

Commitment is the fourth key-factor explaining differences in farmer characteristics. The positive relation between commitment and spontaneous implementation of stone bunds suggests that farmers who are more dedicated to improve their living conditions are more likely to spontaneously implement stone bunds. According to Ryan and Deci (2017), commitment reflects intrinsic motivation, implying that farmers who are committed to improve their living conditions using stone bunds are intrinsically motivated farmers. Results of the PCA also show that the number of farm visits scores high in this key-factor, indicating that farmers who spontaneously implement stone bunds have higher connectedness with their farmland. Farm visiting is important to understand the severity of erosion problems on the farmlands (Amsalu and de Graaff 2006). For instance, rills or gullies formed due to erosion could be discovered through frequent farm visiting and hence enable farmers to perceive the extent of erosion problems on their farmlands (de Graaff et al. 2008). These perceived erosion problems drive farmers to become motivated to practice SLM technology on their own initiative (Prager and Posthumus 2010). Again, statistical results show that SF had better positive future prospects than the NSF. A possible explanation for the observed differences is the higher awareness about erosion effects on the future productivity of farmlands and better knowledge about IFM among SF compared with the NSF.

The fifth key-factor, explaining differences in farmers' characteristics, is the type of family. This key-factor has negative relation with spontaneous implementation of stone bunds. This implies that families which have high available family labour and secure land rights are more likely to implement stone bunds by themselves. Consistently, it is also reported in many studies (for instance, Bodnar and De Graaff 2003; Sietz and Van Dijk 2015) that when a farmer has a large number of economically active family members, they are more able to construct stone bunds on their farmland using their own family labour. However, our results do not support these findings; SF have lower family labour than the NSF. A possible explanation is that SF are young farmers with better education level, and hence better know-how to make use of available labour resources and their social capital. Land tenure security in this research has also a quite particular effect on the implementation of stone bunds. It is often argued that farmers' decisions to invest in SLM activities as well as their choice and implementation of practices are affected by tenure security (Gebremedhin and Swinton 2003; Teshome et al. 2016c). Likewise, Adimassu et al. (2016) considered land tenure security to be an incentive to continue land use management practices. However, results of this study do not support the previous findings. SF were less secure in their land tenure than NSF, but more likely to continue using implemented stone bunds. This may be explained by the more positive perception of stone bunds that SF have and their higher commitment to soil conservation.

Age of farmer is also an important factor in the "Type of family", implying that older farmers are less likely to spontaneously implement stone bunds on their farmlands. Statistical results show that SF were younger compared with NSF. Comparable to this study, Mbaga-Semgalawe and Folmer (2000) found in Tanzania that old farmers are less interested in constructing labour intensive conservation technologies such as bench terraces

and rock walls. Not only are young farmers more energetic and able to implement labour intensive technology by their own initiative, but Kassahun (2006) also disclosed that young farmers are more “optimistic”, therefore more willing or eager to use land management measures than other farmers.

5 Conclusions and recommendations

The aim of this study was to identify key differences in household characteristics between farmers who spontaneously implement stone bunds and farmers who did not in the Girar Jarso *woreda*. The results of PCA and regression analysis have identified five key-factors explaining differences in household characteristics. Most interesting result was that three key-factors (social capital, readiness to change and commitment) are positively related to the spontaneous implementation of stone bunds. This suggests the crucial role of social capital to foster individual farmer’s readiness and commitment to spontaneously implement stone bunds on the farmlands. Among these key-factors, readiness to change and commitment indicate farmer’s intrinsic motivation to implement and integrate stone bunds into the farming system. These two key-factors play a crucial role to foster farmers’ intrinsic motivation to continue using stone bunds that are implemented on their farmlands. The analysis confirmed the hypothesis; even five key-factors are significantly related to the spontaneous implementation of stone bunds.

This research suggests that farmers who spontaneously adopted and implemented stone bunds on their farmlands are intrinsically motivated farmers who are ready to change and improve their productivity and food security using available natural and social resources. This also seems to suggest that lack of available labour or farmland is not the major reason for farmers not to adopt the introduced SLM practices. Most important is the farmer’s mindset and behaviour: their readiness to change and concerns about effect that erosion has on the future productivity of their farmland. Our first conclusion is that when farmers are ready to change, they are able to implement labour intensive stone bunds by themselves; using their own family labour and seeking additional labour through their social networks. Hence, extension workers and government officials should better understand the crucial role of farmers’ intrinsic motivation when dealing with SLM and therefore reformulate their extension strategies and messages. A scaling-up strategy must focus on awareness raising, strengthening intrinsic motivation, ownership and integrated farming.

These findings provide two important recommendations to extension workers and government officials when aiming to foster SLM and when developing scaling-up strategy that helps to sustainably increase agricultural production and achieve food security of small-holder farmers in Ethiopia: (1) the need to create farmers’ readiness to change and (2) the need to focus more on farmers’ intrinsic motivation. Both lead us to conclude that government extension programmes aiming to foster SLM practices in Ethiopia should invest more in activities that focus on changing how farmers think and behave rather than on what farmers do. This will result in more sustainable impact of the extension programme, including the mass mobilization campaign.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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