# Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa

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Original Research Article

# Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle, Southern Africa

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ABSTRACT

The promotion of land, soil and water conservation measures has been a widespread development in sub-Saharan Africa in a bid to tackle degradation and improve productivity. As a result, several governments have launched various campaigns on soil, land and water conservation measures. The aim of this study is to determine some of the factors that influence farmers' awareness (knowledge) and adoption of land, soil and water conservation practices. Data for this study was collected from 312 households using a questionnaire survey in the Chinyanja Triangle of Southern Africa. The study sites were sampled from Tete province of Mozambique, central and southern regions of Malawi and eastern Province of Zambia. We used *t*-tests to classify adopters and non-adopters of soil, land and water conservation measures and binomial logit models to identify the factors that influence farmers' knowledge of conservation measures and adoption of land productivity practices. The results show that the household head's age, education, agricultural advice reception and farmer group membership are critical in raising awareness. While the household head's age, education, agricultural advice reception, farmer group membership, pieces of land owned or used in production and land-to-man ratio influenced adoption decisions. The study, therefore, concludes that in order to improve land productivity in the Chinyanja Triangle, there is a need to consider farmers' heterogeneity in terms of household head's age, level of education, extension services outreach, and socio-economic characteristics. This suggests that governments' policies in the region should be aimed at improving farmers' level of education, extension delivery that will target the elderly and the youth, land ownership, credit access, and social capital such as group formation.



## 1. Introduction and background

The economies of most countries in sub-Saharan Africa, including Malawi, Mozambique and Zambia, are agro-based of which smallholder farmers are major food producers (Kassie, Jaleta, Shiferaw, Mmbando, & Mekuria, 2012). The agricultural sector's fortune directly affects economic development, food security, poverty alleviation and social welfare. However in sub-Saharan Africa, fluctuations in production and volatility of markets have affected development of the sector (Kassie et al., 2012). Despite the fact that the sector employs about two-thirds of the labour force, it contributes only about a quarter of the total gross domestic product (GDP) (Pretty, Toulmin, & Williams, 2011). The importance of the agricultural sector is more conspicuous, especially in rural areas, where families depend heavily on agriculture alone to make a living (AGRA, 2013).

Despite low performance of agricultural sector, there are variations within and among regions across sub-Saharan Africa. In Malawi, for example, the Economic Growth Strategy of 2004 considers agriculture as the pivotal sector for economic development accounting for 39% of GDP, 85% of the labour force and 83% of foreign exchange earnings (Chirwa, 2004). In Zambia, rural households who own small land holdings comprise about 88% of the farming population and often strive to meet their livelihood needs despite contributing 60% to the value of national agricultural output (Saasa, 2003). The land resource has been employed in various proportions to meet both subsistence and commercial needs. In Mozambique, agriculture is also considered the basis for development (Mucavele, 2013). About 90% of rural households are engaged in agriculture, and this equates to 80% of the total population who depend on agriculture. The role of

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agriculture in Mozambique includes supplying food to 80% of Mozambicans, providing employment to about 80% of the population, of which 50% are women, supplying foreign earnings through agricultural produce exports, as well as supplying raw materials to agro-industries and other sectors of the economy, and capital accumulation (Cunguara, Langyintuo, & Darnhofer, 2011).

Although the economies of Mozambique, Zambia and Malawi centre on agriculture, the sector faces many challenges. The casual factors for slow economic growth could be attributed to a number of biophysical and socioeconomic factors limiting agricultural growth (Ajayi, 2007; Misiko & Ramisch, 2007; Pender, Place, & Ehui, 2006). Among biophysical factors, soil fertility depletion is considered the main limiting factor for increasing food production of most smallholder farmers in the region. Issues related to the degradation of land, water and soil resources have mainly been blamed for the continual decline in soil fertility. Sustainable extensive agriculture production options that were coupled with fallowing period of certain parcels of land are increasingly becoming difficult. With increasing population densities per land area and scarcity of new land to exploit, allowing land to lie fallow has become more difficult in the region. Constrained on small farms, most households find themselves in a vicious cycle of poor agricultural productivity, low returns to enable investment, continued resource overuse and increasing demand for land to sustain livelihoods (Misiko & Ramisch, 2007; Pender et al., 2006).

Mucavele (2013) found that the majority of smallholder farmers in Malawi, Mozambique, Zambia and other sub-Saharan African economies still practice unimproved traditional methods of cultivation. Most of the smallholder farmers are said to apply no or minimum improved inputs to their farming activities, and modern soil and water conservation technologies are not practiced. In addition, the lack of diversification in farming systems, with 80–90% of the crop being maize, also aggravates problems of degradation, leading ultimately to soil fertility problems.

