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FACTORS INFLUENCING SMALLHOLDER FARMERS' ATTITUDES TOWARDS INTEGRATED SOIL FERTILITY MANAGEMENT: CASE STUDY OF THE WANKA WATERSHED, NORTHWESTERN HIGHLANDS OF ETHIOPIA

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Abstract

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This paper explores factors influencing smallholder farmers' attitudes towards integrated soil fertility management (ISFM). ISFM is paramount to improve soil fertility for sustainable agricultural productivity, especially in contexts where smallholder agriculture is an important local livelihood and economic activity, as in many countries of the Global South. Alongside the development and availability of new technologies to enhance soil fertility, smallholder farmers' attitudes towards these innovations in specific contexts are key to determining the extent and outcomes of their uptake. A better understanding of these is thus essential to inform measures to increase ISFM practices among smallholder farmers.
This study aimed to assess farmers' attitudes towards ISFM and the factors that determined them based on a case study of the Wanka watershed, northwestern Ethiopia, a major cereal-producing area. Using a mixed methods approach, data obtained from a household survey (146 respondents), focus group discussions, and key informant interviews were analyzed using descriptive statistics and a multiple regression model.
The findings revealed that the attitudes of smallholder farmers towards ISFM in the study area were generally positive, as they considered ISFM compatible with agronomic principles and important to increase agricultural productivity sustainably. The extent of farmers' farming experience, the length of time of applying chemical fertilizer, the number of livestock, and the size of plots were found to be significant predictors of attitudes towards ISFM. The study concludes that considering these factors can better inform interventions designed to enhance farmers' choice of ISFM technologies for improved soil fertility management and sustainable crop production in the study area and other contexts.

Key words: small-scale agriculture, land management, organic and chemical fertilizer, farmer behavior, socioeconomic factors, sub-Saharan Africa.

Introduction

Low natural soil fertility and nutrient depletion form the major challenges to agricultural productivity on smallholder farms across the Global South. In sub-Saharan Africa, small-scale farming based on traditional practices and low capital capacity forms the main livelihood strategy for the majority of the population (Mponela et al., 2016; Sanginga, Woomer, 2009). A decline in soil fertility reduces the per capita food availability on smallholder farms in the region, thus jeopardizing both food security and income generation of smallholder households (Mugwe et al., 2009).

Attempts to use mineral, organic, and structural soil management technologies to improve soil fertility and maximize agricultural productivity have been made throughout the region, including in Ethiopia, as part of poverty alleviation strategies (Place et al., 2003). Mineral fertilizers are an important means of boosting agricultural productivity, but their adoption in sub-Saharan Africa has remained low due to factors including high cost and lack of access to credit, and low availability owing to underdeveloped transport and market infrastructure (Sanginga, Woomer, 2009; Mugwe et al., 2009). Indeed, the application of mineral fertilizers in Ethiopia is one of the lowest in the region and is neither crop nor soil specific (Agegnehu, Amede, 2017). In the absence of adequate access to mineral fertilizers, the intensive application of some chemical fertilizers, such as urea and diammonium phosphate (DAP), in their place has had adverse impacts on long-term soil quality, as it increases the content of toxic metals in the soil through soil acidification (Guteta, Abegaz, 2015; Savci, 2012). Chemical compounds can also move beyond the rooting zone and pollute subsurface water sources (Vanlauwe et al., 2015).

However, the application of organically derived fertilizers alone is deemed to be insufficient to boost productivity or underpin food security in sub-Saharan Africa or the Global South more broadly (Bationo et al., 2012). The production of organic

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fertilizer is limited by shortages in both natural resources and human labor (Vanlauwe et al., 2010) and, with the exception of potassium, which is readily released from dead organic materials, soil nutrients obtained from the application of organic inputs alone are of a lesser value that those that can be obtained from chemical fertilizers (Nalivata et al., 2017). In this way, organic inputs (e.g., crop residues and animal manures) cannot meet the crop nutrient demand particularly over large areas because of the limited quantities available, the slow decomposition rate and the associated low nutrient content of the materials, and the high labor demands for processing and application (Palm et al., 1997).

