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Factors Influencing the Implementation of Soil and Water Conservation in Carrot Farming in East Java, Indonesia

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Abstract. Conservation farming is part of the effort to minimize disturbances in agriculture such as floods, landslides, damage to soil aggregates, and chemical and biological soil properties on sloping land. One of the efforts to develop horticultural farming carried out in Sumberbrantas and Wonokerso villages is mostly carried out on sloping land so it needs attention because land is one of the important production factors in farming. This study aims to analyze the factors that influence farmers' decisions in implementing conservation farming. The research was conducted on carrot farms located in Sumberbrantas and Wonokerso villages, which were determined through a probability sampling approach using a simple random sampling technique conducted in August 2023. The research sample amounted to 59 respondents who were carrot farmers in Sumberbrantas and Wonokerso villages. The variables used include socio-demographics, agricultural extension, knowledge of the importance of land conservation, knowledge of conservation farming, and knowledge of how/techniques to carry out land conservation, with the dependent variable of conservation adoption level analyzed using path analysis to determine the factors that influence farmers in implementing conservation farming. The results showed that agricultural extension variables and conservation farming knowledge directly and significantly affect the level of conservation adoption by carrot farmers in East Java. Meanwhile, socio-demographic variables (age, formal education level, farming duration, household size, and land size) directly affect conservation farming knowledge. This research highlights several important points for agricultural development and conservation. Agricultural extension programs need to be strengthened while more targeted training programs are developed. When designing these programs, it is important to consider farmers' socio-demographic factors for more effective implementation. The research findings will contribute to efforts to support agricultural sustainability in hilly areas and can serve as material for developing more comprehensive agricultural conservation efforts.

Keywords: farming; land degradation; path analysis; soil and water conservation

INTRODUCTION

Soil and water conservation is the utilization of land resources such as soil and water to overcome land degradation. Land degradation is an environmental process that results in decreased soil productivity due to soil erosion and changes in soil hydrological, biological, physical and chemical properties that can occur naturally or through human activities (Abdullahi et al., 2023; Kehinde et al., 2022). Soil damage due to land degradation that occurs over a long period of time can make the land unusable. If attempted to be reused, the land is considered less fertile and unproductive so it takes a long time to restore soil fertility and quality (Jiwa Jeni et al., 2023). Factors leading to land degradation include agricultural activities on hillsides, heavy rainfall, wind, erosion due to tillage and undesirable soil chemical, physical and biological processes due to improper agricultural practices (Belay et al., 2017; Belayneh, 2023). Land degradation due to erosion has a significant impact on agricultural productivity and overall economic growth of the country (Asfew et al., 2023; Betela & Wolka, 2021).

To minimize the occurrence of land degradation due to soil erosion, efforts need to be made, one of which is by implementing soil and water conservation practices. Mitigating soil erosion through appropriate soil and water conservation measures should be a priority to ensure soil health and preserve soil functions, especially on sloping land designated for agriculture (Betela & Wolka, 2021). There are various soil conservation techniques applied by farmers to reduce soil erosion, but effective soil conservation practices are grouped into three main strategies, namely soil management (vegetative methods), mechanical soil

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conservation (mechanical methods), and chemical methods (Sarminah & Karyati, 2018). Soil and water conservation can increase crop yields and land productivity (Debie et al., 2019).

The implementation of soil and water conservation by farmers is influenced by various factors. Most farmers who are in their productive age are more likely to adopt soil and water conservation practices (Betela & Wolka, 2021). Farmers with many years of farming experience have a good understanding of erosion problems and the importance of soil and water conservation in the long term (Belayneh, 2023). Furthermore, Asfaw & Neka (2017) found that educated farmers are able to understand the importance of soil and water conservation measures and are more likely to accept and implement them on the farm. The higher the education level of farmers, the more likely they are to adopt soil and water conservation (Guo et al., 2022). Yirgu (2022), found that land size has a significant influence on the adoption of soil and water conservation measures. Ngaiwi et al., (2023) stated that the number of family members can increase farmers' potential to implement soil and water conservation. In addition, larger household sizes are more likely to engage in agricultural activities (Malila et al., 2023). Furthermore, farmers who are aware of the importance of soil and water conservation measures are more likely to adopt soil and water conservation measures than farmers who are not aware of the importance of soil and water conservation measures. Lack of knowledge and awareness (Xiao et al., 2020) lack of information sources and information exchange (Mugandani & Mafongoya, 2019) and reliance on traditional farming methods are the main causes of non-adoption of soil and water conservation measures (Somasundaram et al., 2020). Hermans et al., (2020) point out that gaps in soil and water conservation adoption are influenced by the exchange and interpretation of information within the farming community. Therefore, through access to agricultural extension services, farmers can obtain various information on conservation farming practices and other information that helps them manage their farms (Maake & Antwi, 2022). Efforts to increase land productivity in the long term can be done by managing land use balanced with farmers' knowledge of environmental sustainability (Santoso et al., 2023). Farmers' knowledge of conservation is an important aspect in the implementation of soil and water conservation measures (Mango et al., 2017).

