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Smallholder Farmers' Perceptions of the Importance of Indigenous Knowledge for Crop Productivity in the East Showa Zone of Oromia, Ethiopia

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Abstract

This article aimed to assess the perceived importance of indigenous knowledge (IK) for crop productivity among smallholder farmers in the districts of the East Showa Zone of Oromia, Ethiopia. A mixed research design involving both qualitative and quantitative data was used for the article. A sample of 125 smallholder farmers was selected using a simple random sampling technique in which the lottery method was used. Descriptive statistics such as frequency, percentage and an econometric model (ordered probit model) were used for analyzing the quantitative data. The qualitative data gathered through open-ended questions were organized, interpreted and analyzed in the form of theme descriptions. The results revealed that indigenous agricultural knowledge plays an important role in boosting crop production, but its potential is limited by inadequate literacy, poor extension support and modernization, among other factors. The model results indicated that respondent age, household size, farming experience, annual income, IK training and extension contact significantly influenced the perceived attributes of IK practices. This suggests that respondents' personal, socioeconomic and psychological variables are among the major factors determining the perceived importance of IK for crop productivity. It is recommended that extension workers work very closely with smallholder farmers and incorporate IK practices in their extension duties, and efforts should also be made to strengthen adult literacy and diversify income sources in the studied communities.

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Introduction

In Ethiopia, the majority of the population lives in rural areas, and smallholders cultivate nearly 85% of the total cultivated farmland (5, 7). These farmers have accumulated a wealth of indigenous knowledge (IK) in agriculture over many generations, which is essential to their survival and means of subsistence in rural areas (17, 15). IK is defined as the body of knowledge arising from intellectual activity in indigenous environments by the World Intellectual Property Organization (19). It comprises the knowledge, abilities, and proverbs that are

passed down orally and are ingrained in the cultural practices of the surrounding communities. These are learned via trial and error methods, ongoing education, and experience (1, 15).

This knowledge (IK) can be applied in various farming seasons; according to (11) and (15), it goes beyond determining weather conditions to clearing fields, plows and sows, cropping, managing soil fertility, controlling disease and pests, harvesting, and preserving seeds. This signifies that IK is still important for agricultural development, even though it differs from modern

knowledge, which is explicit and codified, not to mention that it is produced in universities and research institutes (9, 17). It is often distributed among many individual heads and has been utilized as a basis for local decision making and problem solving (1, 11).

For crop productivity and rural livelihoods, IK is therefore one of the most crucial resources. Many authors (1, 9). Reported that IK has played significant roles in crop productivity improvement and food security for generations around the world. It was also mentioned by (13) and (11) that over 90% of food production in sub-Saharan Africa and approximately 50% of the world's crops still depend on farmer skill. Smallholders' knowledge has proven to be essential for increasing agricultural productivity, even under different circumstances (4). Additionally, (9) asserts that a robust correlation exists between crop productivity and farmers' traditional knowledge.

In a similar vein, smallholders in Ethiopia utilize their IK to produce almost 85% of the country's entire agricultural output (3, 7). This suggests that smallholder farmers' farming knowledge plays a role in the agricultural sector. This knowledge includes techniques for clearing fields, planting, tilling, pulling weeds, harvesting, and storing seeds. Apart from utilizing their traditional knowledge, smallholder farmers must embrace modern technologies to overcome any obstacles they may encounter. This provides them with the chance to improve their IK techniques and increase agricultural output (2, 3).

Previous empirical studies have demonstrated that factors such as perceived technological value, literacy level, annual income, technical training, extension contacts, government policy, and media exposure all affect how much farmers adopt new technology and IK in particular (18, 10). Similarly, (16) reported that age, household size, annual income, extension contacts and access to credit were among the factors explaining smallholder farmers' perceptions of the attributes of technologies. It is noted that through IK, farmers make decisions regarding the timing, methods, and tools used in various agricultural practices. This includes clearing fields for crop cultivation, plowing and sowing, selecting cropping systems, weeding, harvesting, and storing seeds, among other activities (17, 15). However, IK remains overlooked by some modern communities in Ethiopia, including grassroots-level policy implementers (3, 17), and this in turn negatively hampers the potential

benefits of harnessing these technologies for agricultural development.