The major concern is that the degradation of land, water and soil resources adversely affects agriculture. For example, land degradation leads to the deterioration of soil quality. A reduction in land and soil productivity endangers the sustainability of agriculture, environmental stability and quality, and also has an adverse impact on economic and social development. Without taking appropriate soil, water and land management measures, the cost of arresting degradation will get higher and yields will persistently decline thereby increasing recurrence of food insecurity for greater populations of sub-Saharan Africa. It will also affect export earnings from agricultural products.

As a result of the problems arising in agricultural communities, the adoption and diffusion of certain sustainable agricultural practices have become an important issue in the development policy agenda for sub-Saharan Africa, especially as a way of finding solutions to the problems (Ajayi, 2007; Scoones & Toulmin, 1999). The adoption of land, soil and water conservation practices that include mulching, rainwater harvesting, the construction of box ridges and contour ridges, and many other conservation practices has been part of the development policy agenda for agriculture.

Notwithstanding their benefits, the adoption rate of some of these sustainable agricultural practices is still low in the rural areas of developing countries (Kassie, Zikhali, Manjur, & Edwards, 2009; Wollni, Lee, & Thies, 2010), despite a number of national and international initiatives to encourage farmers to invest in them. This is also true for Mozambique, Zambia and Malawi, where, despite accelerated erosion and considerable efforts to promote various soil and water conservation technologies, the adoption of many recommended measures is minimal and soil degradation continues to be a major limitation to productivity (Barungi & Maonga, 2011). Moreover, relatively little empirical work has been done to examine the factors that influence the adoption and diffusion of some of these sustainable agricultural practices, especially land, soil and water conservation practices. In this article, important land, soil and water conservation practices include constructing box ridges and contour ridges, mulching, rainwater harvesting practices, using Vetiver grass, using planting basins and ripping.

The objective of this article is to identify some of the socioeconomic factors that influence awareness (knowledge) and those that influence farmers to adopt land, soil and water conservation practices. This is important in enhancing the adoption process, as targeting those factors can improve both the awareness and adoption of conservation practices. Awareness (knowledge) is considered important, as the innovation decision process begins with the knowledge stage (Rogers, 2003). Rogers (2003) argues that one cannot begin the adoption process without knowing about the innovation. In this stage, a person first becomes aware of the technology through different options. In this article, awareness, together with adoption, was considered, based on the innovation decision theory.

This article fills the gap in understanding adoption of land productivity enhancing technologies, especially in the Chinyanja Triangle of Southern Africa. The adoption of innovation or technology can generally not be said to be a random process, as farmers usually self-select treatment (Faltermeier & Abdulai, 2009). Analysing important factors that raise awareness and those that motivate farmers to adopt certain soil, land and water conservation practices is an important contribution to literature, as results can be used to curb further problems of resource degradation that are a threat to poverty reduction efforts in the region.

## 2. Description of study sites

The study was conducted in the Chinyanja Triangle, including the Furancungo in Tete Province of Mozambique, Budula-siliya in Zambia's eastern Province and Linthipe and Nsipe in the central and southern regions of Malawi (Fig. 1). The common denominator in the region is the inhabitants' mother language, Chichewa. Culturally, the majority of the people in the region share the same beliefs and it is hypothesised that they could share similar approaches to resource management, especially land, on which they all depend for their livelihoods (Amede, Desta, Harris, Kizito, & Cai, 2014; Makate, Makate, & Mango, 2017). Some 38% of the studied area is under shrub cover and is classified as crossed-open deciduous. Tree cover occupies 31% of the research sites. Cultivated and managed areas make up 24% of the area and water bodies occupy 4%. Herbaceous species cover 2% of the sites and bare, artificial and associated areas take up less than 1%. The study sites are dominated by maize as the staple food crop, mixed with legumes and groundnuts.

