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Assessing Farmers' Knowledge, Attitudes, And Behavioural Intentions in Relation to The Transfer of Alternative Wood Preservation Technologies in Rural Ethiopia

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Abstract

Alternative wood preservative technology prevents wood damage and enhances wood service life for local construction in contact with the ground contact. Hence, the promotion of wood preservative technology and the evaluation of knowledge, attitude, and behavioral intention necessitate a causal effect relationship assessment in rural Ethiopia. Farmers were invited for the training in rural kebele, where subterranean termites highly affected local construction with ground contact. During the training, theoretical, demonstration, and group discussion were used as methods for technology transfer. Accordingly, the causal effect relationship of knowledge, attitude, and behavioral intention was evaluated using PLS_SEM using Smart PLS 4 version software. The study results show that, due to local experience, using used motor oil is better preferred over others chemical preservatives. The practical method demonstration influences the attitude of farmers toward future applications. The causal effect analysis result shows that knowledge directly influences attitude (β = 0.609; P-value = 0.000), and subsequently, an attitude directly influences behavioral intention (β = 0.822; P-value = 0.000). Thus, attitude mediates the causal effect relationship between the knowledge and behavioral intention of the farmers. Therefore, the study implies that expanding knowledge of local experience and practical training on technical skills for rural farmers should be given primary attention for forest product technology promotion in rural areas.

1. Introduction

Various technologies related to forest product utilization have been commended for rational utilization and forest resource conservation in Ethiopia (Tadesse et al., 2012). Preservation of wood was among the technologies recommended for treating wood against biodegrading agents as it enhances its wood service life in construction and furniture sectors, particularly for rural construction with ground contact in the Ethiopian context (Desalegn, 2013). Due to the significant damage to forest products by subterranean termites, it was suggested that dissemination of information and technologies related to treating wood for local construction purposes in rural areas (Desalegn, 2015). It was found that different preservative measures like borax and boric acid, and used motor oil for wood products affected by termites; and wood species naturally resistant to termites especially for construction with ground contact need to be promoted (Desalegn et al., 2021).

Research and experiences have shown that the integration of modern technologies and local knowledge needs to be considered for better results in technology transfer. According to Gebrekidan et al., (2018), indigenous knowledge plays a greater role in integrating with modern knowledge in the utilization practices of wood products. Knowledge could better work for the transfer of technology in taking into account the context of local specific as farmers recognizing for technology generation and adoption process (Šūmane et al., 2018). Vagnani & Volpe (2017) put forward research on the innovation process and decision indicating that contextual factors matter for technology take up. Thus, Innovations that are easily communicable, observable, and demand-driven could be received and accepted through awareness creation and increasing knowledge (Wynn, 2017). In complementary, technology attributes like observability, trial-ability, and comparative advantages have significant influences on positive attitudinal change in technology acceptance (Tan, 2020; Saengavut & Jirasatthumb, 2021).

Studies have shown that regardless of technology type; beyond innovation attributes causal relations of knowledge, attitude, and behavioral intention played major roles in the technology adoption process (Bakkabulindi, 2014). Research indicated that rural farmers' technology adoption was highly influenced by the characteristics of adopters mainly knowledge, attitude, and perceptions, as well as by technology character and local context (Meijer et al., 2015). Studies related to technology promotion have shown that knowledge was the base leading to a change in attitude and skill by increasing the level of adoption of technology (Nazuri et al., 2018). Thus, technology adoption requires both technology attributes and, adopters' better knowledge and positive attitude for practical decisions (Zossou et al., 2020).

Studies on knowledge and attitude in the transfer of technology for behavioral change showed that a significant relationship induced a causal effect (Baba-Nalikant et al., 2023). However, technologies need to be available for farmers to practice with better training. Having better knowledge and a positive attitude cannot alone ensure the adoption of technologies (Ntawuruhunga et al., 2020). Thus, the proper interaction of knowledge, attitude, and practice is necessitated in technology promotion (Sivarao et al., 2021). The limitation of technology promotion related to forest product utilization, and the absence of studies on knowledge, attitude, and adoption relationship initiated this study. Based on research results and local experiences; preservatives and methods of forest product treatments for rural construction with modern chemicals and used motor oil techniques as well as information related to selected naturally resistant tree species were promoted for rural farmers. According to Endalamaw & Darr (2021), rural areas can serve as a source of knowledge and technical skills as long-time experience with forest product processing and utilization. Therefore, this study aimed to assess the causal relationship between knowledge, attitude, and behavioral intention of rural farmers on wood preservative alternatives.