Agricultural land use in Sumberbrantas and Wonokerso Villages is still less than optimal. Although farmers' understanding of the need and importance of soil and water conservation is increasing, they have not fully implemented soil and water conservation systems to support agricultural production. Soil and water conservation is important to increase land productivity and improve the living standards of rural households (Karidjo et al., 2018). Therefore, it is important to create enabling conditions so that many farmers can use soil and water conservation methods (Wordofa et al., 2020). The implementation of measures in soil and water conservation can be achieved if they are consistently and thoroughly applied in the farming system (Ali, 2021). This research aims to identify factors that influence farmers in implementing conservation farming. Analysis of these factors is necessary to design appropriate support systems to assist in promoting conservation farming practices.

METHODS

Place and Time of Research

This research was conducted in Sumberbrantas Village, Bumiaji Subdistrict, Batu City and Wonokerso, Sumber Subdistrict, Probolinggo Regency. The determination of the research location was carried outpurposively on the basis of consideration of Sumberbrantas and Wonokerso Villages as potential carrot farming land, the location of agricultural land in both villages is mostly sloping land which is recommended to apply conservation

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farming in order to preserve the environment, farmers in both villages have not fully implemented conservation farming properly. This research is included in quantitative research with a descriptive approach and was conducted in August 2023.

Table 1. Measurement indicators of socio-demographic variables

Characteristics	Scoring Criteria	Category	Frequency	%
Age	1	< 25	2	3.39
	2	25 - 35	16	27.12
	3	36 – 45	18	30.51
	4	46 – 55	17	28.81
	5	> 55	6	10.17
Formal Education	1	Not graduated from elementary school	1	1.69
	2	Elementary school graduate	38	64.41
	3	Junior high school graduate	9	15.25
	4	High school graduate	6	10.17
	5	College Graduation	5	8.47
Length of Time in Farming	1	< 10	22	37.29
	2	10 – 15	14	23.73
	3	16 – 20	6	10.17
	4	21 – 25	10	16.95
	5	> 25	7	11.86
Household Size	1	1	1	1.69
	2	2	7	11.86
	3	3	23	38.98
	4	4	21	35.59
	5	5	7	11.86
Land Area	1	< 0,1	2	3.39
	2	0,1 - < 0,5	31	52.54
	3	0,5 - < 1	12	20.34
	4	1 - 1,5	13	22.03
	5	> 1,5	1	1.69

Source: Primary Data Processed, 2024

Research Materials and Tools

The sampling approach in this study was a *probability* sampling approach using *simple random sampling* technique. The population in this study were carrot farmers in Sumberbrantas and Wonokerso villages totaling 374 people. The sample size was determined using the Slovin formula with an error rate of 12% and the sample obtained was as many as 59 carrot farmers with a total of 374 people.

The data collected in this study are primary data and secondary data. Primary data in a study is obtained directly from the source by taking measurements, counting themselves in the form of questionnaires, observations and interviews. Primary data collection techniques in this study used observation (direct observation at the research site) and interviews (the tool uses a questionnaire). Meanwhile, secondary data is obtained indirectly from other people, offices in the form of reports, profiles, manuals and libraries (Hardani, 2022).

