INITIATIVE ON Mixed Farming Systems

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Assessment of Radio Communication Approaches for the Effective Dissemination of Livestock Production Technologies

A Baseline Report

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The Sustainable Intensification of Mixed Farming Systems Initiative aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecologies and socio-economic settings.

Through action research and development partnerships, the Initiative will improve smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities will be implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).

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Abbreviations and Acronyms

ICARDA	International Center for Agricultural Research in the Dry Areas
MNL	Multinomial logistic regression model
SNNPR	The Southern Nations, Nationalities, and Peoples' Region

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Summary

A key factor hindering the development of agricultural productivity among smallholder farmers in Sub-Saharan Africa is inadequate agricultural technologies that address specific local problems. The modalities used for technology transfer often overlook the unique local contexts and the specific needs of the intended recipients. This study examines various approaches that can be used to effectively disseminate livestock production technologies via radio received by smallholder farmers. Data was collected from 387 respondents in Amhara and Southern regions of Ethiopia. Multinominal logistic regression was used to predict the sources of information about agricultural technologies. Findings suggest that radio is accepted for disseminating information about agricultural technologies. Overall, about 71% of the respondents believe that radio is useful in conveying information about innovative practices in livestock farming. When examining different modalities of communicating agricultural innovations through radio programs, respondents preferred structured lessons, plays, or community dialogues. The most preferred approach was to broadcast programs several times a week in the evening hours, with each episode lasting between 1 and 2 hours. The effectiveness of radio as a medium for disseminating agricultural technologies depends on gender, educational level, religious beliefs, and place of residence. Survey participants highlighted several challenges in leveraging radio to advance agricultural technology. These included a lack of radio programs focused on livestock production, existing programs that did not address locally specific agricultural issues, and electricity supply shortages.

Addressing these challenges could improve the efficiency of information dissemination through the media and help smallholder farmers adopt and use improved livestock production technologies.

Introduction

The Sub-Saharan Africa region has a predominantly rural population whose livelihoods depend primarily on seasonal crop production and livestock farming. The agricultural sector overall employs approximately 70% of the region's workforce and plays a crucial role to its economy (Roseboom et al., 2016). In Ethiopia, crop and livestock production accounts for 80% of total exports and contributes 40% to the national gross domestic product. Nevertheless, the sector in the country is characterized by low productivity and a consumption-based rather than market-orientation due to the limited application of innovations and technologies (Chauvinet al., 2012; Erdaw, 2023).

Livestock production plays an important role in the agricultural sector in Ethiopia. It contributes about 26% of the value of the country's annual crop production. Ethiopia also ranks first in Africa and fifth globally in livestock population. The country has diverse agro-ecosystems and several livestock species and breeds (Management Entity, 2021; Begna, 2023). The diversity of the livestock varies depending on the region. According to the 2022 report of the Ethiopian Biodiversity Institute, the country's livestock population comprises 30 cattle breeds, 14 sheep breeds, 13 goat breeds, 5 chicken breeds and 5 honeybee breeds (EBI, 2020).

Although Ethiopia has a significant livestock population, the efficiency of livestock production and the income generated in this sector are relatively low compared to other African countries with comparable resources. This underperformance is attributed to various factors, including the dominance of traditional farming methods, inadequate research and innovative, underutilization of improved feed resources, shortage of production equipment and limited access to credit (Bachewe et al., 2018, Eeswaran et al., 2022). The sector is also characterized by limited awareness of improved production practices, resulting in suboptimal husbandry practices (Mengistu et al., 2021). There is also a lack of appropriate development policies, strategies, and interventions tailored to address regional-specific issues and improve the profitability of the sector (Bachewe et al., 2018; Begna, 2023).