## 3. Analytical approach

### 3.1. Model choice

A set of factors (demographic, biophysical, institutional, and socioeconomic) may sway farmers to adopt, or reject innovative technologies at the farm level. It is for this reason, that both empirical and theoretical modelling of farmers actions to new innovative technologies has become very important. Both quantitative and or qualitative methods can be used to evaluate the determinants of innovative practices (technologies & methods) adoption. In cases where adoption is measured as a dummy variable that take a value of 1 for adoption and 0 otherwise, estimation

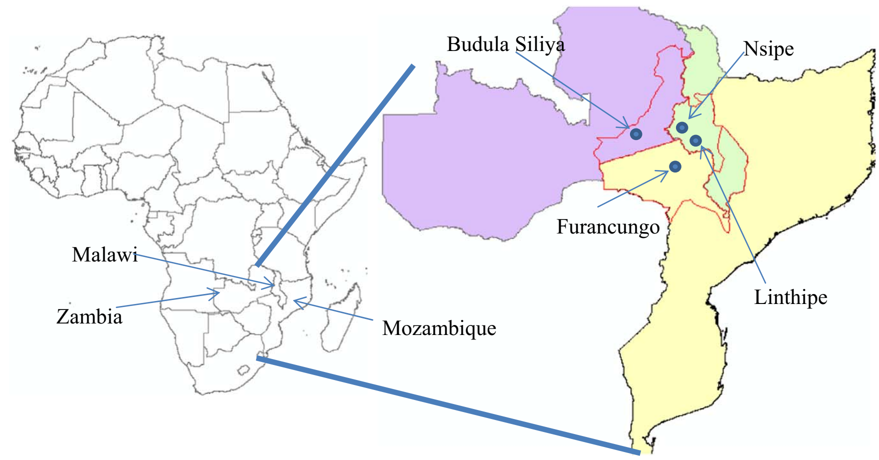


**Fig. 1.** Map showing the location of the Chinyanja Triangle and the research sites.

favors the use of limited dependent variable models such as the probit or logistic model. The two models basically give the same outcomes (i.e. same parameter estimates) and choice between them is usually a matter of preference (Aldrich & Nelson, 1984). However, researchers often prefer the logit (also known as logistic) model because it has faintly flatter tails than the probit model (Gujarati, 2009). In other words the normal curve of the probit model reaches the axis faster when compared to the logit (logistic) function. More so, with the logit model we can report the coefficients as odds ratios. It is because of that reason that we rely on the logistic model in this article. For more on limited dependent variables such as the logistic regression authors are referred to read Gujarati (2009). In this article we report Odds ratios which estimate probability change in adoption associated with a change in the covariate.

*3.1.1. Working hypotheses and variable specification*

This study hypothesises that farmers' decision to adopt new technologies at any time is influenced by the combined effect of socioeconomic, demographic and institutional factors, which are related to their objectives and constraints. It is also hypothesised that farmers' awareness (knowledge) of certain land, soil and water conservation technologies is influenced by the combined effect of socioeconomic, demographic and institutional factors. In this section, the variables to be used in the binomial logistic model and the associated working hypotheses are presented.

The dichotomous dependent variable for the adoption model, Adopt_LSW, indicates whether a household uses soil, land and/or water conservation measures. Adopt_LSW = 1 for adopters and Adopt_LSW = 0 for non-adopters at the time of the survey. For awareness, the dichotomous dependent variable, Aware_LSW, indicates whether a household has knowledge of at least one of the land, soil and water conservation measures available in the study area. Aware_LSW = 1 for households who were aware of the available land, soil and water conservation technologies at the point of the survey and Aware_LSW = 0 otherwise.

The study's independent variables include those hypothesised to influence the adoption and awareness of conservation measures. The list of explanatory variables used in the two models was obtained from existing theoretical explanations, intuition and the author's knowledge of the studied areas.

The explanatory variables hypothesised to influence the adoption of physical soil conservation measures in the study area are presented in Table 1 below:

**Table 1**
Explanatory variables for the adoption decision chosen in this study.

| Variable | Description and variable measurement | Expected sign |
|---|---|---|
| Sexhh | Sex of household head dummy (1=male; 0=female) | Negative/ positive |
| Agehh | Age of household head in years | Negative |
| Eduhh | Number of years' formal education of household head | Positive |
| AgricAdvice | Access to agricultural advice (extension) (1=yes; 0=no) | Positive/ negative |
| Group | Household member belongs to any group/organisation (1=yes; 0=no) | Positive |
| Occuphh farming | Farming as main occupation of household head (1=yes; 0=no) | Positive |
| Hhsize | Size of household | Negative |
| Literacy | Number of people who can read and write in the household | Positive |
| Income | Total annual income in US$ | Positive/ negative |
| LUhh | Total livestock units owned by household | Positive |
| Arableland | Size of arable land owned by household in acres | Positive/ negative |
| landpieces | Pieces of land owned by household (land fragmentation) | Positive |
| Economically active | Number of economically active household members | Positive |
| DepRatio | Dependency ratio | |
| Labour | Number of family members that provide labour | Positive |
| electricity | Access to electricity | Positive |
| ObtainCredit | Access to agricultural credit | Positive |
| MktDist | Distance to nearest market in kilometres | Positive/ negative |
| LandManRatio | Land-to-man ratio (=a fraction of arable land available divided by the number of people in the household) | Negative |

## 4. Empirical literature on adoption decisions and the perceived influence of the variables on the adoption of land, soil and water conservation practices

Empirical studies in developing countries on the adoption of land, soil and water conservation practices by farmers have considered a broad range of factors. The factors can be loosely grouped into personal and household attributes, farm/plot and cropping characteristics, socioeconomic and institutional factors (Knowler & Bradshaw, 2007).