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Table 2. Variable measurement indicators

Variables	Indicator Variable	Scoring Criteria
Agricultural Extension (AE)	General Land Conservation Counseling Counseling on the Importance of Terraces Conservation Farming Extension Viewing the Terracing Demonstration Plots Viewing Conservation Farming Demonstration Plots	(1) Yes; (2) No; (3) Don't know
Knowledge of the Importance of Conservation (KIC)	I know that my area has a high slope I know that if there is no land conservation it will cause landslides I know that if there is no land and water conservation, the soil will be eroded I know that if there is no land and water conservation, farming costs will be more expensive. I know that my land has a high slope and therefore needs conservation farming.	(1) Very don't know ; (2) Little know; (3) Know enough; (4) Know; (5) Very Know
Conservation Farming Knowledge (CFK)	I know the benefits of terracing on sloping land. I know the benefits of terrace reinforcement plants on sloping land. I know the benefits of water infiltration channels on sloping land. I know the benefits of drainage on sloping land. I know the benefits of fertilizing with organic fertilizer	(1) Very don't know ; (2) Little know; (3) Know enough; (4) Know; (5) Very Know
Knowledge of Conservation Techniques (KCT)	I know how to make terraces according to the slope of the land I know the types of plants and how to plant terrace enhancing plants on sloping land I know how to make water infiltration channels on sloping land I know how to make a drainage channel on sloping land I know how to fertilize with manure	(1) Very don't know ; (2) Little know; (3) Know enough; (4) Know; (5) Very Know
Conservation Adoption Rate (CA)	Terrace Treatment Planting of terrace reinforcement plants Creation of infiltration channels Construction of a water drain Penggunaan pupuk kandang	(1) None; (2) 1 - 25%; (3) 25 - 50%; (4) 50 - 75%; (5) > 75%

Source: Primary Data Processed, 2024

Data Analysis Techniques

Path analysis is an extension of multiple linear regression analysis or path analysis is the use of regression analysis to explain the causal relationship between variables (casual models) that have been previously determined, with the aim of explaining the direct and indirect effects and the total effect of variables as causal variables, on other variables which are the effect variables (Sarwono, 2012). The following are some of the hypotheses proposed in this study:

H1. Conservation adoption rate is influenced by agricultural extension.

H2. Conservation adoption rate is influenced by farmers' knowledge of conservation farming.

H3. Conservation adoption rate is influenced by farmers' knowledge of conservation

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techniques/how to do conservation.
H4. Conservation adoption rate is influenced by farmers' socio-demographics.
H5. Farmers' knowledge of conservation farming is influenced by farmers' knowledge of the importance of conservation.
H6. Farmers' knowledge of conservation techniques/how to implement conservation is influenced by farmers' knowledge of the importance of conservation.
H7. Farmers' knowledge of conservation farming is influenced by farmers' socio-demographics.
H8. Farmer's knowledge on conservation techniques/how to do conservation is influenced by farmer's knowledge on conservation farming.
H9. The level of conservation adoption is influenced by farmers' knowledge of the importance of conservation through farmers' knowledge of conservation farming.
H10. Knowledge of conservation techniques/methods is influenced by farmers' socio-demographics through knowledge of conservation farming.
H11. Conservation adoption rate is influenced by farmers' knowledge of the importance of conservation through farmers' knowledge of conservation farming and knowledge of conservation techniques/methods.
H12. Conservation adoption rate is influenced by farmers' knowledge of conservation farming through farmers' knowledge of conservation techniques/how to do conservation.
H13. Conservation adoption rate is influenced by farmers' socio-demographics through farmers' knowledge of conservation farming.
H14. Conservation adoption rate is influenced by farmers' knowledge of the importance of conservation through farmers' knowledge of conservation farming and knowledge of conservation techniques/how to do conservation.
H15. Farming adoption rate is influenced by farmer's socio-demographics through farmer's knowledge of conservation farming and knowledge of conservation techniques/how to do conservation.
H16. Knowledge of conservation techniques/methods is influenced by farmers' knowledge of the importance of conservation farming through conservation farming knowledge.

RESULTS AND DISCUSSION

Socio-Demographic Characteristics

Table 1 shows that most of the respondents in this study were between 36 - 45 years old (30.51). The majority of respondents had completed primary school education (64.41%) followed by respondents with secondary education (15.25%). Carrot farmers with less than 10 years of farming experience constituted the majority of respondents (37.29%) with an average farming duration of 14 years. Furthermore, based on the area of agricultural land, most of them are planted with horticultural crops such as carrots, potatoes, mustard greens and leeks, whether owned, rented or shared by farmers ranging from 0.1 to less than 0.5 ha (52.54%) with an average land area of 0.5 ha. Horticulture, including carrot farming, is the main source of livelihood for most people in Sumberbrantas and Wonokerso Villages.