There are delays and gaps in the dissemination of agricultural innovations to smallholder farmers. There are challenges in effective communication of information to livestock farmers using suitable communication methods. The information

dissemination channels used may not adequately consider the specific context of smallholder farmers, who typically have lower levels of educational and limited access to mass media (Mekonnen et al., 2016; Kebede, 2019; Zerssa et al., 2021; Nyokabi et al., 2023). Research conducted in northern Ghana found that engaging farmers in mobile text messaging and video presentations did not result in the adoption of new technologies. This lack of uptake was attributed to challenges associated with the farmers' inability to read text messages and watch video content on mobile phones and television screens (Damba et al., 2016).

Challenges related to technological diffusion pathways contribute to the slow progression of smallholder farmers' benefits from agricultural innovations (Damba et al., 2016). Therefore, identifying appropriate communication methods, and channels tailored to the specific needs of farmers is essential to enhance their adoption and use of technology. Modalities and approaches for technology transfer must be developed and designed considering the local contexts and needs of the beneficiaries. For example, in remote areas where electricity supply is limited and poverty rates are high, radio serves as an important medium for disseminating information compared to television and social media. This is due to the widespread accessibility of radio devices. Additionally, for farmers engaged in agricultural activities, it is more convenient to listen to radio broadcasts than to watch television or search for information online (Chachhar et al., 2012; Mtega, 2018; Yakubu et al., 2019). The way in which technological innovations are delivered, including transmission routes, timing and methods, can influence their accessibility and benefits to smallholder farmers.

Numerous studies conducted in Ethiopia and other developing countries demonstrate the crucial role of the diffusion of innovations in agricultural development and improving the welfare of smallholder farmers (Wordofa et al., 2021; Dumeh, 2011; Biru et al., 2020; Habtewold and Heshmari, 2023). However, there are limited studies focusing on approaches of disseminating innovations within livestock production systems. The aim of this current study is to provide relevant insights by assessing the acceptability and appropriateness of communicating livestock production technologies, particularly through radio broadcasts to smallholder farmers in the Amhara and SNNP regions of Ethiopia. The study examines

sociodemographic covariates that predict the use of various communication medias as sources of knowledge about livestock production technologies.

Materials and Methods

Study design and setting

The study used a community-based cross-sectional study design and was conducted in the Amhara and SNNP regions of Ethiopia. In 2023, the population size of the Amhara region is estimated to be 23,216,000, while that of the SNNP region is projected to be 13,044,044 (ESS, 2023). In the Amhara and SNNP regions, agriculture is the mainstay economic activity; over 80% and 85% of the population respectively earn their living from it. Most households in the regions practice mixed-subsistence farming systems, which includes growing rain-fed crop production and livestock rearing. Agriculture accounts for 43.2% of the regional GDP in SNNP and 55.4% in Amhara (WSP and ZGEC, 2017; WSP and ETWRDEC, 2018; World Bank, 2020).

The Amhara and SNNP regions of Ethiopia have high potential for livestock production, which can increase the income generated in this sector for smallholder farmers. The regions host diverse livestock genetic resources, and different types of animal feeds are available (Negassa et al., 2017; Mekuria et al., 2018; Debela., 2021). According to the Ethiopian Central Statistical Authority livestock's 2022 Livestock Survey, there are 10.3 million sheep and 6.9 million goats in the Amhara region. The corresponding figures for the SNNP region are 4.7 million sheep and 4.8 million goats. The regional states of Amhara and SNNP account for 24.7% and 14.3% of the total livestock in the country, respectively (CSA, 2020; Management Entity, 2021).

Sample and sampling procedure

The sample size of the study was determined using the following Cochran (1977) formula:

$$n = \frac{Z^2 * \rho * (1 - \rho)}{e^2}$$

Where n is the sample size and z is the critical value of the desired confidence. *p* represents the proportion of the population that accepts information dissemination via radio. Finally, e refers to the margin of error, which indicates the degree of uncertainty that the sample might have. There are currently no studies on the acceptance of receiving information about livestock technologies via radio as a communication medium. According to the acceptable standard when the population

proportion is not known, 0.5 was assumed as the maximum variance (p) for the acceptance of radio as an information source (Sukcharoenpong et al., 2022; Akrong, 2021). Therefore, for a two-tailed test with a 95% level of confidence (1.96) and 5% error margin, the sample size required to estimate the population parameters was calculated to be 385. By including 15 additional continent liability, the goal was to survey 400 respondents. Finally, data were collected from 387 study participants with a response rate of 96%.

