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Sources and intensity of access to agricultural information technologies by smallholder farmers: evidence from Northwest Ethiopia

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Agriculture is a key sector in many African economies, making access to accurate agricultural information vital for boosting productivity. This study investigated the factors influencing smallholder farmers' access to agricultural information in the East Gojjam zone of Amhara, Ethiopia. A cross-sectional survey of 403 households was conducted, and data were analyzed using Stata software with the Ordered Probit model. The study found that farmers' access to agricultural information is significantly influenced by factors such as experience, exposure to electronic and printed media, farm size, access to extension services, input availability, market distance, proximity to development centers, and participation in Farmer Training Centers (FTC). Major constraints to information access included inadequate government policies, insufficient extension services, limited information sources, poor infrastructure, network issues, and a lack of effective knowledge exchange. The study recommends that smallholder farmers increase exposure to various media channels and participate in FTC programs. Additionally, the Ethiopian government should prioritize infrastructure improvements (mobile networks, roads, and electricity), expand extension services, and diversify information sources to improve farmers' access to relevant agricultural knowledge. Addressing these barriers will help enhance agricultural productivity in the study area.

KEYWORDS

access to information, agriculture, farmers, ordered probit model, households

1 Introduction

1.1 Background of the study

Agriculture is the backbone of most developing economies, with small-scale farmers at the core of agricultural production. Access to timely, accurate, and relevant agricultural information is crucial for improving productivity, reducing poverty, and stimulating economic growth in both rural and urban areas. As Benard et al. (2014), point out, sustainable and reliable agricultural information is key to the development of small-scale farmers, benefiting communities across regions. This is particularly important in developing areas where agriculture still serves as the primary livelihood for a significant portion of the population.

However, in many developing countries, access to information remains one of the greatest challenges for smallholder farmers. According to Farrington et al. (2002) emphasize that

agricultural information systems should address both production-oriented factors such as improved farming techniques, credit facilities, and market information and protection-oriented factors, such as health services and social security. When these systems are integrated, they play a vital role in poverty alleviation and improving the overall well-being of smallholder farmers. Without such information, farmers face significant barriers to increasing productivity and resilience, particularly in the face of economic and environmental shocks.

The role of information in enhancing agricultural productivity has been well-documented. Information influences crucial decisions such as what crops to grow, how to manage pests, and when to harvest, as highlighted by Kaniki (1995). Reliable agricultural information sources must be timely, accurate, relevant, and trustworthy. As Starasts (2004) notes, the reliability of sources is particularly important because farmers base critical decisions on available information. Outdated or unreliable data can lead to poor farming outcomes, underlining the importance of accessible and dependable sources. Recent studies have continued to emphasize the importance of reliable information in improving agricultural practices. For instance, Koketso et al. (2023) note that access to quality agricultural information leads to better decision-making, which is directly linked to improved productivity in smallholder farming.

In countries like Ethiopia, where many farmers still rely on traditional farming methods, access to agricultural information is a major constraint to improving productivity. Rice farmers, for instance, obtain information from diverse sources including personal experience, peer interactions, workshops, seminars, and agricultural extension officers (Ogboma, 2010). This issue is not unique to Ethiopia across Sub-Saharan Africa, rural areas face similar barriers to accessing reliable agricultural information. Recent research by Apollo (2022) affirms that mobile phones and digital platforms have the potential to bridge these gaps, providing farmers with real-time weather updates, market prices, and expert advice, which can lead to better crop management and higher yields. Similarly, in Nigeria, farmers rely on extension agents, family networks, radio broadcasts, and agricultural libraries for information (Daudu et al., 2009). As Benard et al. (2014), note, informal channels like family advice and peer networks, alongside formal extension services, remain crucial, particularly in rural areas where access to modern communication tools is limited.

In recent years, the relationship between access to information and farming productivity has gained increasing attention. Bachhav (2012), asserts that the integration of reliable agricultural information systems into farming practices can significantly boost productivity. For example, access to weather forecasts helps farmers decide when to plant, irrigate, or harvest. Similarly, market information allows farmers to time their sales for maximum profit. Mittal and Mehar (2013) also argue that timely, relevant, and credible information is essential for managing risks such as price fluctuations, pests, and extreme weather conditions, which are common challenges in agriculture.

However, the nature of information needs is constantly evolving. As Klair et al. (1998) state that information needs evolve with time due to new technologies, changeable environmental conditions, and changing agricultural policies. In this perspective, introduction of crop varieties or climate-smart agricultural practices will change the type of information farmers require from technical knowledge to information on policy and market trends.

With the advent of digital technologies, mobile phones and digital platforms have emerged as powerful tools for disseminating agricultural information. Aker et al. (2021) highlight how mobile-based applications in regions like Sub-Saharan Africa provide farmers with real-time weather updates, market prices, and expert advice, which can lead to improved crop management and yield forecasts. Despite the promise of these technologies, the digital divide remains a significant barrier. Many rural areas suffer from poor internet connectivity, lack of digital infrastructure, and low levels of digital literacy, which prevent farmers from fully benefiting from these platforms.

In Ethiopia, agriculture remains the primary livelihood for over 70% of the population, but smallholder farmers face significant challenges in accessing modern agricultural information. In regions like Amhara, where farming is largely dependent on traditional, rain-fed systems, farmers often rely on local extension services, peer advice, and face-to-face communication for agricultural guidance. However, the limited coverage and reach of extension services, compounded by the difficulties posed by climate change and market volatility, mean that farmers often lack timely, accurate, and relevant information to improve their productivity and mitigate risks (Alemu et al., 2023; Sulaiman et al., 2023).

This situation is particularly severe in East Gojjam, where infrastructure challenges such as poor internet access and limited mobile connectivity further hinder access to digital agricultural platforms. Many farmers in this region are unaware of new farming techniques, market opportunities, or updated agricultural practices, which leaves them vulnerable to poor yields, low prices, and the impacts of climate change.

The lack of reliable and timely agricultural information continues to be a critical constraint for smallholder farmers in East Gojjam. Despite the clear role that agricultural knowledge plays in enhancing productivity, farmers struggle to obtain the information they need to make informed decisions. This gap is compounded by the challenges of infrastructure, digital illiteracy, and the reliance on outdated information sources. As a result, many farmers are unable to optimize their practices, adopt new technologies, or effectively respond to market fluctuations and climate-related risks.