The personal and household attributes include factors like education, age, family size and gender, among others. Education has been observed to have positive effects on conservation (Ersado, Amacher, & Alwang, 2004). However, as observed by Scherr and Hazell (1994), education might offer alternative livelihood opportunities in off-farm activities, thereby increasing the opportunity cost of labour and competing with labour use for agricultural production. Ersado et al. (2004) found that age has a significantly negative effect on the adoption of productivity-enhancing technology only, as well as on the sequential adoption of productivity-enhancing technology, followed by resource-conserving technology.

Amsalu and De Graaff (2007), who conducted their study in an Ethiopian highland watershed, found a weakly significant positive relation between age and the adoption of stone terraces, emphasising the inconsistency of evidence about the relationship between age and innovativeness (Amsalu & De Graaff, 2007). Contrary to their expectations, Bekele and Drake (2003) found that family size has a significantly negative relation to certain adoption choices. However, Amsalu and De Graaff (2007), who did not find a statistically significant relationship between family size and the adoption of stone terraces, found the continued use of the practice to be negatively impacted on by the size of the family. Pender and Kerr (1998) reported evidence of labour market imperfections in one of their study villages by observing that significantly more conservation investment occurs in households with more adult males and those with less females. Bekele and Drake (2003), Nkonya, Pender, Kaizzi, Edward, and Mugarura (2005) and Amsalu and De Graaff (2007) did not find any significant effect of the gender of the household head on the adoption of conservation practices, however.

Farm size is found to have mixed effects on the adoption of soil and water conservation practices. While various studies (Amsalu & De Graaff, 2007; Bekele & Drake, 2003; Ersado et al., 2004) found positive relationships between the adoption of conservation measures and farm size, Pender and Kerr (1998) found differential effects of farm size on conservation investment across the three villages they studied in India. Studies in different parts of Ethiopia (Amsalu & De Graaff, 2007; Bekele & Drake, 2003; Gebremedhin & Swinton, 2003; Shiferaw & Holden, 1998)) also found a significant positive effect of plot slope on the adoption of soil and water conservation measures. Similar results on the effect of slope have been reported elsewhere by Lapar and Pandey (1999).

Better market access has been observed to increase the adoption probabilities of conservation methods (Ersado et al., 2004). Farmers' access to information, usually measured by contact with extension officers, has had varied effects at different places. Bekele and Drake (2003) found this to have a significant effect on the decision to adopt soil and water conservation practices in the eastern highlands of Ethiopia, but Nkonya et al. (2005), Amsalu and De Graaff (2007) did not find that extension contact had any effect on the adoption of conservation measures.

From the foregoing discussion, it is clear that different factors determine the adoption of conservation practices in different parts of the world or even in different locations within a given country due to differences in the agro-ecological, as well as the socioeconomic settings under which production takes place (Bekele & Drake, 2003; Kessler, 2006). Conclusions emanating from most of the studies have tended to be case specific, and in some cases, contradictory, thereby justifying the proposed study.

## 5. Sampling and data

Sampling units for this study were drawn using the multistage spatially stratified random sampling design of the Land Degradation Surveillance Framework (Vågen, Winowiecki, Desta, & Tondoh, 2010). Four sites, as described in Section 2, were used in making up the sample data. There are 16 clusters within each site. For the Africa Rising sites, the two mother trials (established during the 2012/13 growing season) were used as centre clusters, with the other 14 clusters randomly spread around them. Each cluster covers an area of 2 $km^2$ with 10 randomly located sampling plots from where the land condition survey (LCS) was conducted. For each cluster, five farmers who owned odd-numbered plots (1, 3, 5, 7 and 9) were considered for a socioeconomic questionnaire. The socioeconomic data was collected from owners of the plots sampled during the LCS, thereby geo-referencing farmers to their sampled plots and not their place of residence. Plot owners were identified during the LCS by local persons taken from the nearest village. A household survey was conducted to gather data.