Reliability and Validity Test

In this study, SmartPLS software was used to test reliability and validity. The suitability of the model under study was evaluated using confirmatory factor analysis. As presented in table 3, all factor loading values of the estimates are above the required level (0.5) and significance at the $P < 0.001$ level, where the minimum factor loading is 0.500. According to the Cronbach "s Alpha (CA) value, it is acceptable if the coefficient value is greater than 0.6. The CA coefficient greater than 0.6 indicates that the statement can be used to measure willingness to adopt. **Table 3** shows that the Cronbach's Alpha value ranges from 0.799 to 0.920 so that this CA value is acceptable. Furthermore, the *Composite Reliability* (CR) value which shows the internal consistency problem for all

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variables ranges from 0.843 to 0.940 and is above 0.7 and meets the required value level. Then, to measure the ability to vary each latent variable for each measurement object using the Average Variance Extracted (AVE) value with the required level above 0.5 from table 4, the AVE value obtained ranges from 0.554 to 0.758 so that it is acceptable. In **table 5**, it shows that the VIF values in the measurement model are all less than 5, which means that there is no multicollinearity problem in the measurement model. All variables studied have high internal consistency and combination reliability. The AVE value of all constructs is greater than 0.5 which indicates that the model has good convergent validity. Cronbach's alpha value and CR value are greater than 0.7, which means that all indicators are reliable in forming variables.

Path Analysis

The results of the path analysis model were analyzed using SmartPLS 4.0 software. This study examines several factors that influence farmers' decisions to adopt conservation farming. Referring to several previous studies, the variables of agricultural extension (PP), farmers' knowledge of conservation farming (CFK) and socio-demographic (SD) consisting of age, formal education level, household size, length of farming, and land area provide a good description in explaining the factors that influence farmers' decisions in adopting conservation farming. SD, AE, CFK, and KCT variables influence CA. Then, SD and KIC variables affect CFK. Furthermore, KIC and CFK variables affect the KCT variable. The results of the *path analysis* model are shown in **Figure 1** and **Table 4**.

The results of the path analysis in **Figure 1** and **Table 4 show** that AE and CFK have a significant direct positive effect on the level of conservation adoption (CA) by farmers with a t-value of (0.001 and 0.029), respectively. Furthermore, the KIC and SD variables have a direct positive effect on the CFK variable with a t-value of 0.001 and 0.019. Then the CFK variable has a direct positive effect on the KCT variable with a t-value of 0.001. For indirect effects, the KIC variable has a positive effect on the CA variable through CFK with a t-value of 0.042. The SD variable has a positive effect on the KCT variable through the CFK variable with a t-value of 0.044. Furthermore, the KIC variable has a positive effect on the KCT variable through the PUK variable with a t-value of 0.001.

Effect of Agricultural Extension on Conservation Adoption Rate

Agricultural extension has a significant direct influence on conservation adoption rates. Agricultural extension acts as a conduit of information by disseminating information on conservation practices. This study is in line with research conducted by Maake & Antwi (2022) who argued that through access to agricultural extension services, farmers can obtain a lot of information that can help them manage their farms. Then, research conducted by Asfaw & Neka (2017) showed that farmer households that benefit from extension services tend to have better access to information related to soil and water conservation.

Effect of Conservation Farming Knowledge on Conservation Adoption Rate

Knowledge of conservation farming has a direct and significant influence on the level of conservation adoption by farmers. Farmers' knowledge of the benefits of conservation farming such as improving soil fertility, preventing erosion, and increasing crop yields can encourage farmers to adopt this method. When farmers understand the benefits, they will be more motivated to change their farming methods. This study is in line with research conducted by (Latifah & Ekawati, 2023) which states that increasing farmers' knowledge of the environment will affect the level of adoption of conservation technology.