Consequently, there is no single soil fertility management practice that can enhance sustainable soil fertility and agricultural productivity on its own (Mugwe et al., 2009). This led to the introduction of the integrated soil fertility management (ISFM) strategy in the 1990s as a viable option to improve soil quality and scale up yield sustainably, while being adaptable to diverse biophysical and socioeconomic conditions, as well as environmentally benign (Mponela et al., 2016; Lagerkvist et al., 2015; Guteta, Abegaz, 2015; Agegnehu et al., 2014; Bationo et al., 2012). ISFM is an advanced approach involving the synergistic application of mineral fertilizer, organic inputs (e.g., manure, compost, green manuring, legumes, and crop residue), agronomic practices (e.g., crop rotation, weeding), structural (e.g., construction of bund, drainage ditch, etc.) soil management practices, and improved crop varieties, which are adapted to local conditions efficiently and effectively, so as to enhance soil quality and sustain agricultural productivity (Agegnehu, Amede, 2017; Lambrecht et al., 2014; Thomas, 2012; Vanlauwe et al., 2010; Sanginga, Woomer, 2009).

ISFM is thus considered to be a potentially effective strategy for smallholder farming that relies on traditional methods and lacks capital for investment, as inorganic and organic inputs along with agronomic and physical soil management strategies complement each other. It is commonly noted that inorganic and organic inputs are not available in sufficient amounts, especially in sub-Saharan African countries (Vanlauwe et al., 2002). Furthermore, ISFM approaches contain different essential soil nutrients that are important to address different soil fertility problems. For example, while organic inputs enhance the soil's organic matter content, mineral fertilizers increase key limiting soil nutrients, such as available nitrogen, potassium, and phosphorus (Place et al., 2003), or ameliorate pH if liming is used as a soil management strategy. The application of a combination of measures can also enhance the agronomic efficiency of the applied inputs, soil aggregation, soil microbial activity, resistance to erosion, and soil water infiltration and retention and, in turn, improves sustainable yield increment, particularly in tropical agroecosystems (Agegnehu, Amede, 2017; Mponela et al., 2016). Thus, ISFM has been promoted as a strategy to boost the sustainability of soil quality and crop productivity by using various soil fertility management technologies simultaneously.

Despite the significant advantages of ISFM over the application of a single technology for sustainable improvement of soil resources and agricultural productivity, its adoption by smallholder farmers in sub-Saharan Africa is low (Mponela et al., 2016; Roobroeck et al., 2015). One of the main factors is the negative attitude of smallholder farmers towards the strategy (Lambrecht et al., 2014). Before deciding whether to adopt ISFM or not, smallholder farmers tend to have either positive or negative preconceived attitudes towards it (Mugwe et al., 2009). Several factors have been identified in existing literature. Maro et al. (2013) reported that farmers' attitudes towards ISFM in northern Tanzania are a function of socioeconomic factors such as age, household size, extent of off-farm income, and farming experience. Similarly, a study conducted in Bangladesh revealed that, while the level of education, farming experience, and exposure to communications encouraged farmers to have a positive attitude towards ISFM, farm size and use of mineral fertilizer led to more negative attitudes (Farouque, Takeya, 2007). In Ethiopia, despite several land management technologies having been practiced for several decades, soil fertility and crop productivity remain low. ISFM presents an alternative strategy to enhance soil fertility and increase crop productivity in a sustainable manner; yet, it is at a nascent stage in the country (Guteta, Abegaz, 2015).

Therefore, evaluating smallholder farmers' attitudes toward the idea and the practice of ISFM is crucial to understand and predict the likelihood that they will adopt it, which can then inform interventions to encourage its uptake to promote sustainable soil resource management and agricultural development. This is because understanding the behavioral inclinations of farmers toward any type of technology allows identification of the specific factors influencing their attitude, which is a reflection of individual socioeconomic characteristics (Lagerkvist et al., 2015; Maro et al., 2013; Odendo et al., 2009; Sadati et al., 2010). However, given the predominance of traditional farming practices in Ethiopia, and the nascent status of ISFM in the country, the evaluation of farmers' attitudes towards ISFM is limited. The aim of this study, therefore, is to address this gap by assessing farmers' attitude towards ISFM practices and the factors that determine them, based on a case study of the Wanka watershed in the northwestern highlands of Ethiopia. This case study is appropriate because it is one of the main cereal-producing areas in Ethiopia, located in Amhara National Regional State.