The household survey was conducted to collect primary household socioeconomic data using a structured questionnaire. Collected data includes socio-demographic and economic characteristics of the households, land characteristics and Integrated Soil Fertility Management (ISFM) technology usage. Extension service personnel, agriculture research officers and trained enumerators collected data between December 2012 and June 2013. Local extension service personnel were instrumental in establishing a better working relationship on the ground. Data on different livestock species was further converted into standard livestock units (LUs) using nutritional and feed requirement factors for sub-Saharan Africa (Chilonda & Otte, 2006).

## 6. Results and discussion

### 6.1. Descriptive statistics

Characteristics of the smallholder farmers sampled in the Chinyanja Triangle are shown in Table 2. Farmer characteristics are shown by farmer status (adopters vs non-adopters). Results show that 71.2% (222 out of 312) of the sampled smallholder farmers had adopted at least one of the land, soil and water conservation practices at the time of the survey.

In terms of age, results show that adopters were significantly older than non-adopters. This implies that in the Chinyanja

**Table 2**
Characterisation of adopters and non-adopters of land, soil and water conservation practices in the Chinyanja Triangle.

| Variable n = 312 | Adopters | Non-adopters | p-value |
|---|---|---|---|
| Sample n (%) | 222 (71.2%) | 90 (28.8%) | |
| Age (years) | 48.05 (1.002) | 42.98 (1.657) | 0.0079** |
| Education (years) | 5.44 (0.245) | 4.078 (0.363) | 0.0026** |
| Gender (% male) | 83.8 (0.025) | 81.1 (0.041) | 0.5704 |
| Household size | 5.98 (0.162) | 5.49 (0.238) | 0.1004 |
| Agricultural advice (% with access) | 73 (0.030) | 60 (0.052) | 0.0245** |
| Group membership (% yes) | 40 (0.033) | 19 (0.041) | 0.0003** |
| Distance to the nearest market (kilometres) | 9.13 (1.085) | 7.61 (0.402) | 0.3713 |
| Arable land size (acres) | 9.37 (0.829) | 10.64 (1.283) | 0.4082 |
| Land pieces (land fragmentation) | 2.43 (0.104) | 1.94 (0.103) | 0.0052** |
| Land-to-man ratio | 1.57 (0.124) | 2.15 (0.258) | 0.0246** |
| Livestock units (LUs) | 1.57 (0.315) | 1.17 (0.201) | 0.4306 |
| Income (US$) | 230.57 (15.849) | 215.20 (24.394) | 0.6008 |

*Notes*: *Standard errors in parenthesis*;
** p-value significant at 5% level.

Triangle, older farmers are more likely to adopt land, water and soil conservation technologies in comparison to younger farmers.

In terms of education, adopters were shown to have slightly more years of formal education. Statistics show that adopters, on average, had 5.44 years of formal education, compared to the 4.08 years of formal education of non-adopters, the difference being significant at a 5% level. In terms of gender, the sample did not show any significant differences between adopters and non-adopters. Household sizes were not shown to differ with farmer status. Household sizes were the same between adopters and non-adopters.

Results also show that adopters had better access (70%) to agricultural advice or extension compared to non-adopters (60%). Group membership was another important characteristic considered in this study. Results of the *t*-test show that group membership was high among adopters (40%), compared to non-adopters (19%).

The pieces of land owned or used by each smallholder farmer was also found to be significantly different between adopters and non-adopters. Adopters were found to own or use 2.43 acres on average, compared to an average of 1.94 acres owned or used by non-adopters. This result suggests that the pieces of land owned or used by small-scale farmers (land fragmentation) could be a determinant of the adoption of land, soil and water conservation measures. Furthermore, the land-to-man ratio was found to differ significantly at 5% between adopters and non-adopters. Statistics show that non-adopters had a higher land-to-man ratio of 2.15 compared to the 1.57 of adopters, which is significantly different at a 5% level.

Distance to the nearest market measured in kilometres, arable land measured in acres, LUs and income were found to be the same between the two groups of farmers (adopters and non-adopters). T-tests showed no difference in the characteristics between adopters and non-adopters at the 5% level.

To identify the trends between those farmers who were aware of and those who adopted some of the conservation measures, cross tabulations were run and part of the results were used to come up with Table 3 and Fig. 2. Table 3 and Fig. 2 compare the percentage of farmers who were aware of a specific land, soil or water conservation practice and those who actually adopted the practice at the time of the survey. Results in Table 3 and Fig. 2 show that 37.7% of the sampled farmers were aware of the practice at the time of the survey, but only 33.1% of the farmers had adopted the practice. Some 16.14% of the farmers were aware of Vetiver grass, but only 9.13% had adopted the practice. In terms of basins, 14.5% of the farmers were aware of the practice, but only 9% had adopted the practice. The same applies to ripping. About 1.4% of the farmers were reported to be aware of the conservation practice at the time of the survey, but a smaller percentage of 1.3% had adopted the practice.