Therefore, this study investigated the sources and levels of access to agricultural information among smallholder farmers in East Gojjam. By identifying the most common sources of information and exploring the challenges farmers faced in accessing critical knowledge, the study provided insights into how information dissemination could be improved. Ultimately, the findings contributed to enhancing productivity, resilience, and the livelihoods of smallholder farmers in the study area.

2 Factors influencing farmers' access to agricultural information: an empirical review

The empirical studies reviewed here provide valuable insights into the various factors that influence farmers' access to agricultural information. These studies employ different methodologies and study designs to analyze the impact of socio-economic, technological, and contextual factors on farmers' access to

information. For example, Linh et al. (2016) conducted a survey-based study in rural areas to explore the sources of agricultural information used by smallholder farmers. They employed descriptive statistics to identify the most common sources, including radio, extension workers, and family members, and used regression analysis to examine how these sources affected agricultural productivity. The study found that radio was a particularly effective tool for reaching remote farmers, as it was inexpensive, accessible, and offered timely information on weather, market prices, and farming techniques. This study highlights the significant role of media in bridging the information gap for farmers in rural settings where other communication infrastructures may be lacking.

Similarly, Boz and Ozcatalbas (2010) also conducted a cross-sectional survey to investigate the role of radio and television in disseminating agricultural information in rural Turkey. They used statistical analysis to determine the relationship between media use and access to agricultural knowledge. The findings revealed that radio was the most important source of information for farmers in the study area, particularly because it reached large audiences with minimal barriers. Their results also suggested that television, though a valuable information source, was less accessible to some farmers due to technological and financial constraints. This study, like Linh et al. (2016), emphasizes the importance of media, especially radio, in rural areas.

Beshir et al. (2015) took a different approach by employing qualitative methods to investigate the role of social networks, including family members and peer farmers, in disseminating agricultural information in Ethiopia. Using focus group discussions and in-depth interviews, the study gathered insights from farmers, extension agents, and community leaders. The findings indicated that informal networks, particularly family members and fellow farmers, were the most influential sources of agricultural information, as they provided context-specific, practical knowledge about farming practices. These informal networks were seen as especially valuable in areas where formal extension services were limited or infrequent. Beshir et al. (2015) concluded that while formal information sources like extension agents and media were important, family and peer networks played a central role in ensuring information was relevant, accessible, and culturally appropriate.

Geleta (2015) conducted an econometric study in Ethiopia to examine how gender influenced access to agricultural information in farm households. Using a cross-sectional survey design and logistic regression analysis, the study analyzed data from male and female-headed households to assess their likelihood of accessing agricultural information. The study found a significant gender disparity, with male-headed households more likely to have access to information from formal channels, such as extension services and agricultural training programs. The study suggested that cultural norms and gender roles in rural Ethiopia often limit women's participation in formal information networks, thus reducing their access to agricultural knowledge. Geleta (2015) study underscores the need for gender-sensitive interventions to ensure that women have equal access to agricultural information.

Derebe (2007) examined the impact of household size on access to agricultural information in Ethiopia. Using a survey-based design, the study collected data on household composition and its relationship to information access. Through regression analysis, Derebe (2007) found that larger households were more likely to have greater access to agricultural information. This was attributed to the collective nature of knowledge-sharing within large families, where multiple family members could engage with information sources such as extension services, media, and informal networks. The study concluded that larger households tend to have more diverse access to information, which in turn improves their ability to adopt new agricultural practices and increase productivity.

Tewodaj et al. (2009) conducted a survey-based study in rural Ethiopia to examine the relationship between farmers' educational levels and their adoption of agricultural innovations. Using multivariate regression analysis, the study analyzed the impact of education on farmers' ability to access agricultural information and adopt new technologies. The results indicated that farmers with higher education levels were more likely to adopt modern farming techniques, as they had better access to information and were more receptive to new ideas. The study emphasized the importance of education in improving farmers' decision-making and enhancing agricultural productivity. Tewodaj et al. (2009) also noted that educated farmers were more likely to engage with formal information channels such as extension services and agricultural training programs.

Sheng Tey et al. (2018) explored the role of extension services in providing agricultural information to smallholder farmers. The study used structural equation modeling (SEM) to analyze how different factors, such as the frequency of extension visits, farmer education levels, and access to communication technologies, influenced information access. Their study found that regular interaction with extension agents was crucial in enhancing farmers' access to agricultural information. Farmers who received frequent extension visits were more likely to adopt new agricultural practices and improve their farm productivity. The study also highlighted that the effectiveness of extension services was influenced by the quality of the interaction and the relevance of the information provided.

Rehman et al. (2013) investigated the role of education in enhancing farmers' access to agricultural information in Pakistan. Using a cross-sectional survey design and regression analysis, they collected data on the education levels of farmers and their use of agricultural information. The study found a significant positive correlation between higher education and access to agricultural knowledge. As farmers' education levels increased, so did their likelihood of engaging with formal agricultural information sources, such as extension services, research institutions, and media. Rehman et al. (2013) concluded that improving farmers' educational levels could be a key strategy for enhancing agricultural productivity, as educated farmers were more likely to adopt new technologies and improve their farm management practices.

Daba Chibsa (2016) and Selamawit (2017) explored how access to credit influenced farmers' ability to access agricultural information in rural Ethiopia. Using logistic regression analysis with data from a survey-based design, the study found that farmers with access to credit were more likely to engage with extension services and adopt new agricultural technologies. Credit access enabled farmers to invest in inputs such as fertilizers and seeds, attend training programs, and purchase farm equipment. As a result, these farmers had better access

to agricultural information, which contributed to improved farming practices and higher productivity.

Finally, Mama (2010) investigated the role of farmer groups in facilitating the exchange of agricultural information. Using a qualitative research design with focus group discussions and semi-structured interviews, the study found that group membership provided a valuable platform for farmers to share knowledge, discuss farming challenges, and learn from one another's experiences. Mama (2010) emphasized that farmer groups played a central role in bridging information gaps, particularly in areas where formal extension services were limited. The study concluded that participation in agricultural cooperatives and other farmer groups enhanced farmers' access to information and promoted the adoption of innovative farming practices.