Material and methods

Study site

The Wanka watershed is located between 11° 29¢ 24² N to 11° 42¢ 36² N latitude and 37° 58¢ 12² E and 38° 14¢ 24² E longitude (Fig. 1). The Wanka river is one of the head streams of the Blue Nile basin, and the watershed covers a total area of 252 km^2. The watershed is part of the extensive Afro-Arabian plateau, which was formed by the uplifting of the landmass and the outpouring of lava (Mohr, 1971). The elevation ranges from 2.238 to 4.086 m above sea level (m.a.s.l), with subtropical to Alpine climatic conditions.

The mean annual temperature of the Wanka watershed is 17.3 °C. The mean annual minimum and maximum monthly temperatures are 8.4 and 26 °C, respectively. The mean annual total rainfall recorded in the watershed for the years 1994–2015 is 1320 mm. The rainfall pattern is unimodal with one major (summer) rainy season that extends from June to August and sometimes up to September (NMSAE, 2015). The dominant soil units of the watershed are Chromic Luvisols (41.1%), Eutric Leptosols (34.12%), and Haplic Luvisols (24.84%) (FAO, 1990).

Data collection and analysis

Data for the study were collected through a household survey, key informant interviews, and focus group discussions, and were

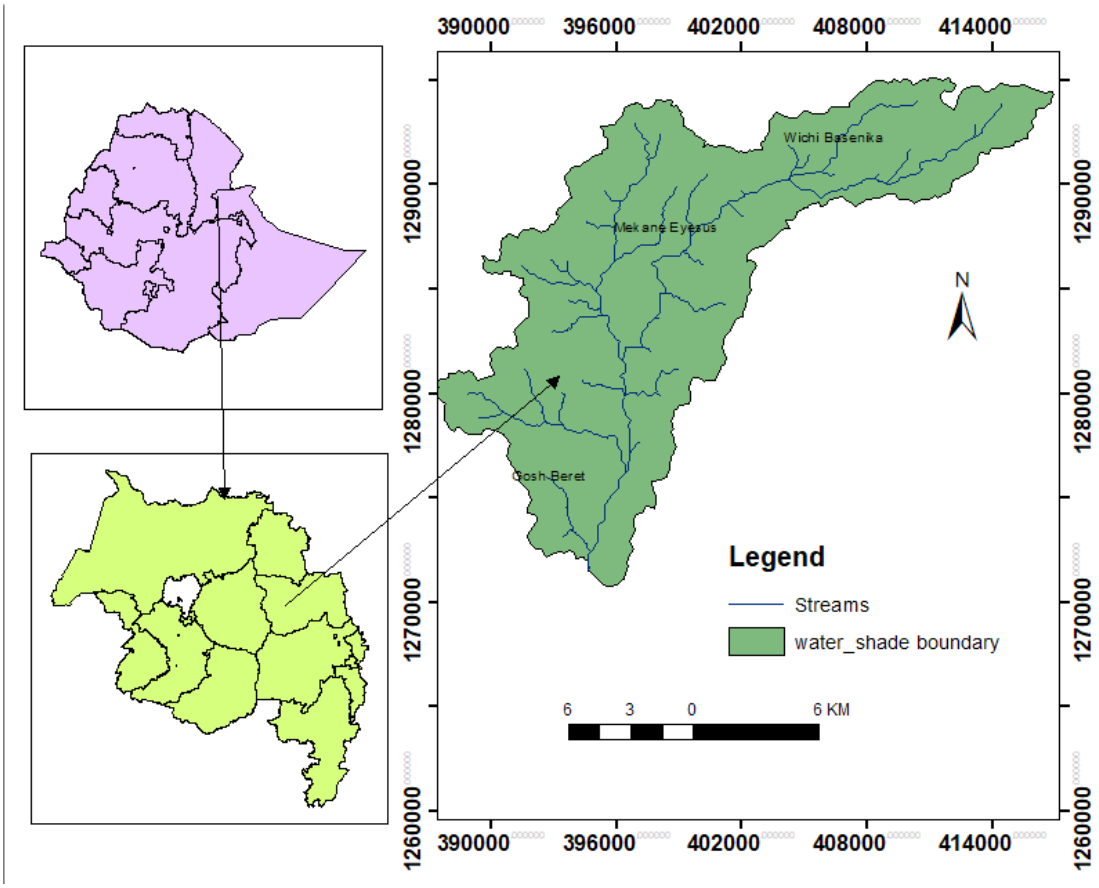


Fig. 1. Location map of the study site.

Table 1. Details of sampled *Gots* (villages) in the Wanka watershed.

Village name	Position in Watershed	Total HHs	Sampled HHs
Washamariam	Upper	287	58
Gudiba	Middle	180	37
Goshberet	Lower	250	51
Total		717	146

Note: HH - household.

analyzed using descriptive statistics and a multiple regression model. A multistage sampling technique was employed to select household heads for the survey. Household heads were taken as the unit of analysis as they are the main actors in farming activities and land management decisions and practices in the study area. Three rural kebeles (the lowest