2. Methodology

2.1 Participants and Setting

The study was conducted in the rural Kebele administration called Golba Aluto in the East Shewa Zone of Oromia, where there was a demand for preservative technologies due to the high damage of subterranean termites on local area. This kebele was also where a research station was established for different experimentation on protection methods. Local people of the village have also some experiences of practice in treating wood for local construction for prevention of wood deteriorating agents. For the study and technology transfer, training was organized through a group approach for theoretical training, method and result demonstration, and group discussion about scientific information and techniques on how to eradicate the influence of termites using treatments for construction purpose. It was indicated that the group approach enhanced the effect of relationships among knowledge, attitude, and practice for technology transfer (Hassan, 2016).

2.2 Instruments

Based on experts with accumulated experience in related research, questionnaires for knowledge evaluation; attitude tests, and behavioral intention in connection to theories of technology scaling up were designed. The questioner for the knowledge test was evaluated based on a four-point scale, which was 4(understanding well), 3(moderate understanding), 2(little understanding), and (unsure); whereas attitude and behavioral intention were assessed based on five points Likert type scale, which were 5(strongly agree), 4(agree), 3(neutral) and 2(disagree) and 1(strongly disagree).

In such a way, 20 indicators were formulated related to general information and techniques about alternatives of preservative methods of Used motor oils, borax and boric acid wood treatments as well as about naturally resistant timber species to termites. Accordingly, 6 indicators for general information; 7 indicators for used motor oil, and 7 indicators for chemical applications were administered separately for later knowledge evaluation. Consequently, six indicators for the attitude test and five indicators to measure behavioral intention for the adoption of preservative methods were applied. Finally, 67 of the training participants, who actively participated in the training were purposively selected and voluntarily interviewed for evaluation of the causal relationship among knowledge, attitude, and behavioural intention to practice.

2.3 Data Analysis

Various literature and established theories proposed for structural equation modeling (SEM) for statistical analysis of unobservable variables through indicators. The model advances over a long time as research needs arise for different objectives on the ground including knowledge management as PLS_SEM introduced for causal effect assessment among latent variables (Cepeda-Carrion et al., 2018). Hence, this study applied PLS_SEM for causal relationship explanation among knowledge, attitude, and behavioral intention. The application of PLS_SEM in social science is highly recommended as reality on the ground such as with small sample size, and non-normal data as well as it combines the explanatory and predicator nature of the model (Hair et al., 2017; Yahaya et al., 2019; Hair et al., 2021). Other authors complemented that PLS_SEM applications for prediction power involve formative indicators for structural model assessment as well as through effect size. They also suggested that the model advantages for reporting through bootstrapping and weighting mechanisms (Ringle et al., 2012; Nitzl, 2016; Hair et al., 2019).

3. Results

3.1 Participants' Characteristics

The training participants were all farmers, and almost the majority were married male household heads (97%) who engaged in rudimentary local construction affected by termites. The average age of the sample respondents was 38.3 yrs, with a minimum and maximum of 20 years and 68 years' age respectively. In terms of educational level, most of them were literate (97%) with basic reading and writing, primary, secondary, and tertiary levels in the Ethiopian context (Table 1).

Table 1 *Participant's profile*

No.	Profile	Categories	Frequency	Percent
1	Gender	Male	65	97.01
		Female	2	2.99
2	Marital status	Single	2	2.99
		Married	65	97.01
3	Educational level	Illiterate	2	2.99
		Read and write	4	5.97
		Primary	27	40.30
		Secondary	30	44.78
		Tertiary	4	5.97

Source: Own data computation (2023)

3.2 Farmers' Awareness of Alternative Preservatives

Knowledge related to alternative preservatives measurement on information, and technical procedures related to alternative tree species, used motor oil, and chemicals have shown the majority of the training participants understood relevant information and technical procedures. Except for chemical treatment, the majority of the farmers viewed their understanding of different alternatives of treatment, durability of tree species, used motor oil, and methods of treatments (Table 2). The results of the study show that over 90% of the respondents at least moderately understood on scale measurements of knowledge tests (K1 to K6) of information related to wood treatments and durability of tree species except for information related to chemicals (K5).