In sum, the empirical studies reviewed employ a rich mix of quantitative and qualitative methods, including survey designs, econometric analyses, regression modeling, structural equation modeling (SEM), and focus group discussions. These diverse methodologies allow for a nuanced understanding of the multi-dimensional factors influencing farmers' access to agricultural information. The findings consistently underscore the significance of socio-economic factors such as education, household size, gender, and access to credit while also highlighting the critical role of information sources like media, extension services, and informal networks. Collectively, these studies reveal the complex interplay of individual, social, and institutional factors that shape the flow of agricultural knowledge and its adoption. The insights drawn from these studies offer valuable implications for designing targeted interventions, informing policy decisions, and enhancing agricultural extension systems. Addressing the various barriers to information access, from gender disparities to infrastructure challenges, can ultimately empower farmers, drive innovation, and significantly boost agricultural productivity.

2.1 Conceptual framework of the study

During the course of this research, we made diligent attempts to identify sources of agricultural information and examine the determinants impacting the accessibility to agricultural information. This information was derived from literature, practical experiences, and field observations. The theoretical structure of this study was built on the assumption that the degree of accessibility to agricultural information is influenced by a variety of individual, socioeconomic, and institutional factors. These factors exemplify the variations in their influence on information access. The theoretical framework of this study is depicted in Figure 1.

3 Research methodology

3.1 Description of the study area

The investigation was conducted in the East Gojjam Zone, located within the Amhara National Regional State of Ethiopia. Geographically, the area is positioned at approximately 10°20′ North and 37°43′ East, with an elevation ranging from 500 meters to 4,154 meters above sea level. The zone is bordered by Oromia Region to the south, West Gojjam to the west, South Gondar to the north, and South Wollo to the east, with the Abay River forming natural boundaries along the northern, eastern, and southern edges. The highest peak in the area is Mount Choqa (also known as Mount Birhan), a prominent landmark in the region. East Gojjam is selected for this study due to its ecological, socio-economic, and cultural significance. The region is agriculturally vital and represents a diverse set of landscapes, from lowlands to highlands, which makes it an ideal location for examining the interplay between environmental conditions and human activity,

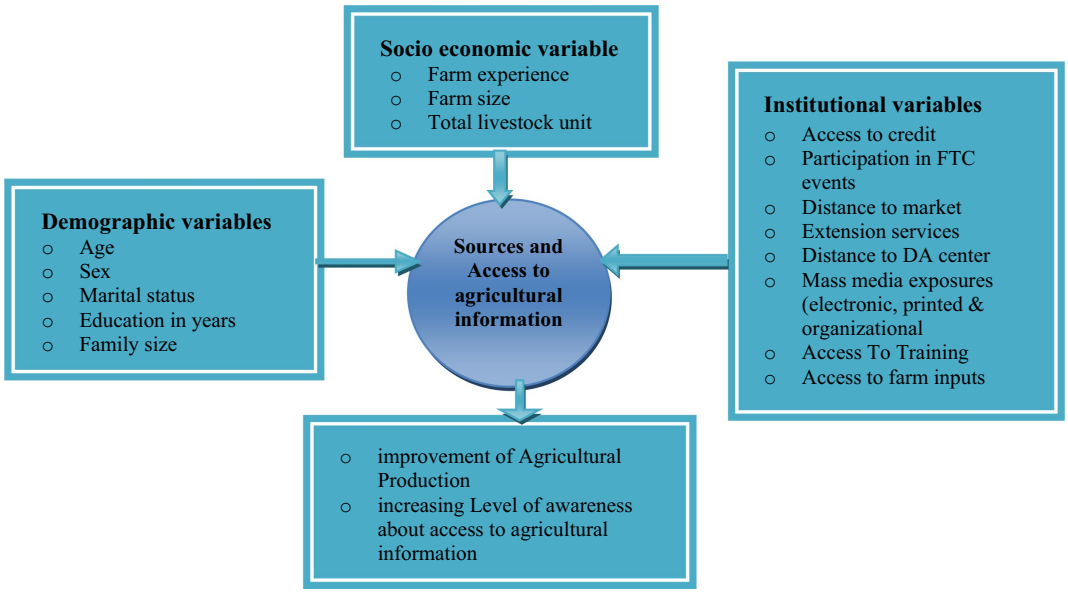

FIGURE 1
Conceptual framework of the study. Source: own composition based on a review of relevant literature.

particularly in terms of agriculture, water resources, and population dynamics (Tilahun et al., 2019).

The climate of East Gojjam is characterized by a temperate highland climate, with annual rainfall ranging from 800 mm to 1,200 mm. Average temperatures vary between a mean minimum of 7.5°C and a mean maximum of 25°C, which supports a wide range of agricultural activities. The fertile soils and favorable climate conditions allow for the cultivation of cereals such as teff, maize, wheat, and barley, alongside pulses and root crops. Livestock farming is also an essential aspect of the local economy, with cattle, sheep, and goats being raised for both consumption and trade. These agricultural activities are vital to the livelihoods of the region's residents and shape the socio-economic landscape of East Gojjam (Dereje et al., 2012).

The selection of East Gojjam for this study is driven by its proximity to the researcher, facilitating direct engagement with local farmers and agricultural systems. The region's diverse agro-ecological zones make it a key area for examining agricultural productivity, but smallholder farmers in the zone often face challenges accessing timely, relevant information due to limited extension services, poor infrastructure, and reliance on traditional knowledge. This study aims to explore how agricultural information is disseminated to and utilized by farmers, with a focus on the role of extension services, digital platforms, and local farmer groups. By leveraging the researcher's close proximity, the study can provide valuable insights into improving information access and enhancing agricultural practices, ultimately boosting productivity and sustainability in East Gojjam and similar rural regions of Ethiopia.

3.2 Sampling procedures and sample size determination

A sampling methodology with multiple stages was employed in the selection of respondents for the present study. The East Gojjam zone was deliberately chosen as the focal point within the Amhara regional state. In the subsequent stage, three districts and six Kebeles were randomly selected. Ultimately, a total of 403 respondents were chosen in a random manner, utilizing a probability proportion to the sample size formula. The significance of 5% of the overall sample size was taken into account to enhance representation. The determination of the sample size for this study was carried out using the sample size determination formula developed by Cochran (1963). Cochran (1963:75) devised an equation to compute a representative sample for proportions in extensive populations. The Cochran equation is presented as follows, and the sample size has been determined accordingly.

$$n = \frac{z^2 pq}{(e)^2}$$

$$n = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2}$$

$$n = \frac{0.9604}{0.0025} \approx 384 + 5\% \; of \; (384) = 403 \quad (1)$$

Which is valid where n is the sample size, z^2 is the abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level, e.g., 95%), e is the desired level of precision, p is the anticipated proportion of an attribute that is present in the population, and q is 1-p. The value for Z is found in statistical tables which contain the area under the normal curve (Israel, 1992).