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Table 3. Reliability and validity test

Variables	Indicator	Loadings	Cronbach's Alpha	CR	AVE	VIF
Socio-Demographic (SD)	SD1	0.834				2.306
	SD2	0.702				1.761
	SD3	0.843	0.88	0.909	0.627	2.159
	SD4	0.804				2.192
	SD5	0.797				3.312
Agricultural Extension (AE)	AE1	0.853				3.302
	AE2	0.863				2.731
	AE3	0.906	0.92	0.94	0.758	4.404
	AE4	0.837				2.878
	AE5	0.892				3.578
Knowledge of the Importance of Conservation (KIC)	KIC1	0.598				1.429
	KIC2	0.865				3.613
	KIC3	0.885	0.873	0.905	0.619	3.624
	KIC4	0.882				5.164
	KIC5	0.689				3.502
Conservation Farming Knowledge (CFK)	CFK1	0.647				1.535
	CFK2	0.75				2.432
	CFK3	0.753	0.872	0.902	0.572	2.389
	CFK4	0.914				3.71
	CFK5	0.894				3.94
Knowledge of Conservation Techniques (KCT)	KCT1	0.500				1.969
	KCT2	0.792				4.367
	KCT3	0.76	0.846	0.869	0.597	3.437
	KCT4	0.893				3.766
	KCT5	0.849				3.508
Conservation Adoption Rate (CA)	CA1	0.648				1.449
	CA2	0.775				2.013
	CA3	0.782	0.799	0.843	0.554	2.235
	CA4	0.79				3.453
	CA5	0.785				3.949

Note: CR: Composite Realibility; AVE: Average Variance Extracted; VIF: Variance Inflation Factors (Source: Data Processing Results, 2024).

The Effect of Knowledge of the Importance of Conservation on Knowledge of Conservation Farming

Knowledge of the importance of conservation directly and significantly influences knowledge of conservation farming. This is by research conducted by (2019), which states that the more farmers understand the importance of conservation, the more knowledge they have about effective conservation farming practices. Awareness of the importance of conservation then encourages farmers to seek information and solutions to overcome environmental problems on their land.

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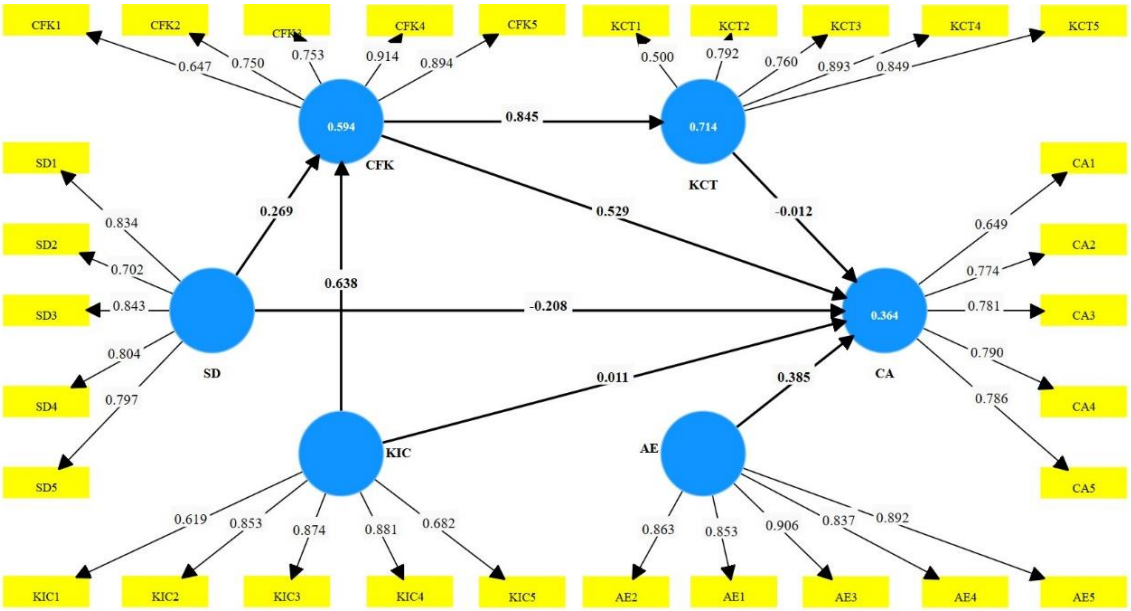