Table 2 *Knowledge test on alternative preservatives and timber species*

No.	Indicators	Well		Moderate		Little		Not sure		Median
		Fre	%	Fre	%	Fre	%	Fre	%	
1	Different alternatives of preservatives for wood durability treatment(K1)	46	68.66	16	23.88	1	1.49	4	5.97	4

2	The durability of perishable wood species utilization can be increased through alternative treatments (K2)	49	73.13	16	23.88	1	1.49	1	1.49	4
3	Natural durable wood species can further durable(K3)	45	67.16	20	29.85	2	2.99	-	-	4
4	Used motor oil is among the preferable traditional preservatives(K4)	55	82.09	12	17.91	-	-	-	-	4
5	Boric and borax acid in combination is proven to be modern wood preservatives(K5)	25	37.31	30	44.78	7	10.45	5	7.46	3
6	The dipping method can serve both traditional and modern preservatives for wood treatments(K6)	40	59.70	26	38.81	1	1.49	-	-	4

Source: Own data computation (2023)

3.3 Knowledge Test on Technical Procedures of Preservatives

The results on technical procedures for used motor oil and chemicals have shown majorly positive results regarding steps needed to be taken, and their applications for local construction. Particularly, the measurements presented for used motor oil (K7 to K13) relatively scored better than for chemical (K14 to K20) measurements by the participants (Table 3). Thus, the median statistical results of all statements presented of used motor oil measured at 4-point score, while the median results of some statements for measurement of chemical is 3 though the majority statements showed 4-point score.

Table 3 *Knowledge of technical procedures of used motor oil and chemical*

No.	Indicators	Well		Moderate		Little		Not sure		Median
		Fre	%	Fre	%	Fre	%	Fre	%	
1	Preparation of an empty barrel and three stove stones (K7)	55	82.09	12	17.91	-	-	-	-	4
2	Putting the empty barrel on three stone stoves (K8)	49	73.13	16	23.88	1	1.49	1	1.49	4
3	Adding used motor oil into a barrel (K9)	54	80.60	12	17.91	1	1.49	-	-	4
4	Dipping part of the wood, which will be in contact with the ground (K10)	52	77.61	13	19.40	1	1.49	1	1.49	4
5	Boiling oil at the necessary boiling point with wood ready for treatment (K11)	47	70.15	18	26.87	1	1.49	1	1.49	4
6	Cooling barrel with oil and treated wood for 24 to 36 hrs. (K12)	45	67.16	18	26.87	2	2.99	2	2.99	4
7	Taking out and cleaning for application of treated wood(K13)	43	64.18	22	32.84	-	-	2	2.99	4
	Indicators for chemical procedures									
8	Preparation of empty barrel or plastic container (K14)	44	65.67	22	32.84	1	1.49	-	-	4
9	Adding water with a proportion of 95% to the prepared container (K15)	33	49.25	30	44.78	2	2.99	2	2.99	3
10	Adding chemicals with the concentration of chemicals (5%); the ratio of borax t (K16)	39	58.21	23	34.33	5	7.46	-	-	4
11	Mixing and stringing chemicals effectively (K17)	37	55.22	26	38.81	-	-	4	5.97	4
12	Immersing part of the wood to be treated (K18)	36	53.73	26	38.81	1	1.49	4	5.97	4
13	Keeping it for 24 to 36 hours based on the density of the species (K19)	38	56.72	20	29.85	4	5.97	5	7.46	4

24	Taking out from the chemical and drying before application(K20)	33	49.25	29	43.28	3	4.48	2	2.99	3

Source: Own data computation (2023)

3.4 Farmers' Attitude on Alternative Preservatives

The measurement of the attitude of farmers on the attitudes` measurement scale has shown that positive attitude towards alternative preservatives, which can prevent and enhance the durability of wood for local construction. Thus, the methods are not technically complex and are believed to improve local practice as well as accessible at the local level. However, there was some doubt that the chemical preservative method may not be available at the local level. It seems that used motor oil is a better alternative preservative as locally available, and also improves local technical applications (Table 4).