administrative unit in Ethiopia, comprising a group of villages) that are entirely found within the watershed were selected, with varying elevations: Wuchbasenqua in the upper reaches (2700–2800 m.a.s.l), Mekaneyesus in the middle section (2400–2600 m.a.s.l), and Goshberet in the lower watershed (2238–2300 m.a.s.l). Three elevations were included, as soil management practices differ across them (Geta et al., 2013). One got (village or sub-kebele) was then randomly selected from each kebele from a list obtained from the kebele administrations, which comprised Washamariam got (Wuchbasenqua kebele), Gudiba got (Mekaneyesus kebele), and Goshberet got (Goshberet kebele). A systematic random sampling technique was used to select 146 household heads proportionally from the gots (Table 1), equating to a sample size of 20%, based on a list of households provided by the local administration. The sample size was determined using Yamane's formula (1967) at a precision (e) level of 0.075 (Rutebuka et al., 2019), which indicated 143 respondents. An additional three respondents were included to satisfy the threshold requirement in case a selected household head was unavailable.

Structured survey questionnaires were used to collect information about farmers' socioeconomic characteristics and their attitudes towards ISFM. The latter information was obtained through questions that gauged participants' level of agreement/disagreement with statements concerning ISFM, which were developed based on existing literature (Lagerkvist et al., 2015; Vanlauwe et al., 2015; Bationo et al., 2012; Sanginga, 2012; Farouque, Takeya, 2007). A five-point Likert rating scale that ranged from strongly agree to strongly disagree was used. To ensure the valid-

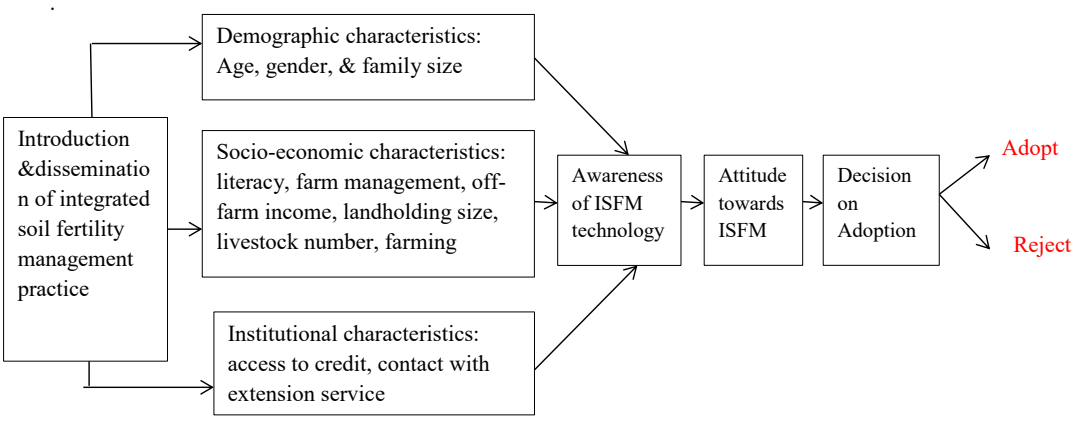


Fig. 2. Conceptual framework of farmers' attitudes towards ISFM (adapted from Neupane et al., 2002 and Mugwe et al., 2009).