Hence, it is very important for smallholder farmers to adopt modern technologies in addition to their indigenous knowledge to counter any challenges they are facing. This also enables them to build upon their IK practices, thereby improving agricultural production (2). However, smallholder farmers' perceptions of the attributes that IK has for crop productivity and the factors affecting their perceptions are not fully understood in the study districts. The problem is further complicated because of the weak attention given to the value IK in favor of conventional practices in the country (3).

This raises some questions concerning how important IK practices are for crop productivity and the factors influencing smallholder farmers' perception levels in the districts of the East Showa Zone, particularly at the grassroots level. To this end, this article has attempted to answer three critical questions: (1) What types of agricultural indigenous knowledge are being practiced for farming activities among smallholder farmers? (2) How important is indigenous knowledge for crop productivity compared to that of conventional practices advised by extension workers? (3) What are the major factors influencing smallholder farmers' perceptions of the attributes that IK has for crop productivity? Addressing these research questions can yield important information and provide insights into IK's ability to improve agricultural productivity among smallholder farmers in the face of climate change and dwindling resources.

Materials and Methods

Study Area

This study was conducted in the districts of the East Showa Zone of Oromia, Ethiopia, particularly at the grassroots level. This zone has 10 districts, and it extends 7° 33' 50" North to 9° 08' 56" North and 38° 24' 10" East to 40° 05' 34" East. It shares boundaries with the Afar National Regional State in the Northeast Region, the Amhara National Regional State in the North Region, the Arsi Zone in the Eastern and Southern Nations, and the Nationalities and Peoples of Ethiopia Regional State in the West and Northwest Regions. The total population is estimated to be 1, 964, 540, of which 1, 149, 814 are rural dwellers and 814, 726 are urban dwellers (East

Showa Zone Agricultural Office, 2017). Figure 1 shows a map of the study area.

The agro-climatic zone is dominated by subtropical (61.1 percent) and tropical (38.1 percent) zones with altitudes ranging from less than 1000 m to more than 3000 m below sea level. The annual rainfall falls between 650 mm and 1200 mm, while the annual temperature ranges from 15°C to 28°C. The agricultural system is mixed, and it constitutes both crop and livestock production where farmers keep cattle to obtain oxen for tilling farmlands (5).

Subsistently oriented smallholder agriculture is the dominant crop production system in the zone during the 'Meher' and 'Belg' seasons on private land holdings, although few commercial crops such as sugarcane are produced around 'Wonji' and 'Metchara'. The area is also known for its excellent quality *Teff* grain, which is an important staple food grain in Ethiopia, followed by wheat and pulses.

Sampling Technique and Data Collection

The target population for this article comprises all smallholder farmers who are living in the four districts of the East Showa Zone of Oromia, namely, Adami-Tulu Jido Kombolcha, Dugda, Lume and Ada'a. Two-stage cluster sampling techniques involving random sampling and probability proportion to size were employed to select the smallholder farmers. Cluster sampling is used because the study area is geographically dispersed and a large population requires a great deal of effort and cost to acquire the desired information. Thus, the ten districts in the East Showa Zone were clustered into two broad categories based on their land use patterns.

In the first stage, four districts—the Adami-Tulu and Dugda districts—from the intensively cultivated cluster and the Lume and Ada'a districts—from the moderately cultivated cluster—were selected through random sampling techniques, for which the lottery method was used. In the second stage, two kebele administrations from each district were selected purposively based on their dominance in crop production. These are Haleku Gulenta and Oda Ashura from the Adami Tulu District; Wolda Qalina and Shumi-Gamo from the Dugda District; Nanawa and Ejere from the Lume District; and Ude and Dire from the Ada'a District. Finally, 125 smallholder farmers were selected using a simple random sampling technique on the basis of the Yamane (1973) formula. The following formula was used:

$$n = \frac{N}{1+N(e)^2}, \quad n = \frac{4,176}{1+4,176(0.09)^2}$$

Where,

N= Population size

n= Sample size

e = margin of error (0.09) and 95% confidence level.