**Table 3**
Awareness and adoption proportion of land, soil and water conservation practices in the Chinyanja Triangle.

| **Conservation practice** | Awareness (%) | Adoption (%) |
|---|---|---|
| Contour ridges | 37.7% | 33.91% |
| Planting Vetiver grass | 16.14% | 9.13% |
| Rainwater harvesting | 4.4% | 5.22% |
| Mulching | 2.44% | 6.09% |
| Box ridges | 22.25% | 37.39% |
| Enclose/set aside | 0.98% | 3.04% |
| Digging planting basins | 14.67% | 3.91% |
| Ripping | 1.47% | 1.30% |

Notes: Shown in the table are proportions revealing awareness (measured by farmer perception) and actual adoption of conservation practices by the farming household at the survey time.

However, the trend was different for some conservation practices like rainwater harvesting, mulching, the use of box ridges and enclose/set aside land. The percentages were higher for adoption than for awareness. For rainwater harvesting, awareness was at 4.4%, compared to 5.2% for adoption. For mulching, awareness was at 2.4%, compared to 6% for adoption. For the use of box ridges, awareness was at 22.25%, compared to 37.39% for adoption, and enclose/set aside awareness was at 0.98%, compared to 3.04% for adoption. The observed higher percentages in adoption than for awareness could partly be explained by the probable inconsistencies expected in capturing farmers' knowledge (measured by perception) on some of the practices.

The different patterns of conservation practice awareness and their subsequent adoption somehow confirm Rogers' diffusion of innovations (Rogers, 2003), which is one of the dominant models of technology adoption. Results confirm that adopters can be classified as early adopters and laggards. The theory of diffusion of innovations somehow explains the adoption behaviour of land, water and soil conservation practices by smallholder farmers in the Chinyanja Triangle (Fig. 2).

### 6.2. *Factors influencing awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle*

Table 4 shows the logistic regression results of the factors influencing knowledge and the adoption of the land, water and soil conservation practices. A number of variables were hypothesised to explain smallholder farmers' decision to adopt conservation measures and those likely to influence awareness. Results show that some attributes of household heads, such as age, education, access to agricultural advice, group membership, pieces of land owned or used by the farmer and land-to-man ratio, significantly influenced adoption decisions, while the household head's age, education, access to agricultural advice and group membership significantly influenced awareness of the conservation practices available.

The household head's age significantly influenced the likelihood of both awareness and adoption of conservation measures by farmers in the Chinyanja Triangle. The odds of a farmer unexpectedly adopting any of the land, soil and water conservation measures available in the Chinyanja Triangle were found to increase with the age of the farmer. Specifically, a one-year increase in age is associated with a 3% increase in the odds of the adoption of available land, soil and water conservation practices in the Chinyanja Triangle. The same applies to awareness. A one-year increase in the age of the farmer is associated with a 2.8% increase in the odds of the farmer being aware of at least one of the available land, soil and water conservation technologies in the Chinyanja Triangle. Results imply that age positively influenced both the awareness and adoption of conservation measures in the study areas. A probable explanation is that older farmers, with their experience, easily get information from extension personnel and other sources. Consequently, they tend to be aware of new developments in agricultural systems and hence assess and adopt new practices more often than younger farmers. Results are consistent with those of Amsalu and De Graaff (2007), who found a significant positive relation between age and the adoption of stone terraces. However, the results were contrary to findings of some other studies ( Shiferaw & Holden, 1998; Sureshwaran, Londhe, & Frazier, 1996).