Table 2. Description of variables.

Variables	Description	hypothesized effect
1. Dependent variable		
Farmers' attitudes towards ISFM	Total value of farmer's response for ISFM (score)	
2. Independent variables		
Age	Respondent's age in years	+
Gender	Gender of household head (1 = male, 0 = female)	±
Household size	Number of family members in adult equivalent	+
Literacy	Respondent's education level (1 = illiterate, 2 = literate)	+
Plot size	Area used for crop cultivation in hectares	±
Farming experience	Farmer's experience of farming in years	+
Length of use of chemical fertilizer	Number of years that farmers have utilized chemical fertilizer	±
Number of livestock	Number of livestock owned by households in Tropical Livestock Units (TLU) +	+
Access to credit	Accessibility of credit (1=yes, 0=no)	±
Off-farm income	Existence of off-farm income to the household (1=yes, 0=no)	±
Contact with extension service	Existence of contact with rural extension agent by respondent in the last cropping seasons (1=yes, 0=no)	+

ity of the Likert scale statements, the results were compared with other studies on ISFM and presented to local and regional experts. The questionnaires were piloted with 15 randomly selected household heads. Cronbach's alpha (α) coefficient was calculated to check the internal consistency of the Likert scale questions, which gave a result of 0.78. To group the responses on attitudes towards ISFM, means and standard deviations (SDs) were used as follows (Tsehaye, Mohammed, 2013; Sadati et al., 2010):

- Very high (A) = mean +SD < A < max,
- High (B) = mean < B < mean + SD,
- Moderate (C) = mean_SD < C < mean,
- Low (D) = Min < D < mean_SD.

Key informant interviews with six community elders (aged 50–71 years) and one focus group discussion with eight participants (between the ages of 35 and 65) were also used to substantiate and deepen the household survey data. Participants with longer experience and higher levels of knowledge were purposely selected for interviews and focus groups and were identified by consulting with local development agents. All the interviewees and focus group participants were male, as they were more involved and active in farming and land management practices. Descriptive statistics (percentages, means, and SDs) and a multiple regression model were used to analyze the data. A multiple regression analysis was carried out to identify factors that are the best predictors of farmers' attitudes towards ISFM (Hayran et al., 2018; Bagheri, 2010; Agahi et al., 2011; Sadati et al., 2010; Farouque, Takeya, 2007). Statistical Package for Social Sciences (SPSS) (version 23) was used to analyze the data.

Multiple regression model

Multiple regressions is useful to understand how well a set of variables is able to predict a particular outcome and to determine the best predictor of an outcome in a set of variables (Pallant, 2007). The model was used in this study to identify the likely predictors

of farmers' attitudes towards ISFM and to inform responses to encourage uptake of the strategy. A multicollinearity check was done using the Variance Inflation Factor (VIF) and was found to be within the acceptable range (<2). The variables used were socioeconomic variables (predictor variables) and farmers' attitudes (score) considered as outcome variables, as follows:

$$Yi = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \ldots + \beta nXn + ei, \quad (1)$$

where Yi = i^{th} farmer's value (score) for attitude toward ISFM, β0 = coefficient of constant term, β1–βn = coefficients of independent variables, X2–Xn = independent variables and ei = error term.

Specification of variables

Farmers' attitudes are the main factor determining the adoption of a given agricultural technology and are, in turn, mainly influenced by a range of characteristics relating to farmers' socioeconomic status. The main predictor variables of farmers' attitudes toward a given soil fertility management technology based on existing literature include literacy, farming experience, household size, length of use of chemical fertilizer, age, gender, number of livestock, contact with extension services, off-farm income, and access to credit (Hayran et al., 2018; Lagerkvist et al., 2015; Tsehaye, Mohammed, 2013; Bagheri, 2010; Agahi et al., 2011; Sadati et al., 2010). Thus, these were considered as independent variables in this study, while the dependent variable was farmers' attitudes towards ISFM (score) (Table 2, Fig. 2).