This article employed a semistructured interview guide and FGDs to collect pertinent data from the participants. The aim of the interview schedule, which included both closed- and open-ended questions, was to gather crucial information on the respondents' opinions and views about IK. Due to its superior response rate compared to other interview formats, a semistructured, in-person interview is utilized (6). Four extension workers were trained as moderators to allow the key themes of discussion during the FGDs to be discussed more easily. Of the 125 smallholder farmers included in the semistructured interviews, 115 (92%) were approached.

Analytical Techniques

To analyze the data obtained from the open-ended questions, content analysis was performed, and descriptive statistics, including frequency counts, percentages, and ordered probit models, were used for quantitative data. Smallholder farmers were asked to rate their perceptions of the attributes that IK has for crop productivity using a three-point ordinal rating scale: low, medium and high. Hence, the dependent variable was ordered and discrete in nature, and according to (8), employing the ordered probit model was appropriate for the empirical estimation. This model is widely used to estimate the value of ordered dependent variables; Y^* is unobservable, and it can be formulated as a threshold model with a latent variable (1).

$$Y^* = \beta'X_i + \varepsilon \quad (1)$$

Where Y^* is an unobserved variable that corresponds to the perceived importance of IK for crop productivity, β' is a vector of unknown parameters to be estimated, X_i is a vector of explanatory variables and ε is the random error term of the latent variable.

The dependent variable (i.e., smallholder farmers' perceptions of the importance of IK for crop productivity) in this article exhibits itself in the ordinal categories, which were coded as 0, 1 and 2. The model, based on the latent regression function, was expressed as:

$$Y_i = \begin{cases} 0, & \text{if } Y_i^* \leq \mu_0 \\ 1, & \text{if } \mu_0 \leq Y_i^* \leq \mu_1 \\ 2, & \text{if } \mu_1 \leq Y_i^* \leq \mu_2 \end{cases} \quad (2)$$

Where Y_i ($i = 0, 1$, and 2) and smallholder farmers are rated as 'low', 'medium' or 'high' because IK is more important for crop productivity than conventional practices are. The μ_s are the unknown parameters or the threshold values that are jointly estimated with β -coefficients. In this context, it is assumed that the random term of the ordered probit model follows a standard normal distribution. Thus, the model is estimated using the maximum likelihood probability estimation for each of the observed ordinal responses, with ordinal values of 0, 1 and 2 given as:

$$P(Y=0/X) = F(-\beta'X_1),$$

$$P(Y=1/X) = F(\mu_1 - \beta'X_1) - F(-\beta'X_1), \quad (3)$$

$$P(Y=2/X) = F(\mu_2 - \beta'X_1) - F(\mu_1 - \beta'X_1)$$

Where $F(\cdot)$ is the cumulative standard distribution function. $P(\cdot)$ is the probability of smallholder farmers rating either 'low', 'medium', or 'high' given the X variables. X is a vector of independent variables that affects the perceptions of smallholder farmers, and β is a vector of unknown parameters to be estimated.

Results and Discussion

Types of Agricultural IK Practices

The findings showed that smallholder farmers are familiar with indigenous techniques for predicting climate conditions, preparing farm fields, controlling weeds, managing soil fertility, controlling diseases and pests, and preserving seeds. However, most IK practices of the studied communities were not systematically captured and preserved in explicit forms, suggesting that they remain in tacit forms. These findings agreed with the findings of (11) in Tanzania and (15) in Ethiopia, who reported that farmers had various IK practices, although most of these technologies left undocumented.

Wind direction and the moon's form were the two most widely used local indicators in the study districts to predict when rain would begin. Upon identifying the variations in winds throughout the summer and winter, some of them proceeded with their agronomic activities.