3.3 Data collection methods and data sources

In order to fulfill the objectives of the study, data of both qualitative and quantitative nature were collected from both primary and secondary sources of information. The collection of primary data involved the use of various methods such as structured interviews, observations, key informant interviews, and focus group discussions. On the other hand, secondary data were obtained from published and unpublished documents, the district Office of Agricultural and Rural Development, as well as relevant materials like statistical reports, books, journals, and web sites.

To obtain the necessary data, a research design that employed a cross-sectional approach was utilized. This approach allowed for the collection of data at a single point in time. Multiple tools for data collection and analysis were employed in this particular study. Quantitative data were derived from personal interviews conducted with 403 sample households, while qualitative data were acquired through personal observations, focus group discussions, and key informant interviews with relevant entities. A pre-tested and structured interview schedule was employed to facilitate the interviews with the respondents. Furthermore, a pilot study was conducted in order to obtain a sufficient number of non-sample respondents for the purpose of restructuring. Based on the nature and extent of the responses received, modifications were made to the interview schedule to ensure that it effectively elicited the necessary information from the respondents. Lastly, secondary data for the study were obtained from district agricultural offices as well as various publications.

3.4 Methods of data analysis

The analysis necessitated the adoption of diverse methodologies contingent upon the objectives of a particular study and the characteristics of the available data. Following the process of editing, verification, and cleansing, the quantitative and qualitative data obtained from survey participants underwent analysis using Stata version 17 software. Descriptive statistics such as mean, standard deviation, frequency, and percentage, along with inferential statistics, were employed to examine the quantitative data. Additionally, an ordered probit model was utilized to assess the degree of access to agricultural information among smallholder farmers.

3.4.1 Model specifications

The econometric model specification in this study employs the ordered probit model to estimate and analyze the likelihood of farming households falling into one of three categories of agricultural information access: low, medium, or high. In this context, the dependent variable y represents the ordered categories of information access, with values ranging from 0 to *j*, where *j* = 1,2,3 corresponds to low, medium, and high levels of access, respectively. The ordered probit model is grounded in the latent variable approach, where an unobserved continuous variable y∗ is postulated to underlie the observed categorical outcomes. This latent variable is modeled as a linear function of explanatory variables X_i, which include household-level socioeconomic and institutional characteristics, and a normally distributed error term ϵ_i, as expressed in the following equation:

$$y^* = \beta_i X_i + \epsilon_i \tag{2}$$

Here, y∗ represents the unobserved continuous variable that captures the intensity of agricultural information access, while βi is a vector of coefficients to be estimated. The error term ϵi is assumed to be normally distributed with mean zero and variance σ^2, and the model assumes that ϵ_i has a cumulative normal distribution, consistent with the standard specification of probit models (Josselin et al., 2017; McCullagh, 1980).

The observed categorical outcomes are determined by threshold values μ_1, μ_2, μ_3, which partition the latent variable y∗ into discrete categories. Specifically, the outcome y takes the value of 1 (low access), 2 (medium access), or 3 (high access), depending on where the latent variable y∗ falls relative to these thresholds:

$$\gamma = \begin{cases} 1, if\ 0 < y* \leq \mu 1 \\ 2, if\ \mu 1 \leq y* \leq \mu 2 \\ 3, if\ \mu 2 \leq y* \leq \mu 3 \end{cases} \tag{3}$$

The thresholds μ_1, μ_2, μ_3, indicate the cutoffs between the ordered categories, and their estimation is crucial to understanding the distribution of information access levels in the sample. The interpretation of the estimated coefficients involves examining the direction and magnitude of the relationship between explanatory variables and the likelihood of a household having higher levels of access to agricultural information. A positive coefficient for a particular explanatory variable suggests that an increase in that variable is associated with a higher probability of accessing higher levels of information.

This model allows for a nuanced understanding of how various socioeconomic and institutional factors influence the likelihood of farming households falling into different categories of information access, which is particularly useful for policymakers aiming to enhance agricultural extension services and information dissemination.

4 Results and discussions

4.1 Socio-economic characteristics of respondents

Based on the empirical evidence presented in Table 1, several key demographic and socio-economic characteristics of the study participants are highlighted. A significant portion of the respondents (35.73%) lacks formal education, while 30.77% are literate but have not completed formal schooling. Additionally, 29.28% have completed elementary education, and 4.22% have reached secondary education, which aligns with findings from Aikins (2014).

Regarding marital status, 86.6% of participants are married, with smaller proportions being divorced (4.96%), widowed (4.71%), or single (3.75%). This marital trend reflects the predominance of male-headed households in the region, where men often manage the family farm, even when women have land ownership, a finding also observed in previous studies (Aikins, 2014; Kelil and Mamo, 2017).

Gender dynamics further reveal that 86.85% of respondents are male, with females constituting 13.15% of the sample. This male-dominated participation reflects the socio-cultural context, where men are typically the heads of agricultural households, although women contribute significantly by managing annual crops and generating income for the family.

In terms of health, 38.46% of respondents have faced health complications, which could limit their ability to access agricultural knowledge and engage in farm management, as a farmer's physical health is essential for effective participation in agricultural activities (Deressa et al., 2011). Furthermore, access to financial and extension services is critical for smallholder farmers' agricultural success. The study reveals that 66.75% of respondents have access to credit, while 33.25% do not. Similarly, 67.49% have access to agricultural extension services, which are crucial for improving farming practices and productivity. These services are often a determinant in farmers' ability to improve yields and adopt new technologies.

The respondents' average age is 42 years, with an average family size of 5.46 members and an average farm size of 1.86 hectares. Additionally, the average distance to the market center is 59 min, which could influence the accessibility of agricultural inputs and outputs.

4.2 Sources of agricultural information for small holder farmers

The primary sources of agricultural information utilized by smallholder farmers in the research area have been comprehensively documented and are presented in Table 2 below. Radio emerges as the most favored source (42.68%), closely followed by the Office of Agriculture (39.21%) and extension services (37.72%), as illustrated in the aforementioned table. Family members (31.51%) rank as the subsequent significant sources of agricultural knowledge, followed by neighboring farmers (25.32%), the FTC (23.08%), farm input distributors (14.39%), and printed media (10.67%). Conversely, leaflets, research institutions, academic institutions, television, 8,028 call services, religious institutions, magazines, non-governmental organizations (NGOs), and video recordings are identified as the least utilized sources of agricultural information among smallholder farmers.