Study participants were identified using an on-site randomized controlled approach to conduct an experimental study on the effectiveness of using radio as a dissemination channel to improve the productivity of small ruminant production among smallholder farmers. First, districts, hereinafter referred to as woredas, with high potential for livestock production, were identified. Comparable villages were then selected within the woreda sample to serve as control and treatment areas. Finally, in collaboration with the local administrative authorities, study participants were randomly selected from the target group who are currently engaged in or plan to start sheep fattening operations soon in each of the sample villages.

Data collection procedure

The primary data collection was conducted using a structured survey instrument that included various sections on perceptions and practices of using various communication media to obtain information on improved agricultural practices. The survey also inquired about the modalities of target groups for receiving information about livestock technologies from radio broadcasts. Additionally, the survey asked for detailed information on the sociodemographic characteristics of the study participants.

An experienced data collection team was recruited and provided training on the questions included in the tool and survey protocol. During the data collection period, principal investigators closely monitored the process and provided support to ensure the completeness and consistency of the completed surveys. Potential respondents were informed about the purpose of the study and their right to participate or decline to participate in the study. Only those who agreed to participate were interviewed. The survey was conducted in the study areas between April and July 2023.

Data analysis

Data management and analysis were performed using STATA 17. The study used descriptive statistics to summarize the results on the profile of the participants and the types of technology information related to livestock production that smallholder farmers would most prefer to be communicated via radio.

Six questions were used to assess study participants' perceptions of the appropriateness of using radio to disseminate agricultural information to smallholder farmers. Perceptions of radio were measured using a 5-point Likert scale, with 1 indicating complete disagreement and 5 indicating complete agreement. The study participants' perceptions of the appropriateness of using radio to disseminate agricultural information to smallholder farmers were assessed. Perceptions of radio were measured using a 5-point Likert scale, with 1 indicating complete disagreement and 5 indicating complete agreement. Study participants' perceptions of the appropriateness of using radio to disseminate agricultural information to smallholder farmers were assessed. Perceptions of radio were measured using a 5-point Likert scale, with 1 indicating complete disagreement and 5 indicating complete agreement. The average score for each of the perception indicators was estimated for the total sample and per study district. Based on the literature in the area, the calculated mean scores were then interpreted in three groups: disagree (if the score was between 1 and 2.3), neutral (2.4-3.6) and agree (3.7-5) (Wilcox and Lewandowski, 2016; Lionello et al, 2021). We also created a single-score metric showing the overall perception level of radio by summing up responses to the six related questions. This score ranges from 6 to 30 and, based on the standard described earlier, the calculated scores were categorized as disagree (6–13), neutral (14–21), and agree (22–30).

In addition to mean scores, confidence intervals to show the reliability of estimated statistics and their likely existence in the population were created (Das, 2019; Hemming and Taljaard, 2021). To examine whether there are any statistically significant differences in the mean scores of perceptions across the study woredas in the study, one-way analysis of variance (ANOVA) was used. Since a series of Likert-scale questions were used to create aggregated perception scores, the reliability and

internal consistency of the indicators using Cronbach's alpha test was checked (Alemayehu et al., 2022; Kathar and Sohel, 2023).