Results and discussion

Socioeconomic profile of household heads

The majority of the household heads surveyed (94.5%) were male. Household heads were aged between 24 and 80 years, with an average age of 52 for male and 45 for female household heads. The household size ranged from one to 10 family members, with an average of six. A significant proportion (62.3%) of households heads was illiterate. The average length of farming experience of the respondents was 24 years, and more than half had over 25 years of experience. The average plot size was 1.12 ha, which is slightly lower than the regional average of 1.15 ha, but higher than the national average of 0.90 ha (CSA, 2007). The average number of livestock was found to be 5.14 Tropical Livestock Units (TLU). The majority (62%) of farmers had no off-farm income; yet, over half of the respondents (56%) had access to credit. Just over half (57%) of the respondents previously had contact with a rural extension service, and over 75% of the respondents had been using chemical fertilizer for more than 10 years.

Farmers' attitudes toward ISFM

Overall, most farmers' attitudes towards ISFM were found to be high or moderate. As shown in Table 3, 4.1% (Six) and 59.6% (eighty seven) of respondents showed very high and high attitudes towards ISFM, respectively. Also, 33.6% (49) respondents had a moderate attitude towards the strategy, while only 2.7% (four) of respondents expressed a low attitude. The interviewees and the focus group participants also reinforced the survey results by emphasizing the importance of implementing a combination of land management practices, reporting that the application of modern technology alone, without any other land management activities (e.g., farm land preparation, crop rotation, drainage ditches), would neither maximize nor sustain soil fertility.

Table 3. Distribution of respondents according to their attitude towards ISFM.

Level of attitude	Frequency	Percentage
Low (D) (1—2.53)	6	4.1
Moderate (C) (2.53—3.68)	49	33.6
High (B) (3.68—4.83)	87	59.6
Very high (A) (4.83—5)	4	2.7
Total	146	100

Notes: A ‑very high: Mean +StD<A<Max; B ‑ high: Mean<B<Mean +StD; C ‑ moderate: Mean-StD<C<mean; D ‑ low: min<D<mean-StD

As shown in Table 4, a rank order of statements about ISFM based on the mean and SD of responses to statements was used to evaluate farmers' attitudes towards ISFM (Hayran, 2018; Marzban et al., 2016; Farouque, Takeya, 2007). Accordingly, it was found that the majority of the respondents had a high attitude towards the application of various soil fertility management techniques in combination to enhance agricultural productivity (M = 4.3). Farmers also underscored the complementary nature of inorganic and organic soil fertility management practices (M = 3.96) and the importance of ISFM in ensuring compatibility with agronomic principles (M = 3.96). Hence, they ranked statements that express the importance of the combined application of organic and inorganic fertilizers and their complimentary nature with agronomic principles in the second and third place, respectively. Conversely, it was found that farmers had a low attitude towards the high cost of application of ISFM (M = 3.32), as well as the application of a single technology to enhance soil fertility and productivity (M = 3.3) (Table 4).

These results imply that farmers have a sufficient understanding of the ineffectiveness of applying only one technology across all land use types and agroecological settings as a means of enhancing the sustainable productivity of soil. Their long experience of farming enables them to appreciate the advantages of ISFM and its compatibility with agronomic principles. They were also aware that the application of ISFM is less costly than the application of single soil fertility management technology (e.g., use of chemical fertilizer), which suggests that emphasis should be placed on policies and strategies that support and encourage to farmers to adopt the combined use of soil fertility improvement technologies, such as motivating farmers to produce and use compost, as well as to improve the affordability of chemical fertilizers. This finding concurred with that of Lagerkvist et al. (2015), who reported neutral to positive attitudes of farmers towards ISFM in Kenya, yet contradicts that of Farouque and Takeya (2007), who found negative attitudes of ISFM among farmers in Bangladesh. While the factors playing a role in these contrasting results may be different, our findings demonstrate that farmers were positive towards ISFM, which creates a fertile ground to enhance ISFM practice widely in the study area, as well as potentially in other parts of Ethiopia.