Table 4 *Farmers' attitude on alternative preservatives and application*

No.	Indicators	S. Agree		Agree		Not decided		Disagree		S. Disagree		Median
		Fre	%	Fre	%	Fre	%	Fre	%	Fre	%	
1	It is possible to protect the wood from borers using both traditional and modern (A1)	38	56.72	26	38.81	2	2.99	1	1.49	-	-	5
2	The chemical preservatives method can be an alternative to the traditional method (A2)	25	37.31	38	56.72	3	4.48	1	1.49	-	-	4
3	Treating wood through the dipping treatment method is a better alternative to t (A3)	41	61.19	23	34.33	3	4.48	-	-	-	-	5
4	Wood treatment methods using both traditional and modern preservatives are not t (A4)	47	70.15	18	26.87	2	2.99	-	-	-	-	5
5	Treating wood using both traditional and modern preservatives is not costly (A5)	31	46.27	34	50.75	2	2.99	-	-	-	-	4
6	Both used motor oil and chemicals are locally available and accessible in areas (A6)	38	56.72	25	37.31	4	5.97	-	-	-	-	5

Source: Own data computation (2023)

3.5 Farmers' Behavioral Intention on Alternative Preservative

Based on five statements presented for the willingness of farmers to practice, the study results show over 90% at least wanted to practice in the future. Hence, over 50% strongly agree to consider alternative methods to replace local practice, which is scientifically proven for local construction in contact with the ground for prevention of damage due to borers. However, some of the farmers wanted to make sure that they wanted to test on a small scale whether preservatives work successfully before full implementation (Table 5).

Table 5. Farmers' Willingness to Practice Preservatives

No	Indicators	S. Agree		Agree		Not decided		Disagree		S. Disagree		Median
		Fre	%	Fre	%	Fre	%	Fre	%	Fre	%	
1	I will consider preservative methods as	38	56.72	25	37.31	4	5.97	-	-	-	-	5

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	an alternative to our local practices (W1)											
2	I intended to adopt the methods for our daily construction purposes in contact w (W2)	35	52.24	27	40.30	5	7.46	-	-	-	-	5
3	I wanted to shift from previous local practices to scientifically proven practices (W3)	36	53.73	28	41.79	3	4.48	-	-	-	-	5
4	I will apply preservative methods within the coming three months (W4)	25	37.31	35	52.24	7	10.5	-	-	-	-	4
5	I will replace the dipping method with the place brushing method for treating wood (W5)	26	38.81	35	52.24	6	8.96	-	-	-	-	4

Source: Own data computation (2023)

3.6 PLS_SEM Analysis

The PLS_SEM analysis required Outer measurement and Inner measurement evaluation. Thus, the assumption of the reliability and validity of measured indicators, and their constructs need to be fulfilled. Consequently, the inner model measurement will be followed mainly by constructs relationship with structural path diagram analysis as well as statistical power (Hair et al., 2021).

3.6.1 Reliability and Validity of Outer Measurement Model

Reliability and Validity tests of indicators for latent variables are required before analysis of the inner model. Reliability is the internal consistency of indicators to measure unobservable variables. Accordingly, indicators are expected to be consistent for the application of different studies; Validity is the designed instrument that should be the appropriate measure of the set objective, and bring similar results in different contexts. Thus PLS_SEM required a test of the outer model through outer loading, Cronbach alpha, composite reliability, and Average extracted variance. Thus, the results loadings, Cronbach alpha, and Composite reliability are recommended to be >0.7; >0.5 points could be accepted for loadings considering other measurements. For Average Extracted Variance, it is considered >0.5 points (Hair et al., 2019).

The study result indicates that the outer indicators fulfilled the expected score of >0.5 points. The result of Cronbach's alpha and composite reliability are higher than 0.7. Subsequently, the results of Average Variance Extracted (AVE) greater than 0.5. One indicator(W5) for behavioral intention was removed from the analysis due to the construct showing more errors in fulfilling the requirement of the AVE point. As a result, the range of indicators for the Information, Motor oil, Chemical, Attitude, and Behavioural intention constructs have fulfilled the required measurements for reliability and validity. As shown in Table 6, the results of indicators loading, reliability, and validity are presented below.

Table 6 *Indicators` loading, reliability, and validity results*

Indicators	Information	Motor oil	Chemical	Attitude	Behavioral	Cronbach's alpha	Composite reliability	AVE
K1	0.748							
K2	0.812							
K3	0.833					0.819	0.832	0.53
K4	0.561							
K5	0.622							
K6	0.760							
K7		0.769						
K8		0.751						
K9		0.864						
K10		0.802				0.842	0.859	0.52

K11		0.742						
K12		0.546						
K13		0.524						
K14			0.627					
K15			0.752					
K16			0.657			0.890	0.892	0.61
K17			0.823					
K18			0.869					
K19			0.814					
K20			0.885					
A1				0.837				
A2				0.622				
A3				0.905		0.789	0.840	0.50
A4				0.559				
A5				0.515				
A6				0.725				
W1					0.835			
W2					0.798	0.708	0.767	0.53
W3					0.654			
W4					0.597			