Descriptive statistics was used to summarize how the participants would prefer to receive information about livestock production technologies via radio. Preferences were measured based on four radio communication aspects: information delivery method, frequency of program broadcast, time of day, and length of lesson per program. Additionally, relative frequencies were estimated to show the experience of smallholder farmers in using different modes of communication channels to obtain information on livestock production technologies. Pearson's chi-square ($\chi 2$) test was used to examine the relationship between the use of various types of media and the socioeconomic profiles of the respondents. Since the variables are categorical in nature and mutually exclusive, this test is appropriate for our analysis (Belachew and Ababu, 2021).

A multinomial logistic (MNL) regression model was used to examine the factors that determine the likelihood of using different communication modes as sources of knowledge on livestock technologies. Unlike other discrete choice models, MNL regression is useful for evaluating the factors associated with behavioural choices of individuals when the outcome variable has more than two categories. The other advantage of the model is that it does not depend on the assumptions of multiple linear regression such as normality and homoscedasticity (Green, 2003; Wooldridge, 2006; Upton, 2016; Tung, 2020). The basic econometric model showing the likelihood of choosing a specific outcome category is provided below:

$$\Pr(y_i = j|X) = log \frac{\Pr\,(y_i=j|x)}{\Pr\,(y_i=K|x)} = \frac{expo(X_i\beta_j)}{\sum expo(X_i\beta_K)} \ldots. (1)$$

Where y is an outcome variable that has K number of categories, which in our case are different sources of information about livestock production systems. Among the available categories of j=1,....K, say the last category K, is arbitrarily assigned as a reference category. The referent category (K) serves as a comparison group for a specific category (j). The MNL regression is transformed into the following linear function to predict the natural logarithm of the probability ratio for the jth category of the outcome variable (Zhao and Cen; 2014):

$$\Pr(y_i = j|X) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + \varepsilon \ldots\ldots (2)$$

In the notation, yi refers to the probability that the respondent i would prefer an outcome category j as compared to the available K options. On the other hand, X are various socioeconomic factors that could predict the frequency of choosing jth category and β' s are coefficients to be estimated in the model. Finally, ε is the error term which indicates the effect of various factors omitted from the above equation.
By fitting question (2), the model for factors predicting the incidence of receiving agricultural technologies from various sources of information is specified as follows:

$$\Pr(SKAI_i = j|X) = \beta_0 + \beta_1 Sex_i + \beta_2 AG_i + \beta_3 Edu_i + \beta_4 Rel_i + \beta_5 HS_i + \beta_6 HIS_i + + \beta_7 PR_i + \varepsilon_i \ldots (3)$$

Where SKAI is a source of knowledge about agricultural innovations for the individual ith and it has three options: 1 = radio, 2= agricultural agents and 3= sources of information through media. The model controlled for various covariates as predictors of the outcome. The factors included sex of the respondent, age group (AG), highest level of education attended (Edu), religious affiliation (Rel), household size (HS), and main income source for the household (HIS). Additionally, place of residence (PR) as measured across the six study sites or woredas is included in the analysis to account for any local contexts driving the phenomenon under consideration.
The coefficients estimated from the multinomial logistic regression analysis only show the direction of the association between the predictors and the outcome variable and are difficult to interpret. Since they do not provide the actual magnitude of changes, we predicted the relative risk ratios after multinomial logistic regression (Green, 2003; Makate et al., 2019). Furthermore, the consistent estimation of Equation (3) using MNL depends on the assumption of independence from irrelevant alternatives (IIA). This requires that the likelihood that an individual prefers a particular source of an innovation over the reference category is independent of other alternative sources of information (Vijverberg, 2011; Makate, 2019). To confirm the IIA assumption, we used the Hausman specification test with a null hypothesis that coefficients for factors

predicting the use of radio as a source of livestock production do not depend on the inclusion of agricultural extension agents as a source of information.