Essentially, Obeng-Koranteng et al. (2017) concur with the findings of this study by affirming that radio, fellow farmers, and extension agents are the primary sources of agricultural knowledge for smallholder farmers in Ghana. This observation aligns with the research conducted by Ronald et al. (2015) who ascertain that neighbors, friends, radio, family or parents, and personal experience

TABLE 1 Socio-economic and institutional characteristics of respondents.

Variables	Category	Frequency	Percent	Mean
Educational status	No formal education	144	35.73	
	Read and write only	124	30.77	
	Primary education	118	29.28	
	Secondary education	17	4.22	
Marital status	Single	15	3.75	
	Married	349	86.60	
	Divorced	20	4.96	
	Widowed	19	4.91	
Sex	Male	350	86.85	
	Female	53	13.15	
Health status	Yes	155	38.46	
	No	248	61.54	
Access to credit	Yes	269	66.75	
	No	134	33.25	
Extension services	Yes	273	67.49	
	No	131	32.51	
Age				42
Family size				5.46
Farm size				1.86
Market distance				59.33
Distance from development center				29

Source: filed data, 2023.

TABLE 2 Respondents' major sources of agricultural information.

Source	Frequency	Percent	Rank
Radio	172	42.68	1
Agriculture offices	158	39.21	2
Extension workers	152	37.72	3
Family members	127	31.51	4
Neighbor farmers	102	25.31	5
FTC	93	23.08	6
Farm input distributors	58	14.39	7
News paper	43	10.67	8
Leaflets	18	4.47	9
Research & academic institutions	17	4.22	10
Television	16	3.97	11
8,028	11	2.73	12
Religious leaders	7	1.74	13
Magazines and NGOs	4	1.00	14
Religious institutions	3	0.74	15
Academicians	2	0.50	16
Video records	1	0.25	17

Source: filed data, 2023.

serve as the principal sources of agricultural information for smallholder farmers in Zanzibar. Furthermore, the present study exhibits similarities with that of Isaya et al. (2018).

Correspondingly, Yaseen et al. (2016), ascertain that the majority of farmers prioritize neighbor-friends-relatives as the foremost source of information for smallholder farmers residing

in rural regions of Pakistan, which corroborates the findings of this study.

Qualitative data from key informant interviews (KIIs) further support these trends, with male respondents (KII1–5, KII 12–17, and KII 24–29) highlighting extension officers, family members, neighboring farmers, and radio as their primary sources of agricultural knowledge. These consistent patterns suggest that smallholder farmers in various rural settings rely heavily on community-based and mass communication channels, with radio serving as a central medium for information dissemination.

4.3 Level of access to agricultural information by gender

Based on a preliminary survey conducted prior to the actual data collection, respondents' access to agricultural information was categorized into three levels: low, moderate, and high. This classification was made based on the respondents' gender and their self-reported levels of access to agricultural information. The distribution of respondents' access is presented in Table 3 below, which provides a breakdown of the frequency and proportion of individuals falling into each category.

The survey results aim to give a clearer picture of gender-based differences in access to agricultural knowledge, highlighting whether men or women in the study area experience varying levels of accessibility to vital agricultural information. This classification will serve as a foundation for further analysis and interpretation of the data collected in subsequent stages of the research.

As shown in Table 3, the preliminary survey revealed that half of the female respondents (25 individuals) fell into the low-access category for agricultural information. In contrast, the majority of male respondents were categorized under the moderate to high levels of access. This analysis suggests that male smallholder farmers generally have better access to agricultural information compared to their female counterparts. This trend is consistent with broader patterns observed across various regions, where women involved in agricultural work often face greater barriers to accessing vital agricultural knowledge.

Factors such as cultural norms, limited mobility, and lower levels of formal education can contribute to this disparity. The finding that women have less access to agricultural information is further supported by research conducted by Lamontagne-Godwin et al. (2018a), which highlights the gender gap in agricultural knowledge access in rural communities. Despite differences in geography and culture, this issue remains a common challenge for women in agriculture globally.

4.4 Frequency of access to agricultural information

The study's findings on access to agricultural information reveal that a significant proportion of respondents reported never acquiring information from formal sources. As shown in Table 4, 98.26% of respondents never accessed agricultural information from NGOs, 97.77% from magazines, 96% from religious leaders or academicians, 92.31% from research institutions, 95.53% from leaflets, 95.52% from television, and 94% from academic institutions. These figures highlight the limited reach of formal sources such as media outlets, government organizations, and academic institutions among smallholder farmers. These findings are consistent with global trends observed in similar studies, where smallholder farmers in rural areas often face barriers in accessing agricultural information through formal channels.

Access to agricultural information is the ability to identify, acquire, and effectively utilize agricultural information. The aim of the study was to understand how often farmers access agricultural information from various sources. Aker et al. (2021) have noted that despite efforts to improve access, factors such as inadequate infrastructure, high costs, and information that is not tailored to local needs prevent many farmers from engaging with these sources.

In contrast, the study found that informal sources of information, such as family members, neighbors, and radio, are more widely accessed by farmers. This is in line with recent studies, including those by Chandna et al. (2021), which show that smallholder farmers in rural areas often prefer informal sources due to their accessibility and practical relevance. Chandna et al. (2021) found that farmers in rural India primarily relied on family and peer networks rather than formal institutions like NGOs or academic sources. Similarly, Kiptot et al. (2021) highlighted that radio remains the most accessible and trusted source of agricultural information for smallholders in East Africa, as formal sources are often out of reach or irrelevant to the day-to-day needs of farmers.

The limited access to formal sources of agricultural information is further confirmed by Lamontagne-Godwin et al. (2018b), who emphasize that rural farmers, particularly women, face significant barriers to accessing high-quality agricultural knowledge from formal channels. Despite the availability of information through institutions like NGOs, research bodies, and the media, these sources fail to reach a large portion of the rural farming population. This gap underscores

TABLE 3 Level of access to agricultural information by gender.

Level of access	Gender			
	Female		Male	
	Frequency	%	Frequency	%
Low	25	6.2	133	33
Moderate	17	4.22	132	32.75
High	11	2.73	85	21.10

Source: filed data, 2023.

TABLE 4 Frequency of access to agricultural information.