Results also show that, for education, a one-year increase in the number of years the farmer attended formal education actually increases the odds of adoption and awareness of the conservation measures by 13% and 22% respectively. This result simply shows the importance of education in raising the awareness of the farmer and increasing the farmer's chances of adopting important conservation measures for sustainable farming practices. Results were

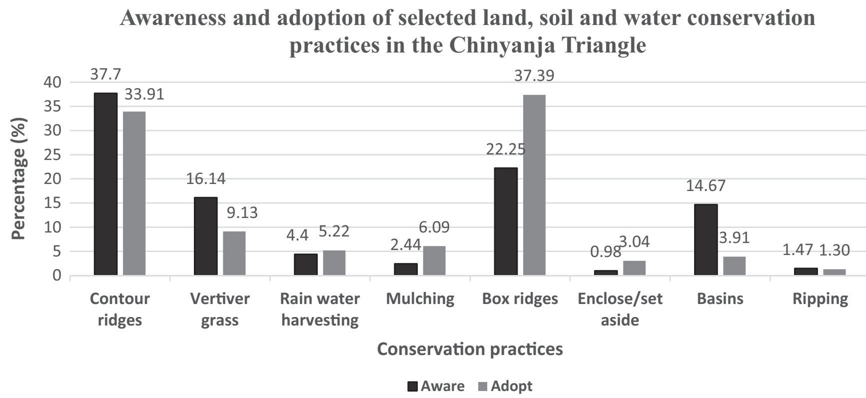


**Fig. 2.** Awareness and adoption of land, soil and water conservation practices in the Chinyanja Triangle.

**Table 4**
Logit regression results: adoption and awareness of land, soil and water conservation technologies within the Chinyanja Triangle.

| Variable | | Adoption model | | Awareness model | |
|---|---|---|---|---|---|
| | Variable measurement | Odds ratio | Standard error | Odds ratio | Standard error |
| Constant | Constant | 0.0783647$^{***}$ | 0.0700518 | 0.217$^{**}$ | 0.219 |
| Sexhh | Gender of household head | 1.037363 | 0.3969003 | 0.821 | 0.3969003 |
| Agehh | Age of household head in years | 1.029625$^{***}$ | 0.0108617 | 1.028$^{**}$ | 0.0108617 |
| Eduhh | Years of formal education | 1.131867$^{**}$ | 0.0561531 | 1.221$^{***}$ | 0.0561531 |
| AgricAdvice | Access to agricultural advice | 1.709151$^{*}$ | 0.5076618 | 2.626$^{***}$ | 0.5516253 |
| Group | Membership to community group/organisation | 2.569133$^{***}$ | 0.8853006 | 2.096$^{*}$ | 0.0897203 |
| Qoccup farming | Farming as main occupation | 1.356035 | 0.5516253 | 1.100 | 0.1407127 |
| Hhsize | Household size | 1.004585 | 0.0897203 | 0.980 | 0.1170304 |
| Literacy | Number of people who can read and write in the household | 0.9964237 | 0.1051483 | 0.982 | 0.1236829 |
| Income | Total annual income in US$ | 0.9998779 | 0.0006354 | 1.001 | 0.1051483 |
| LUhh | Total livestock units owned by household | 1.011693 | 0.0645886 | 1.003 | 1.601677 |
| Aland_size | Arable land Size owned by household in acres | | | 1.059 | 0.046 |
| landpieces | Pieces of land owned by household | 1.292485$^{**}$ | 0.1596813 | | |
| economically active | Number of economically active household members | 1.182343 | 0.1407127 | 1.045 | 0.138 |
| DepRatio | Dependency ratio | 1.053135 | 0.1170304 | 1.055 | 0.125 |
| Labour | Family labour | 0.9082504 | 0.1236829 | 0.865 | 0.134 |
| electricity | Access to electricity | 2.321876 | 1.601677 | 2.344 | 1.665 |
| ObtainCredit | Access to agricultural credit | 0.8266229 | 0.3011849 | 1.280 | 0.559 |
| MktDist | Distance to nearest market in kilometres | 1.00963 | 0.0140418 | 1.016 | 0.020 |
| LandManRatio | Land-to-man ratio | 0.8524684$^{**}$ | 0.0655738 | 0.772 | 0.149 |
| Number of obs. | Number of observations | **304** | | 304 | |
| LR chi2(18) | | **52.93**$^{***}$ | | 49.68$^{***}$ | |

*Notes*:
$^{*}$ p-value significant at 10%;
$^{**}$ p-value significant at 5%;
$^{***}$ p-value significant at 1%.

consistent with those of several other studies (Amsalu & De Graaff, 2007; Ersado et al., 2004; Pender & Kerr, 1998;), who found that educated farmers are able to process information and evaluate technologies.

As far as agricultural advice is concerned, the odds of adoption were found to be 1.71% greater for smallholder farmers with access to agricultural advice. The odds of awareness were found to be 2.63% greater for farmers with access to agricultural advice. The result implies that agricultural advice plays a very important and effective role in disseminating information on new practices and technologies. Hence, farmers with access to agricultural advice have an edge in getting information about land, soil and water conservation technologies, and also of adopting the practices. Actually the result implies that extension (agricultural advice) remains the main source of information on improved production methods and sustainable agricultural practices in smallholder agriculture, which is consistent with the findings of Bekele and Drake (2003). Nyangena and Juma (2014) found similar results in their study and attributed the higher adoption rate to increased knowledge and awareness of the existing technologies provided by extension services.