The study revealed that by merely observing the direction from which the moisture-holding cloud is approaching, smallholder farmers are able to forecast whether or not rainfall will occur. It is believed that not every cloud that is capable of retaining moisture will result in precipitation. The majority of them acquired and learned this information from watching the moon's location and from elders as well. (1) reported similar results in Uganda.

The findings showed that smallholder farmers used traditional calendars in addition to climate prediction cultural models to make judgments about agronomical activities such as clearing farmland, sowing, weeding, and harvesting crops. However, some of these techniques and indicators, such as the colorful migratory birds in Adami-Tulu and Dugda, are location specific. It can be inferred that the respondents did not employ metrology, in part due to its high prevalence of illiteracy and lack of accessibility, to prepare farmlands.

Table 1 shows that smallholder farmers used traditional techniques such as crop rotation, early plowing, planting legume crops, burning crop wastes, and applying animal manures to maintain soil fertility. Similar observations were made by (17) in Ethiopia and (11) in Tanzania. The results also revealed that family labor, as well as hired labor and labor exchange employing an ox plow, was used to prepare land for crop cultivation.

Table 1 shows that 67 smallholder farmers, or 58.3 percent, used tillage, crop rotation, and hand picking as traditional weed control methods. These results were consistent with the findings of (7), which showed that the majority of Ethiopian farmers used similar indigenous technologies, including hand picking and ox plowing, to carry out farming tasks. Similarly, (17) reported that the indigenous practices of manual weeding and tillage were the main practices used by smallholder farmers in Ethiopia.

Overall, the results showed that the introduction of pests and crop diseases may be prevented by using local traps, tillage techniques, burning crop leftovers, early planting, smoking, hand picking, façades, and crop rotation. To stop the spread of pests and illnesses from their farm fields, these approaches are further enhanced by hand-picking and rogueing out unhealthy plants. However, there were differences in the extent to which these methods were used both among and within the groups under study. The results of (1) and (9) are consistent with this outcome. According to their study, farmers in

Uganda primarily use three methods to reduce the impact of pests and diseases: tillage, early planting, and smoking.

Perceived Importance of Agricultural IK

Table 2 shows that approximately 26 (22.6 percent) and 31 (27 percent) of the respondents rated the importance of IK practices as high and low, respectively. In contrast, half of the respondents (50.4 percent) thought that IK was moderately important. Thus, by introducing individuals in the low and moderate categories into the higher perceiver group, there is enough room to increase the quality of IK. This is consistent with the findings of (9), who discovered that the qualities of IK were not given enough credit despite their importance for development.

The data obtained through FGDs from participants also supported the above findings. The discussants felt that IK is more effective than modern ones in the areas of clearing fields, planting, weeding, enhancing soil fertility, processing and preserving seeds. For instance, the smallholder farmers who participated in the discussion clarified that when making decisions about when to plant, harvest, and plow, farmers' understanding of the climate is more significant than their understanding of metrology.

In the FGDs, smallholder farmers stated that using local seeds reduced the risk of adulteration, missing seeds, and unnecessary expenditures. They also believed that local seeds were more useful than current varieties. Thus, from the perspective of smallholder farmers, IK was more important than modern IK for clearing fields, planting and sowing, cropping, weed control, enhancing soil fertility, and preserving seeds. These findings corroborated those of (11, 17), who discovered that farmers may reduce crop failure risks by using local seeds and broadcasting. Similar findings were reported by (15) in the western region of Ethiopia.

Factors Influencing Perceived Attributes of IK for Crop Productivity

The model results indicated that the quality of fit of the model is high (i.e., with acceptable pseudo $R^2 = 0.8457$, $p=0.000$) and is significant at less than the 5 percent level. This means that the model has high power in explaining the influence of explanatory variables on the importance of IK for crop productivity as perceived by smallholder farmers. The chi-square statistic for the

ordered probit model is 105.27 and is statistically significant, indicating that the parameters used in the model are different from zero.