Access from	Frequency of access to agricultural information								Mean
	Never		Sometimes		Once a week		Daily		
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	
Radio	215	53.35	146	36.23	13	3.23	29	7.20	0.643
Extension workers	55	13.65	326	80.89	20	4.96	2	0.50	0.923
Research institutions	372	92.31	29	7.20	2	0.50	0.00	0.00	0.082
Local government	353	87.59	49	12.16	1	0.25	0.00	0.00	0.126
Office of agriculture	236	58.56	162	40.20	5	1.24	0.00	0.00	0.427
Family members	150	37.22	177	43.92	55	13.65	21	5.21	0.868
Video records	396	98.26	7	1.74	0.00	0.00	0.00	0.00	0.017
Farm input distributor	297	73.70	102	25.31	4	0.99	0.00	0.00	0.273
Leaflets	385	95.53	17	4.22	1	0.25	0.00	0.00	0.047
Conference events	239	59.31	161	39.95	3	0.74	0.00	0.00	0.414
Religious leaders	386	95.78	12	2.98	5	1.24	0.00	0.00	0.055
Village leaders	356	88.34	45	11.17	2	0.50	0.00	0.00	0.122
Television program	384	95.52	15	3.73	2	0.50	1	0.25	0.055
FTCs	199	49.38	194	48.14	10	2.48	0.00	0.00	0.531
Neighbors	187	46.40	192	47.64	19	4.71	5	1.24	0.608
Academic institutions	379	94.04	21	5.21	3	0.74	0.00	0.00	0.067
Magazines	394	97.77	9	2.23	0.00	0.00	0.00	0.00	0.022
NGOs	397	98.51	6	1.49	0.00	0.00	0.00	0.00	0.015
Religious institution	387	96.03	12	2.98	4	0.99	0.00	0.00	0.050
Academicians	387	96.03	16	3.97	0.00	0.00	0.00	0.00	0.040
Newspapers	366	90.82	37	9.18	0.00	0.00	0.00	0.00	0.092

Source: filed data, 2023.

the need for more inclusive and locally relevant strategies to enhance agricultural knowledge dissemination and better support smallholder farmers in overcoming the barriers they face.

4.5 Association of socio-economic characteristics and accesses to information

Socio-economic factors significantly influenced smallholder farmers' access to agricultural information, as outlined in Table 5. A notable correlation was found between farm size and access to agricultural information ($p = 0.012$), suggesting that farmers with larger farms tend to have better access to agricultural knowledge. This finding is consistent with previous studies by Aikins (2014) and Beshir et al. (2015), which also identified farm size as a key determinant of information access among smallholder farmers.

Additionally, the study revealed a significant relationship between total livestock units and access to agricultural information, with a Chi-square value of $\chi^2 = 4.922$, $p = 0.007$. This indicates that the number of livestock owned by farmers plays a crucial role in determining their ability to access agricultural information. These results underscore the importance of socio-economic characteristics in shaping how farmers engage with agricultural knowledge.

4.6 Association of institutional factors and accesses to information

Institutional factors also played a significant role in determining smallholder farmers' access to agricultural information, as shown in Table 6. The analysis revealed a significant relationship between access to credit ($p = 0.014$) and distance to market ($p = 0.003$) with access to

TABLE 5 Association of socioeconomic characteristics & access to agricultural information.

Variables	$\chi 2$ (α = 0.05)	p-value
Educational status	10.3203	0.112
Gender	1.6240	0.444
Age	99.1415	0.717
Family size	21.4869	0.716
Marital status	12.0638	0.061*
Farm experience	105.0408	0.133
Total farm size	77.8256	0.012**
Total livestock unit	4.922	0.007***
Membership	3.9427	0.139

Sources: filed data, 2023.

TABLE 6 Association of institutional factors and access to agricultural information.

Variables	$\chi 2$ (α = 0.05)	p-value
Access to credit	8.5130	0.014**
Frequency of access to market	16.1217	0.003***
Development center	70.5904	0.000***
Access to extension services	10.8917	0.004***
Participation in FTC events	0.4394	0.803

Sources: filed data, 2023.

agricultural information. These findings align with those of who found that financial resources and market access are key factors influencing the availability of agricultural knowledge to farmers.

Furthermore, the study showed a strong correlation between distance from the development center ($p = 0.000$) and access to extension services ($p = 0.004$) with the likelihood of farmers accessing agricultural information. These results suggest that proximity to development centers and the availability of extension services are critical for enhancing farmers' access to agricultural knowledge. This conclusion is consistent with earlier research by Aikins (2014), who also identified access to credit, market proximity, and extension services as vital factors in improving smallholder farmers' information access.

4.7 Determinants of access to agricultural information

Table 7 provides an exposition of the marginal effect of access to agricultural information by smallholder farmers through the ordered probit model. The table reveals that out of the 20 explanatory factors, 10 of them were found to be statistically significant at various levels of significance, namely 1, 5, and 10%.

Farm experience holds great importance for smallholder farmers in their pursuit of agricultural information for their farming practices. A unit increase in farm experience is associated with a 0.56% decrease in the probability of falling into the low access category and a 0.5% increase in the likelihood of falling into the high access category for agricultural information. This outcome aligns with the prediction made by the hypothesis, which suggests that farmers with more experience are more likely to have access to agricultural knowledge. This finding is consistent with a study conducted by Diekmann et al. (2009). Furthermore, the significance of farming experience as a predictor for access to and utilization of agricultural information among Kenyan smallholder tea farmers has also been demonstrated in the research conducted by Koskei et al. (2013). Governments and NGOs can also develop tailored training initiatives to support less experienced farmers.

Total farm size also plays a crucial role in farming activities as it impacts the economic and informational aspects of agricultural production and productivity for farmers. A one-hectare increase in farm size corresponds to a 3.84% decrease in the probability of having poor access to agricultural information and a 3.40% increase in the probability of having high access to agricultural information. This finding is similar to the study conducted by Beshir et al. (2015), which found that as farm size increases, so does access to agricultural information. To ensure smaller farms are not left behind, policies could focus on facilitating land consolidation or cooperatives and providing financial support to help smallholders scale up their farms, improving both productivity and access to agricultural information.

Exposure to electronic media is a significant factor in accessing agricultural information for smallholder farmers. The results indicate that being exposed to electronic mass media is associated with a 21.40% decrease in the probability of having low access to agricultural information, a 2.50% increase in the probability of having moderate access, and an 18.90% increase in the probability of having high access. This finding is in line with the research conducted by Mbanda-Obura et al. (2017), which highlights the pivotal role of electronic media exposure in accessing agricultural information for smallholder farmers. This study is also supported by the findings of Lucky and Achebe (2013).