Table 4. Mean ranking and standard deviation of farmers' attitudes towards ISFM.

No.	Statement scoring on a scale of 1 to 5, whereby 1 low and 5 is very high	Mean	StD	Rank
1.	It is not advisable to apply merely one type of soil fertility management technique on a given plot to scale up productivity	4.3	1.053	1
2.	It is important to combine mineral fertilizers with organic manure or crop residue	3.89	1.038	4
3.	Inorganic and organic (e.g. manuring, crop residues, legumes) soil fertity inputs complement each other so it is essential to apply them in combination	3.96	0.901	2
4.	An integrated soil fertility management system encourages the application different agricultural inputs in accordance with sound agronomic principles	3.96	1.016	2
5.	An integrated soil fertility management system not only enhances the sustainability of soil fertility, but also encourages the efficient use of resources	3.87	1.146	5
6.	The application of various soil fertility management practices in combination by farmers needs to be encouraged by agricultural extension agents	3.87	1.078	5
7.	The application of selective seed and chemical fertilizer needs to be practiced in combination with crop rotation, otherwise there is no sustainable productivity	3.84	1.057	7
8.	It is preferable to manage soil fertility to a large extent by the combined use of mineral fertilizer with manure or crop residues	3.75	1.195	8
9.	The integrated soil fertility management system is expensive, so I am not interested in using it	3.32	1.404	15
10.	10 Farmers need to select only one soil fertility management technique for all types of plot, rather than apply different methods in combination*	3.3	1.217	16
11.	The application of green manure (e.g. lupin) in combination with chemical fertilizer does nothing to improve soil fertility*	3.4	1.118	14
12.	The application of organic fertilizer in combination with chemical fertilizer encourages weeds, so I am not interested in applying it*	3.7	1.153	9
13.	Agricultural production can only be increased using organic inputs from applying chemical fertilizer*	3.3	1.123	16
14.	Soil fertility should mainly be managed only by increasing the application of chemical fertilizer*	3.43	1.264	12
15.	The application of organic and inorganic fertilizers in combination is not effective in maintaining good soil quality*	3.68	1.202	10
16.	Organic fertilizers are as efficient as chemical fertilizers in increasing yield, so it is better to use them alone than in combination with chemical fertilizer*	3.55	1.145	11
17.	The application of chemical fertilizers adversely affects sustainable soil quality, so it should not be utiliz ed*	3.421	1.452	13

Note: * – Negative statements.

Table 5. Factors influencing farmers' attitudes towards ISFM in the Wanka watershed.

Variables	B	Beta	t-value	Sig.
(Constant)	49.277			
Age	0.187	0.213	2.874	.005
Plot size	-7.041	-0.274	-4.111	.000
Number of livestock (TLU)	0.615	0.212	3.231	.002
Length of use of chemical	0.170	0.145	2.088	.039
Fertilizer				
Farming experience	0.248	0.299	4.040	.000

Notes: R2 – .486; Adjusted R2 –.443; F –11.5.

Factors influencing farmers' attitudes towards ISFM

The above results suggest that it is indispensable to identify and prioritize the determinants of farmers' attitude towards ISFM to potentially be able to enhance them. The regression result confirmed that of the 11 predictor variables, five – age, farming experience, number of livestock, length of use of chemical fertilizer, and plot size – were found to be significant predictors of farmers' attitudes towards ISFM. These variables together accounted for about 44.3% of the variation in farmers' attitudes towards ISFM.

Farming experience was the most significant positive predictor in the study area and explained about 29.9% of the variation

in farmers' attitudes towards ISFM (Table 5). This finding coincided with that of Farouque and Takeya (2007), who reported that farmers with long farming experience were able to acquire knowledge and skills that strengthened their attitude towards ISFM. ISFM is knowledge intensive (Place et al., 2003); thus, farmers who have longer farming experience have a better understanding of the use of ISFM in increasing soil nutrient recovery, which subsequently fosters a positive attitude toward it, than those with less farming experience. Experience enables farmers to understand the limitations of the application of a single technology and, subsequently, the benefit of ISFM. This implies a policy recommendation around the need to create a conducive environment for transferring local farming knowledge from experienced farmers to rural youth.