Results

Basic profiles of the study sample

387 individuals from six woredas of the Amhara and SNNP regions participated. In this study. Of these, 228 (59%) were women and about half of them were aged between 21 and 30 years old. Regarding the educational level of the participants, 206 (53%) attended primary school level, while 115 (30%) completed secondary education. On the other hand, 42 (11%) of the participants had no education at all. In half of the households surveyed, the number of family members ranged from four to six, whereas approximately 29% of the households had over six members. Regarding religious affiliation, 50% of the respondents identified themselves as Orthodox Christians, 37% as Protestants, and 13% as Muslims. Food crop production is the primary source of income for approximately half of the study participants. The background information of the participants is shown in Table 1.

Table 1: Socio-demographic characteristics of the study participants

Variable	N	%
Sex		
Male	159	41.1
Female	228	58.9
Age (years)		
Less than 21	51	13.2
21-30	196	50.8
31-40	110	28.5
Above 40	29	7.5
Level of education		
No education at all	42	10.9
Primary	206	53.4
Secondary	115	29.8
Above secondary	11	2.9
Other	12	3.1
Religion		
Orthodox	193	49.9
Muslim	52	13.4
Protestant	142	36.7
Household size		
1-3	80	21.4
4-6	186	49.7
Above 6	108	28.9
Main income source		
Cash crop	45	11.6
Food crop	194	50.1
Dairy production	50	12.9

Sheep fattening	46	11.9
Other	52	13.4
Woreda		
Basona Worena	187	48.3
Doyogena	100	25.8
Limo	25	6.46
Silti	25	6.46
Tembaro	25	6.46
Wera	25	6.46
Total observation	387	100.0

Perception on the usefulness of radio to disseminate agricultural technologies

The study examined the target audience's perception of the appropriateness of using radio to communicate livestock production technologies using questions on a five-point Likert scale questions (1=strongly disagree to 5= strongly agree). The participants have positive perception about the various aspects of using radio as communication media and most of the mean scores fall in the category of agreement (that is 3.7 and 5). The mean perception score regarding the potential of radio to reach the majority of smallholder farmers is 3.86 (Table 2). This score indicates that there is agreement about the effective coverage of the target population using radio broadcasts. Similarly, the average scores for access to radio apparatus, trustworthiness and the importance of information broadcast via radio are above the minimum threshold (3.7 score) of agreement. The average score on time efficiency when receiving information through radio is 3.59 and it falls under the category of neutral perception (2.4-3.6 score). None of the estimated perception scores falls under the category of disagreement (that is between 1 and 2.3).

Table 2: Mean perception scores on the appropriateness of radio for disseminating agricultural technologies.

	Woreda						p-value	Total
	Basona Worena	Doyogena	Limo	Silti	Tembaro	Wera		
Possibility of reaching majority of the rural communities using radio to communicate them about	3.63	4.07	4.12	4.16	4.28	3.76	0.0025	3.86

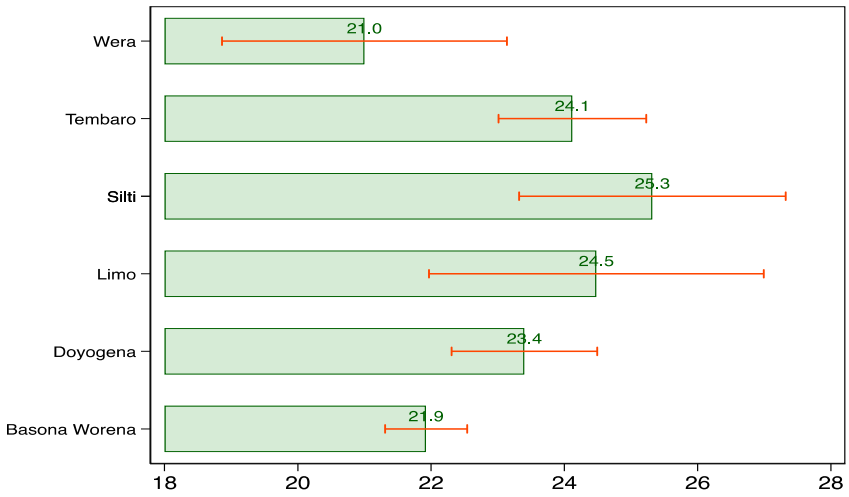
livestock production technologies								
Availability of radio apparatus and related accessories from the nearby market	3.60	3.92	4.24	4.20	4.16	3.28	0.0004	3.78
Time efficiency of accessing livestock production information using radio	1.13	3.75	4.08	4.24	3.64	3.40	0.0003	3.59
Understandability of livestock production information delivered using radio for minority groups	3.40	3.93	3.96	4.32	3.88	3.64	0.0000	3.68
Trustworthiness of livestock information disseminated over radio	3.83	3.73	3.96	4.12	4.04	3.32	0.0522	3.81
Importance of livestock information disseminated over radio	4.10	4.00	4.12	4.28	4.12	3.60	0.1294	4.05