TABLE 7 Marginal effect of access to agricultural information.

Variables	Level of access to agricultural information		
	Low	Moderate	High
Farm experience	−0.00556* (0.0033)	0.00065 (0.000495)	0.005* (0.0035)
Age	0.00421 (0.00355)	−0.0005 (0.0005)	−0.0037 (0.00313)
TLU	−0.000187 (0.0058)	0.000022 (0.0007)	0.00017 (0.00517)
Gender	0.0336 (0.0560)	−0.0040 (0.00680)	−0.0296 (0.04935)
Marital status	0.0406 (0.0410)	−0.0047 (0.00514)	−0.0359 (0.0363)
School per years	−0.00245 (0.0060)	0.0003 (0.00071)	0.0022 (0.0052)
Total family size	−0.0060 (0.0098)	0.0007 (0.0012)	0.0050 (0.0086)
Total farm size	−0.0384* (0.0220)	0.0044 (0.0034)	0.0340* (0.0193)
Membership	0.0046 (0.0373)	−0.0005 (0.0043)	−0.0041 (0.0330)
Health status	0.0247 (0.0340)	−0.0028 (0.0042)	−0.0218 (0.0305)
Electronic media	−0.214*** (0.0352)	0.025** (0.0120)	0.189*** (0.032)
Printed media exposure	−0.126*** (0.0477)	0.0147 (0.0095)	0.111*** (0.041)
Organizational media	−0.160*** (0.0551)	0.0186** (0.0093)	0.141*** (0.051)
Extension services	−0.307*** (0.070)	0.036** (0.0158)	0.271*** (0.068)
Access to farm inputs	−0.213*** (0.038)	0.025* (0.0130)	0.188*** (0.032)
Access to training	−0.043 (0.0367)	0.005 (0.0050)	0.038 (0.032)
Access to credit	−0.023 (0.034)	0.0027 (0.0042)	0.020 (0.030)
Distance to market	0.0008** (0.0004)	0–0.0001 (0.00007)	−0.00072** (0.00036)
Distance to DC	−0.0018** (0.00093)	0.00022 (0.00014)	0.0017** (0.00083)
Participation	0.107 *** (0.036)	−0.0125* (0.0074)	−0.094*** (0.032)

Standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.
Source: filed data, 2023.

Exposure to printed media is another critical factor that impacts smallholder farmers' access to agricultural information. The findings reveal that being exposed to printed media is associated with a 12.60% decrease in the likelihood of having poor access to agricultural information and an 11.10% increase in the likelihood of having good access. This suggests that farmers, who are exposed to printed media such as newspapers, leaflets, magazines, books, etc., have a higher likelihood of accessing agricultural knowledge. This research aligns with the studies conducted by Adolwa et al. (2012) and Ssegujja et al. (2010).

Exposure to various organizational information sources is found to be associated with a 16% decrease in the probability of experiencing inadequate agricultural access, a 1.86% increase in the probability of having moderate agricultural access, and a 14.10% increase in the probability of having high agricultural access. Farmers who have been exposed to information sources provided by organizations such as the FTC, agriculture offices, universities, research institutions, religious institutions, and local governments are more likely to have access to agricultural information. This study bears resemblance to the research conducted by Sani et al. (2015). Strengthening the reach and accessibility of these institutions by establishing local information hubs could ensure that farmers, especially those in rural areas, benefit from regular engagement with extension services, which have also been shown to improve access to agricultural knowledge. Governments should prioritize increasing funding for extension services and consider introducing mobile extension units to reach underserved areas.

The accessibility of extension services is a crucial and noteworthy institutional component that significantly influences the level of agricultural information access for smallholder farmers. Access to extension services is associated with a 30.70% reduced likelihood of having low agricultural information access, a 3.50% increased likelihood of having moderate agricultural information access, and a 27.10% increased likelihood of having high agricultural information access, as indicated by the final findings. These findings are supported by the studies conducted by Derebe (2007) and Selamawit (2017).

The availability of farm inputs is one of the fundamental institutional factors that affects farmers' access to agricultural knowledge. Access to farm inputs is linked to a 21.30% lower risk of experiencing inadequate agricultural access, a 2.50% higher likelihood of having moderate agricultural information access, and an 18.80% increased likelihood of having high agricultural information access, according to the findings. The accessibility of farm inputs has a notable impact on the access to agricultural information for smallholder farmers.

The proximity of the market center to one's home is a significant aspect in the farming activities of smallholder farmers. For every unit increase in market distance, there is a 0.080% higher likelihood of having poor access to agricultural information and a 0.072% lower likelihood of having high access to agricultural information. This study is supported by the research conducted by Aika (2017).

The distance from the development center also plays a role in the productivity of farming activities. The findings of this study suggest that for every unit increase in distance from the Development Center, there is a 0.18% lower likelihood of having poor access to agricultural information and a 0.072% higher likelihood of having high access to agricultural information. Similarly, a study reported by Simon et al. (2015) found that distance from the extension center has a positive and significant effect on smallholder farmers' participation in collective marketing. Similarly, Beshir et al. (2012) reported that distance to development has a positive effect on the probability of adoption and intensity of use of chemical fertilizer.

Participation in FTC events is associated with a 10.7% increase in low agricultural access, a 12.50% decrease in intermediate agricultural access, and a 94% reduction in high agricultural access. This outcome suggests that farmers who do not participate in FTC events are more likely to fall into the low access category, but less likely to be in the moderate and high access categories. Consequently, individuals who frequently engage in extension activities, training, and field trips are more inclined to acquire skills and knowledge about agricultural productivity. Therefore, the presence of extension participation in rural areas is crucial for smallholder farmers. In a similar vein (Mwalukasa, 2013) discovered that involvement in FTC activities has a positive and substantial impact on farmers' access to agricultural information. Expanding FTCs, increasing the frequency of their activities, and providing incentives for farmers to attend could further strengthen the diffusion of agricultural knowledge.

Overall, the findings suggest that a comprehensive and integrated approach is needed to support smallholder farmers. Policies should aim to enhance media access, strengthen institutional support, improve infrastructure, and increase the availability of extension services and farm inputs. By addressing these multiple dimensions, local governments and NGOs can create an enabling environment for farmers to thrive, ensuring that agricultural knowledge reaches those who need it most. Tailored interventions should also focus on vulnerable groups such as women, young farmers, and those with smaller land holdings to bridge gaps in access and enhance overall agricultural productivity and rural development.