Source: Own data computation (2023)

3.6.2 Discriminant Validity

Discriminant validity was measured by the Fornell-Larcker and Heterotrait-monotrait (HTMT) criterion among latent variables (Hair et al., 2019). According to Garson (2016), Fornell-Larcker measures the correlation of constructs in each column expected to be lower than the square root of AVE of the variables in the diagonal presentation of the top of the table in smartPLS analysis output. Henseler et al., (2015) suggested that HTMT better establish discriminant validity due to bias with the Fornell-Larcker criterion. Thus, the results of HTMT to measure discriminant validity could be established below 1.0 though favored below 0.85 to go with the next stage of analysis.

The study results show that the Fornell-Larcker criterion for the establishment of discriminant validity is acceptable except for latent variable behavioral intention. Thus, the diagonal values, which are the square root of the AVE value greater than the shared variance of the other latent variables except for Attitude with Behavioral intention. On the other hand, the results of the HTMT criterion show that below recommended value (<85) exception of Behavioral intention latent variable though still it can be accepted below 1.0 (Table 7& 8).

Table 7 *Fornell-Larcker criterion output*

	Attitude	**Chemical**	**Information**	**Used motor oil**	**Behavioral intention**
Attitude	0.708				
Chemical	0.455	0.781			
Information	0.523	0.611	0.730		
Motor oil	0.577	0.601	0.672	0.724	
Behavioral intention	0.753	0.272	0.366	0.349	0.728

Source: Own data computation (2023)

Table 8 *Heterotrait- monotrait criterion output*

	Attitude	Chemical	Information	Used motor oil	Behavioral intention
Attitude	-				
Chemical	0.539				
Information	0.644	0.700			
Used motor oil	0.714	0.699	0.782		
Behavioral intention	0.918	0.394	0.481	0.456	-

Source: Own data computation (2023)

3.6.3 Structural Model Results

Following the outer measurement model; the causal effect of knowledge, attitude, and behavioral intention of the training participants were evaluated. Knowledge is assigned and measured as the higher order construct through the formative indicators of information, motor oil, and chemical after latent variable scores. According to (Garson, 2016; Hair et al., 2019), the structural model was assessed through multicollinearity (VIF), coefficient of determination(R2), PLS prediction (Q2), and f2 effect size after the measurement model fulfilled a satisfactory level.

The structural model result shows that there is no collinearity indication among the variables. Thus, the results of the Variance Inflation Factor (VIF) for all variables are below 5. Through the process of bootstrapping (5,000 subsamples and a 5% significance level), the structural relationship of the variables was analyzed. The result of path analysis shows that knowledge directly and significantly affects attitude (β=0.609 & t= 6.64) at the same time attitude influences positively and significantly behavioral intention (β= 0.822 & t= 12.815) of training participants at 1% level. In contrast, the results show that there is a negative relationship, and no influence of knowledge on the behavioral intention of participants (β= -0.112 & t= 1.126). Consequently, attitude mediates between knowledge and behavioral intention significantly at <1% level (indirect effect vale=0.501, P-value= 0.000). Thus, the indirect effect of attitude resulted in a significant total effect of knowledge on behavioral intention at a < 1% probability level (total effect value=0.389, p-value=0.000).

Further assessment of the structural model shows that the R2 value for attitude is 3.71 and Behavioral intention is 0.577. The f2 value of knowledge on attitude is 0.59; attitude on behavioral intention is 1.005; while knowledge on behavioral intention is 0.019. According to (Hair et al., 2019), the structural model f2 effect size is categorized into small, medium, and large when the values are 0.20 to 0.15; 0.15 to 0.35; and above 0.35 respectively. Accordingly, knowledge on attitude and in turn attitude on behavioral intention has a large effect on dependent variables except that knowledge on behavioral intention has a small effect. The predictive relevance of the model(Q2) of Attitude and Behavioral intention variables are supported as the Q2 results show above 0(attitude=0.291 & Behavioral intention= 0.105) (Table 9).