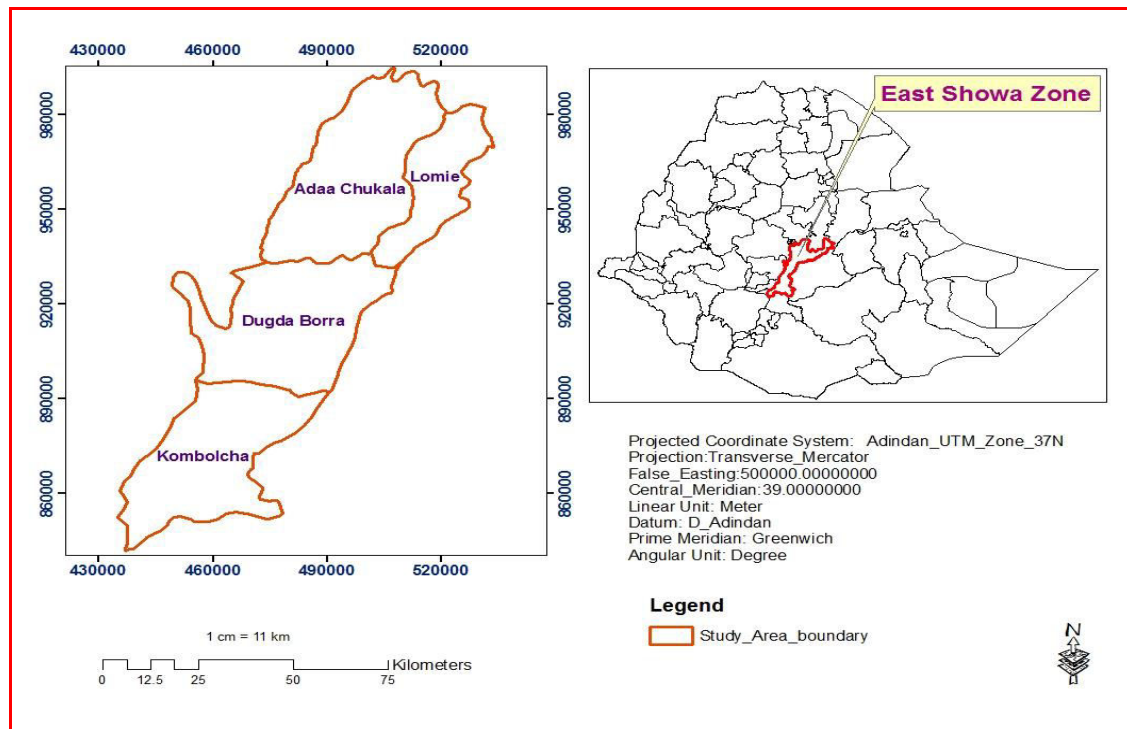
The results indicated that age, household size, farming experience, annual income, IK training and extension contact significantly explained smallholder farmers' perceptions of the importance of IK. This means that the attributes of IK that respondents perceived to be important for crop productivity improved with age, farming experience, local participation, and training received; additionally, the coefficient sign of extension contacts and annual income was significant but negative in explaining smallholder farmers' perceptions of the attributes of IK for crop productivity (see Table 3).

These results corroborated those of (14) and (10), who discovered that factors such as age, family size, annual income, experience, and access to credit were statistically significant in explaining smallholder farmers' decisions to adopt agricultural technologies.

Their findings indicated that respondents were more inclined to embrace the conventional agricultural system if they had more years of expertise, fewer households, and lower annual incomes. However, individuals with better education and regular extension contacts favor alternative technologies over traditional technologies to increase crop productivity (16, 3).

The age of the respondents was significantly and positively related to smallholders' perceptions of the importance of IK. A unit increase in the age of the household head to terminal age creates an increase in the perceived importance of IK by 3.95 percent and 5.7 percent for the moderate and high categories, respectively, and a decrease of 1 percent for the low perceiver group. This implies that as respondents age, their tendency to better understand the contributions that IK could have to farming activities also increases. This finding conforms to (14) and is an indication that older farmers could have a greater perception of the role IK plays in improving agricultural productivity.