4.8 Constraints of access to agricultural information

Smallholder farmers in the research area face several significant barriers to accessing agricultural information, which limits their productivity. The most prominent obstacle, cited by 88.34% of farmers, is the lack of government intervention or legislation supporting access to agricultural information. Poor mobile network connectivity (81.64%) and inadequate extension services (80.65%) are also major challenges, as they hinder farmers from receiving timely advice and expert guidance. Additionally, 80.10% of farmers reported a lack of formal information services, while 79.60% pointed to poor infrastructure, including transportation and electricity, as limiting their access to both markets and information.

Other constraints include limited awareness of information sources (77.67%), insufficient knowledge-sharing networks (75.68%), and ineffective public relations efforts (70.72%). Language barriers (63.28%) and weak media signals (60.79%) also reduce farmers' ability to access agricultural content, with irregular media airtime (46.9%) further complicating matters. These findings align with previous studies (Adetimehin et al., 2018; Siyao, 2012) which identified similar challenges, such as outdated information, insufficient funding, and infrastructure gaps. Interviews with farmers confirmed that inadequate knowledge-sharing, limited access to inputs, and poor infrastructure are key constraints to accessing agricultural information.

Likewise, several respondents from key informant interviews (KII 1–5, KII 6–11, KII 12–17, KII 18–23, KII 24–29, and KII 30–35) emphasized that inadequate knowledge-sharing, subpar infrastructure, limited access to farm inputs, and insufficient extension services are the primary constraints to accessing agricultural information. Network issues and a lack of understanding about the importance of utilizing agricultural information were also highlighted as significant barriers. These findings align with previous studies, including those by Adetimehin et al. (2018) and Siyao (2012), which identified similar challenges, such as outdated information, insufficient funding, and gaps in infrastructure.

To overcome these barriers, a coordinated approach is needed, including improved infrastructure, better extension services, and stronger government support for agricultural information dissemination. Tailored solutions addressing the specific needs of smallholder farmers are crucial for enhancing productivity in the region (Figure 2).

5 Conclusion and recommendation

This research assessed the sources, accessibility levels, and limitations faced by smallholder farmers in accessing agricultural information in the East Gojjam zone, Amhara, Ethiopia. The study surveyed 403 households across six districts, revealing that smallholder farmers primarily rely on sources such as radio, the Office of Agriculture, extension services, family members, neighboring farmers, Farmer Training Centers (FTC), and farm input distributors for agricultural information. In contrast, sources such as leaflets, research and academic institutions, television, 8,028 call services, religious institutions, magazines, NGOs, and video records were found to be less utilized by farmers in the area.

The ordered probit model analysis showed that several factors had a statistically significant impact on the access to agricultural information, including farm experience, exposure to electronic and printed media, total farm size, access to extension services, proximity to markets and development centers, and participation in FTC events. These factors were significant at the 1, 5, and 10% levels, underscoring the complex and multifaceted nature of agricultural information access.

The study also identified key barriers that restrict smallholder farmers' access to agricultural knowledge. These included inadequate government policies, insufficient extension services, limited availability of information services, poor infrastructure, network connectivity issues, and a lack of effective knowledge exchange. These challenges severely hinder farmers' ability to obtain

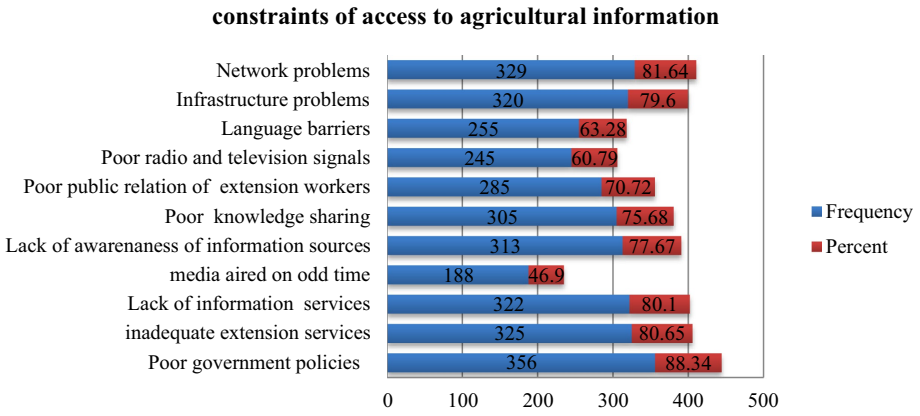

FIGURE 2
Constraints of access to agricultural information. Source: filed data, 2023.

relevant information, which in turn affects their productivity and overall agricultural development.

Given these findings, it is clear that improving rural infrastructure is essential to enhancing the accessibility of agricultural information. Key areas for improvement include mobile network coverage, road infrastructure, market services, and electricity availability. The Ethiopian government should prioritize investments in these areas to facilitate more effective information flow and increase agricultural productivity. Additionally, efforts to strengthen extension services, increase the availability of diverse information sources, and foster knowledge-sharing networks among farmers, agricultural institutions, and development organizations should be part of a broader strategy to improve access to agricultural knowledge in rural Ethiopia. By addressing these challenges, the government can empower smallholder farmers with the information needed to boost productivity, improve food security, and promote sustainable agricultural practices across the region.

5.1 Limitations of the study

A key limitation of this study is the reliance on self-reported data, which may introduce biases due to farmers' subjective perceptions, memory recall, or social desirability. This can affect the accuracy of assessing the impact of information access on productivity. The study's sample may also lack representativeness, especially among marginalized groups, and its findings may not be generalizable beyond East Gojjam due to regional differences. Additionally, challenges like language barriers, illiteracy, and inconsistent access to technology may affect data quality. Acknowledging these limitations is important for a more nuanced interpretation of the findings.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Bahir Dar University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

ZS: Writing – original draft, Software, Resources, Methodology, Data curation. BT: Writing – review & editing, Supervision, Conceptualization. KE: Writing – review & editing, Supervision, Conceptualization.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Appendix

Table A1

TABLE A1 Key informant interview.

Code	Gender
Interview conducted in Bassoliben district, June, 2023	
KII 1–5	Men
KII 6–11	Women
Interview conducted in Gozamin district, July, 2023	
KII 12–17	Men
KII 18–23	Women
Interview conducted in Debre Elias district, September, 2023	
KII 24–29	Men
KII 30–35	Women