Figure 1. Path Analysis Model

Table 4. Hypothesis test results

Hypothesis	Influence	Path Coefficients	P-value	Hasil
H1	Direct	AE -> CA	0.001***	Accepted
H2	Direct	CFK -> CA	0.029**	Accepted
H3	Direct	KCT -> CA	0.976	Rejected
H4	Direct	SD -> CA	0.147	Rejected
H5	Direct	KIC -> CFK	0.001***	Accepted
H6	Direct	KIC-> KCT	0.834	Rejected
H7	Direct	SD -> CFK	0.019**	Accepted
H8	Direct	CFK -> KCT	0.001***	Accepted
H9	Indirect	KIC -> CFK -> CA	0.042**	Accepted
H10	Indirect	SD -> CFK -> KCT	0.044**	Accepted
H11	Indirect	KIC -> KCT -> CA	0.995	Rejected
H12	Indirect	CFK -> KCT -> CA	0.977	Rejected
H13	Indirect	SD -> CFK -> CA	0.148	Rejected
H14	Indirect	KIC -> CFK -> KCT -> CA	0.978	Rejected
H15	Indirect	SD -> CFK -> KCT -> CA	0.979	Rejected
H16	Indirect	KIC -> CFK -> KCT	0.001***	Accepted

Note: ***,**,* significance at α 1%, 5%, and 10%, R^2 PUK = 0.594 (Medium), R^2 PTK = 0.714 (Medium), R^2 TAK = 0.364 (Weak). Source: Data Processing Results, 2024

Socio-demographic Influence on Knowledge of Conservation Farming

Farmers' socio-demographics, consisting of age, formal education level, length of farming, household size, and land size, significantly influence farmers' knowledge of conservation farming. This is in line with research conducted by Guo et al., (2022) which states that the increasing age, the higher their knowledge of environmental sustainability. Gusti et al., (2022) stated that farmers with many years of farming

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experience tend to understand better and know land conditions. Educated farmers are considered to have access to new technologies and innovations and are more receptive to new ideas (Kerse, 2018).

Larger farmer households allow for the exchange and application of knowledge on conservation farming (Belachew et al., 2020). Kerse (2018) found that land size positively impacted conservation farming knowledge. This suggests that farmers with relatively large land holdings have greater opportunities to access conservation information and thus have the knowledge capital to optimize their land.

Effect of Knowledge of Conservation Farming on Knowledge of Conservation Techniques/Methods

Knowledge of conservation farming directly and significantly influences knowledge of conservation techniques/methods. Farmers' knowledge of conservation farming equips them with the necessary skills and techniques to implement conservation activities effectively. This study is in line with the research of (2023), which states that farmers' knowledge of conservation can help farmers develop technical skills in conservation, and knowledge of techniques/how to do conservation can influence farmers in implementing conservation agriculture.

The Effect of Knowledge of the Importance of Conservation on the Level of Conservation Adoption Through Knowledge of Conservation Farming

Knowledge of the importance of conservation indirectly influences the level of conservation adoption through conservation farming knowledge. Knowledge of the importance of conservation can increase farmers' motivation to learn and adopt conservation farming practices. Knowledge of conservation farming can increase farmers' confidence in implementing conservation because they know how and what to do. Combining these two knowledge can encourage farmers to change their behavior and adopt sustainable conservation practices. Therefore, farmers' understanding of land conservation is crucial because knowing about conservation farming will help them implement conservation (Siswanto et al., 2021).

Effect of Importance of Conservation Knowledge on Knowledge of Conservation Techniques/Methods through Conservation Farming Knowledge

The importance of conservation knowledge indirectly influences knowledge of conservation techniques/methods through conservation farming knowledge. The more conservation knowledge farmers have, the greater their awareness of environmental issues such as land degradation, erosion and biodiversity loss. This awareness can motivate farmers to find solutions to prevent these environmental problems (Sileshi et al., 2019).

CONCLUSION

Based on the results, it can be concluded that young, productive and highly educated farmers with many years of farming experience are more open to new conservation technologies and methods such as having skills in natural resource management including conservation. Farmers with larger household sizes can access conservation information more easily. Then, farmers with relatively large land holdings have greater access to conservation information, so they have the knowledge capital to optimize their land. Furthermore, effective agricultural extension can increase farmers' knowledge and awareness of the importance of soil and water conservation, as well as provide information on appropriate techniques and methods to be applied. Adequate conservation knowledge is important for farmers to effectively implement conservation measures.

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Suggestions from this study include the need for basic policies such as organizing training and workshops for farmers on effective conservation techniques and involving the government, research institutions, and the private sector in efforts to encourage the implementation of soil and water conservation. The researcher realizes the limitations of the variables used in this study, such as climate change and weather variability variables. Therefore, other variables not examined in this study can be considered for future research.

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