The coefficient of farming experience was positive and significantly ($P=0.000$) related to smallholders' level of perception of IK. A one-unit increase in farming experience decreased the probability of smallholder farmers perceiving the importance of IK to be low by 1 percent and increased the probability of IK being moderate to high by 2.4 percent and 3.5 percent, respectively.

Figure.1 Map of the study area (Adopted from East Showa Zone Properties, 2020)**Table.1** Summary of agricultural IK practices by smallholder farmers (N=115)

Types of IK	Indigenous methods or techniques used
Climate forecasting 45 (39.1 percent)	- Most of them often used different sign or local indicators such as plants, birds and tree leaves to predict rainfall and pattern of its distributions. - They carefully observed the environment around them; shape of the moon, wind directions and major changes took place to predict rainfall.
Preparing farm fields & tools used 109 (94.8 percent)	- Preparing land for cultivation commences after the first rain has started in Adami-Tulu and Dugda. 'Maresha' and ox-drawn plow are the dominant indigenous technology used for plowing while some of them used tractors in that regard. - They also used ox for thrashing while some others used thrashing machine.
Weed control 67 (58.3 percent)	- Tillage, hoes, hand weeding and crop rotation are used to control weed. - They reported that hand weeding gives aeration for plants. - Some others used hand weeding supplemented by agro-chemicals.
Managing soil fertility 82 (71.3 percent)	- Most of the smallholders used crop rotation, tillage practices and crop residues to maintain soil fertility. - Although lesser extent, some of them used animal manures and compost. - Still some others were used inorganic fertilizers together with IK practices.
Disease and pest control 28 (27 percent)	- They utilize a mixture of locally available resources such as ash, animal urine, salt, pepper and water as insecticide to control crop diseases. - Hand picking and dressing seeds with ash are used to minimize the impact of crop diseases. - A small flag was used to keep away birds from farm fields.

Sources: Authors' own survey results, 2022

Table.2 Distribution of respondents' perceptions of IK attributes (N=115)

Level of perception	Frequency	Percent	Valid Percent	Cumulative Percent
Low	31	27.0	27.0	27.0
Moderate	58	50.4	50.4	77.4
High	26	22.6	22.6	100.0

Sources: Authors' own survey results, 2022

Table.3 Ordered probit marginal effects of the perceived attributes of IK on productivity

Log likelihood = -61.8514 Pseudo R2 = 0.8457			Number of observations = 115 LR chi2 (11) = 105.27 Prob > chi2 = 0.000		
Variables	Coef.	P>z	Marginal effects		
			Low	Moderate	High
			Prob(Y=0)	Prob(Y=1)	Prob(Y=2)
Sex	0.592	0.427	0.035	0.0311	0.0225
Age	0.060	0.001***	-0.001	0.0395	0.0572
Education	-0.433	0.287	0.010	0.0224	-0.0324
Family size	-0.230	0.001***	0.010	0.0230	-0.0333
Farm size	0.227	0.575	0.010	0.0167	-0.0242
Farming experiences	0.280	0.006**	-0.010	0.0242	0.0350
Annual farm income	-0.001	0.010*	0.001	0.0023	-0.0036
Training on IK	0.185	0.001***	-0.010	0.0272	0.0394
Extension contact	1.487	0.002***	-0.060	-0.1270	0.1840
Local participation	-0.417	0.143	0.020	0.0380	-0.0550
	Coef.	Std. Err.	(95% Conf. interval)		
/cut1	-1.370	2.737		-6.73544	3.995297
/cut2	3.650	2.774		-1.7879	9.087454

Significance: *** if $p < 0.01$; ** if $p < 0.05$; * if $p < 0.10$

Thus, experienced smallholder farmers are more likely to understand the contribution that IK could have to crop productivity than less experienced farmers. These findings support those of (10) in Tunisia, who noted that experienced farmers are reluctant to change their traditional farming practices.