Results from the logistics analysis reveal that group membership was another significant factor in influencing both awareness and adoption. The odds of awareness are 2.1 times greater for farmers who belong to farmer groups within their communities. The odds of the adoption of conservation practices are 2.6 times greater for farmers who belong to farmer groups within their communities. A possible explanation is that farmers in farmer groups get information from other members. Some farmers who are early adopters of certain practices/technologies can share testimonies (success stories) on the practices they tried, which can encourage other farmers to adopt those particular practices. Bandiera and Rasul (2006) also found that group membership enhances social networking, which facilitates the sharing of experiences about technologies and building confidence in those interested in the technologies. Moreover, farmer groups generate what is called ‘social capital’ which facilitates information sharing. Therefore, members of those groups benefit from the generated social capital within those groups, which positively affects knowledge and the adoption of conservation measures. Results are consistent with those of Bekele and Drake (2003), and Nkegbe, Shankar, and Ceddia (2012). The authors came to similar conclusions in their studies of farmer adoption decisions. Their findings confirmed the importance of social capital in influencing the adoption of conservation practices.

In addition, pieces of land owned or used by the household for agricultural purposes was also a significant influencing factor for the adoption of conservation practices. An additional piece of land owned or used by the household increases the odds of the adoption of conservation practices by 29%. A possible explanation might be that, with an increase in the pieces of land owned, risk of loss of harvest due to a lack of proper conservation practices may increase. Hence, the farmer is encouraged to adopt conservation practices to minimise the potential losses. More pieces of land used by the farmer are associated with greater wealth and increased availability of capital, which therefore increases the probability of investment in soil, water and/or land conservation measures. Results are consistent with those of Tadesse and Belay (2004), who made conclusions in support of this finding. They found ownership of more pieces of land to be associated with greater wealth and the increased availability of capital resources, which increases the likelihood of farmers making investments in land, soil and water conservation measures.

The land-to-man ratio was another significant factor that influenced adoption. The odds of adoption were found to decrease by 15% with an increase in the land-to-man ratio by a single unit. Results imply that an increase in the land area per capita actually discouraged people to adopt conservation measures. A possible explanation is that, with an increase in the arable land area, costs of installing some of the conservation measures, such as labour costs, increase. This discourages the adoption of those particular practices. This is consistent with the findings of Lapar and Pandey (1999). The authors found that costs associated with installing land, soil and water conservation measures increased with the size of arable land, which therefore acts as a barrier to adoption by the smallholder farmer.

## 7. Conclusions and implications

This study did set out to analyse the behaviour of smallholder farmers in the adoption of land, soil and water conservation measures within the Chinyanja Triangle, and tried to identify socioeconomic factors that influence knowledge and the adoption of available conservation measures within the study area.

Empirical results show that certain socioeconomic characteristics like the age and education of the household head, agricultural advice reception, farmer group membership, pieces of land owned or used in production, and land-to-man ratio differ significantly between adopters and non-adopters. Results also show that awareness and adoption patterns of specific conservation measures vary and could possibly explain Rogers' innovation decision theory. Moreover, empirical results from the binomial logistic regressions show that the major socioeconomic factors influencing knowledge of land, soil and water conservation measures in the study area are age, number of years of formal education, agricultural advice reception and farmer group membership. On the other hand, major factors that influence the adoption of land, soil and water conservation measures in the study area are the age of the household head, the household head's number of years of formal education, agricultural advice reception, farmer group membership, pieces of land owned or used in production by the farmer and land-to-man ratio.

An important implication of the results is that any intervention in land, soil and water conservation practices in the study area should recognise heterogeneity in household socioeconomic and farm-specific characteristics. In addition, results imply that knowledge (awareness) is an important aspect in the adoption of soil, land and water conservation measures, and any proposed interventions should pay more attention to awareness in order to improve the adoption of available conservation measures for better results.

Study results suggest that governments' policies should encourage formation of grassroots organisations such as farmer groups. This will not only ease targeting the extension group approach but also will improve social capital amongst farmers. Farmer to farmer learning has been determined to enhance adoption of new technologies. It is also necessary to enhance farmer education, and increase extension outreach in order to disseminate information on new technologies and to raise awareness. Therefore, the innovation decision process in conservation practices is enhanced.

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