Furthermore, farmers who had experience of using chemical fertilizer over a long period of time were able to understand its adverse impact on soil quality, as prolonged application increases the acidification of soil (Savci, 2012). As a result, they tended to reduce the application of chemical fertilizers and increase the use of organic fertilizers to enhance soil quality sustainably. This suggests that agricultural extension programs should place more emphasis on farmers' experiences in soil fertility management, rather than simply consider them as recipients of modern agricultural technologies and agricultural advice.

Similarly, the number of livestock owned by farmers significantly and positively predicted their attitudes towards ISFM, whereby the greater the livestock herd, the more likely that the farmer would regard ISFM positively. This factor explained about 21% of the variation in farmers' attitudes towards application of ISFM (Table 5), probably because those farmers who own a large number of livestock are likely to have a larger quantity of animal manure available to them than those with smaller herds. A similar finding was also reported in Kenya (Lagerkvist et al., 2015). Organic inputs make a significant contribution to nutrient availability in the soil as they add nutrients, facilitate mineralization-immobilization patterns, and provide soil organic matter as well as energy for microbial activities (Palm et al., 1997). In Ethiopia, the majority of farmers practice both crop cultivation and animal husbandry, meaning that it is very difficult to separate arable and livestock farming in this context. In turn, this implies that strategies aimed at improving the livestock sector (e.g., improvement in animal feed, health, and breeding) not only need to receive adequate attention, but can also act as a channel through which soil fertility can be improved consequently.

Unlike the other significant factors, the influence of plot size was found to be negative, whereby farmers with smaller landholdings had more positive attitudes towards ISFM than those with larger ones. This contradicted the finding of Farouque and Takeya (2007), who reported the positive impact of plot size on farmers' attitudes towards ISFM. However, the association between small plot size and farmers' attitude towards ISFM in this study area may be due to the fact that, as the plot size increases, the amount of organic inputs required also rises, and the cost may become unaffordable to farmers with larger plots. In addition, the distance between the plot and the home may be a factor, as the transportation of large quantities of organic fertilizer such as animal manure becomes more difficult, which may foster disapproval among farmers. This would make sense, since the costs of inputs and labor will influence the selection and profitability of soil management systems (FAO, 2000). The finding from this study implies that farmers with small plots can manage ISFM easily as it demands less labor, but that the fragmentation of plots can have negative repercussions on its viability. As the fragmentation of land in the study area is ongoing, especially due to subdivision among heirs, policy responses should consider the impacts of plot size and introduce measures to avoid further fragmentation where possible.

Conclusion

The study revealed that smallholder farmers in the Wanka watershed generally have a positive attitude towards ISFM. They perceived that ISFM enhances agricultural productivity and soil fertility sustainably, organic and inorganic fertilizers are complimentary, and ISFM is compatible with agronomic principles. Furthermore, key factors were identified that influenced farmers' attitudes towards ISFM, including length of farming experience, number of livestock, and plot size and coherence. These findings suggest that there is potential to enhance the practice of ISFM in the study area through policy and/or rural extension support measures that assist farmers to enhance and strengthen existing soil fertility practices, improve the availability of inputs, promote additional technologies that enhance ISFM (e.g., expanding green manuring technology), as well as undertake monitoring and evaluation to identify further areas of support. In addition, beyond the study site and more broadly, the findings suggest that considering the various socioeconomic predictors of openness towards ISFM may be able to enhance its uptake in other contexts where it is less enthusiastically received (e.g., Bangladesh), by devising appropriate strategies that enable farmers to acquire sufficient knowledge about the relevance and importance of ISFM, such as through training and experience sharing.

Authors' contributions

WA conceived and designed this work as well as analyzed and interpreted the statistical results. MA provided insight and guidance for the study. JB provided insight and edited the language. All authors contributed substantially to the drafting and revisions of the manuscript and approved the submitted version. All authors are responsible for the accuracy and integrity of the manuscript and data. All authors read and approved the final manuscript.

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