Table 9 *Path coefficient bootstrapping result*

Paths	β	SD	t-value	P-values	significance
Knoweldge -> Attitude	0.609	0.092	6.64	0.000	supported
Attitude -> Behavioral intention	0.822	0.064	12.815	0.000	Supported
Knowledge -> Behavioral intention	-0.112	0.1	1.126	0.130	unsupported

Source: Own computation (2023)

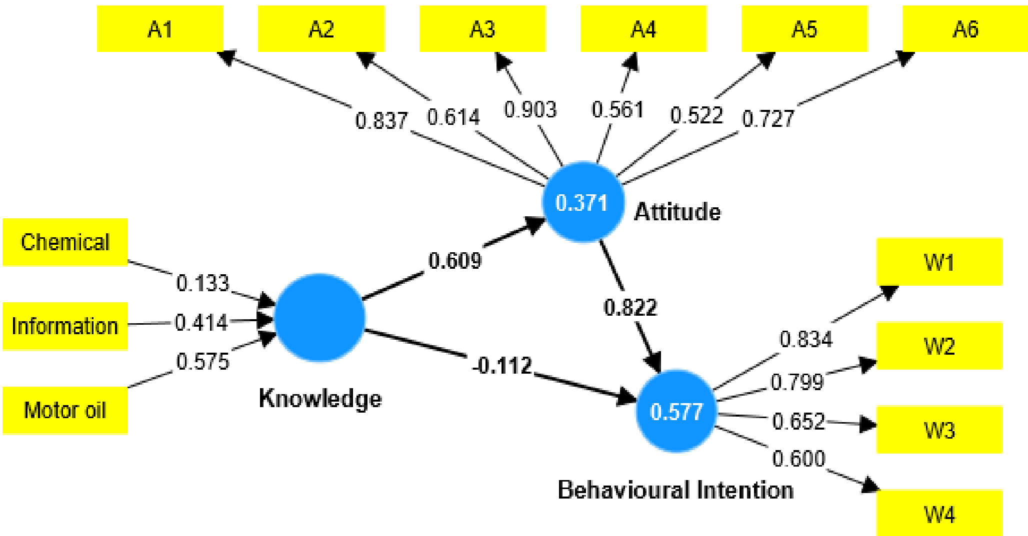

Fig. 1 *Path diagram of the causal relationship*

4. Discussion

The result shows that local experience with technical practical training fosters technology transfer. Local conditions need to be addressed, which hinders technology from taking up knowledge, attitudes, and perceptions (Dzvene et al., 2022). According to Tokede et al., (2020), technology adoption requires practical knowledge transfer to adopters as it causes a positive attitude and willingness for adoption. Used motor oil preservative method with improved application preferred other than chemical (borax chemical and boric acid in combination) as local people experienced with some practice for the application of used motor oil. Consequently, the study shows that positive attitude results due to the availability of used motor oil at the local level as well as for its technical easiness for application. Whereas, chemical preservatives are not easily affordable and accessible at the local level as well as require some safety measures.

In terms of causal relationships, attitude played a major role as a mediator specific to this study. As already mentioned, accessibility, affordability, and technical easiness were the major attributes of technology to be considered for technology adoption. Likewise, behavioral intention is highly influenced by the positive attitudinal change of the training participants for future application of preservatives on wood for local construction. A positive relationship between knowledge and attitude could foster the adoption level of technologies (Galadima et al., 2019). On the contrary, research on technology practice was found to be low as users' knowledge and attitudes were moderate (Gebremedhin et al., 2016).

5. Conclusion and Recommendations

Subterranean termites are one of the highly damaging woods with ground contact in rural areas. Preservation of wood is among the technologies recommended for appropriate utilization of wood as it enhances the wood age service for the construction and preservation of wood resources. Hence, training was organized in rural Kebele, where termites highly affect local construction like houses and fences. Theoretical and practical training was provided on how to preserve wood for local construction on alternatives of technologies considering local knowledge and modern chemicals based on research results. Data was collected from the participants and evaluated on the role of knowledge and attitude in the willingness of farmers to practice recommended technologies.

The integration of local knowledge with alternative technologies increases the knowledge of farmers in the preservation of wood particularly for locally available used motor oil. Intensive training in theoretical and practical helps to strengthen knowledge and change the attitude of the farmers positively, which indicates their willingness to practice in the future. The cause-and-effect relationship of Knowledge on attitude, and in turn attitude on willingness to practice shows positive results.

The need to focus on method demonstration for transferring knowledge and skills based on local alternative technologies for wood treatment is recommended. The study also implicates further training and follow-up of training participants is important for creating model farmers in treating wood for the best experience sharing results. Overall, attention has to be given to locally available and affordable technologies to change the attitude of farmers for future implementation.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

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