The coefficient of household size was negative and significantly ($P=0.001$) related to the perceived attributes of IK. The marginal effect showed that a one-unit increase in the family size of the respondents was likely to increase their perception by 1 percent for the low and 2.3 percent for the moderate category, whereas the probability of perceiving the greater importance of IK decreased by 3.3 percent. This shows that as the household size increases, their exposure to outside information also increases, which will provide them with an opportunity to obtain new ideas and practices for farming activities. Similarly, (2) posits that those who

have better exposure to outside information are more likely to adopt new ideas, practices and technologies than their counterparts.

The model results indicated that annual farm income was negative but significantly explained the smallholder farmers' perceptions regarding the contribution that IK could have to crop production. A one-unit increase in total annual income decreases the probability of perceiving the contribution of IK to crop productivity by 0.36 percent for high groups and increases it by 0.10 percent and 0.23 percent for low and moderate categories, respectively. This implies that as farm income increases, the affordability of alternative technologies also increases; thus, farmers could place more emphasis on modern technologies than on indigenous technologies. This contradicts the finding of (14), which indicated that the level of income has a

positive relationship with farmers' perceptions of technology adoption in Kenya.

Those who had received various types of IK training positively perceived the contribution that IK could have to crop productivity. The computation of the marginal effect shows that a difference in a unit increase in training received on IK increases their perception by 2.7 percent and 3.9 percent for moderate and high categories, respectively, and decreases it by 1 percent for the lower groups. Those who received frequent training are more likely to perceive a greater contribution of IK than less trained individuals. This conforms to the study of (12), which indicated that farmers who received training are more likely to adopt new technologies as they become exposed to their advice.

Table 3 indicates that the ratings of smallholder farmers who had frequent contact with extension workers were positive for the 'high' and 'moderate' categories but negative for the 'low' category perceiver. The marginal effect results show that a difference in a unit increase in extension contact decreases the perceived importance of IK by 6 percent and 12.7 percent for the low and moderate categories, respectively, and increases it by 18.4 percent for the high perceived group. This finding contradicts the study of (12), which indicated that farmers who had more frequent extension contact are more likely to adopt new technologies as they become exposed to extension services.

Conclusion and Policy Recommendations

This study revealed that smallholder farmers are knowledgeable about different types of IK practices and are not limited to preparing farm fields or cropping systems, predicting climate conditions, controlling weeds, managing soil fertility, or processing and preserving seeds. However, most of these technologies (IK) were not systematically captured and preserved in explicit formats, suggesting that they remain in tacit form. Most IK users fell into the moderate category, followed by those with low IK attributes. There is sufficient scope for increasing the attributes of IK by bringing low and moderate categories into the higher perceiver group.

The model results showed that with increasing age, experience, extension contact, and IK training, the perceived importance of IK improves from low to moderate to high. Compared to those with lower annual incomes, those with greater incomes are less likely to

recognize the role that IK plays in agricultural productivity. These results suggest that the perceived importance of IK for agricultural yield was largely determined by the respondents' personal, socioeconomic, and psychological characteristics. Thus, indigenous methods of agronomic practices, climate prediction, and seed storage should be continuously captured, disseminated, and conserved to support agricultural development.

Declarations

We declare that none of the authors has any financial or nonfinancial competing interests. This work is our original research, and we obtained informed consent from participants during data collection.

Conflict of interest

The authors declare no competing interests.

Ethical clearance

The UNISA-CAES Health Research Ethics Committee has granted ethical approval with reference numbers 2019/CASE_HREC/114. The low-risk application was reviewed by the UNISA-CAES Health Research Ethics Committee on January 23, 2020, in accordance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment. This was done to ensure that the field survey was conducted properly, with the right procedures and respecting privacy. The researcher strictly adhered to and implemented the UNISA research ethics policy.

Data availability statement

The SPSS files and all other required data have been securely stored and are available for use by the publishing house and other researchers upon request. The study's supporting information files and article both contain the data that supported the study's conclusions, which are accessible through the data repository.

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