A one-way analysis of variance (ANOVA) was employed to check if there are statistically significant differences in the mean scores of perceptions among the study sites.

Despite the overall positive perception of various aspects of radio across the study sites, there are considerable variations in the mean scores. Table 2 shows that the mean scores regarding the role of media in covering majority of community members ranges from 3.63 in Basona Worena woreda to 4.28 in Tembaro woreda. The one-way ANOVA test indicates statistically significant differences in these scores (p=0.0025). Similarly, there are also disparities in attitudes regarding access to radio apparatus, time efficiency, and trustworthiness of the information. On the other hand, the perception scores regarding the importance of the information disseminated via radio are generally high, and there are no significant differences across the sampled woredas (p=0.1294).

By aggregating responses to the six perception indicators included in Table 2, scores showing overall attitude towards the applicability of radio in using transmission channels for agricultural innovation were created. Prior to calculating these scores, the reliability and consistency of responses to the perception indicators using Cronbach's alpha tests was assessed. The calculated Cronbach's alpha value was 0.85, indicating that the internal consistency was satisfactory since alpha values above 0.7 are considered good and those above 0.8 are better (Taber, 2017; Kathar and Sohel, 2023). Accordingly, the average overall perception score is calculated to be 22.8 with a confidence interval of 22.3 and 23.3. This score falls within the range of positive perception scores (i.e., from 22 to 30). In the sample, the number of study participants with at least 22 aggregated scores is 275 (71.1%). This suggests that the study participants generally believe that radio can be used as an important communication medium to inform agricultural innovations for smallholder farmers in their residential areas. Figure 2 shows the average aggregated perception scores with 95% confidence intervals across the study sites.

Figure 1. Mean scores and 95% Confidence Intervals of overall attitude towards the role of radio in disseminating agricultural technologies.



The result indicates an overall positive attitude towards the role of radio in disseminating technological technologies to smallholder farmers across the study woredas and none of the estimated scores in the study woredas were in the range of overall negative attitudes (from 6 to 14). The mean scores ranges from 21.0 (CI: 21.3-

22.5) in Wera woreda to 25.3 (CI: 23.3-27.3) in Siti woreda. The F-statistics from the one-way analysis of variance was 4.69 with p=0.0004, indicating a significant difference in the overall perception scores across the study sites.

Preferred aspects of livestock production techniques to learn using radio

Survey participants expressed interest in learning more about various aspects of livestock production methods through radio broadcasts. About 87% of respondents were interested in learning more about feeding preparation and management techniques (Table 3). There was also a high preference for a better understanding of animal health and disease prevention techniques. The proportion of respondents who expressed interest in increasing their knowledge of building improved livestock sheds and equipment was 62%. Additionally, about half of the participants want to get information via radio on how to improve their practices in buying and selling livestock. Other agricultural areas on which respondents would like to receive radio communication include selection of rams for fattening, rules and regulations for cooperatives or groups, and methods of ram identification.

Table 3: Types of information smallholder farmers most prefer to receive via radio broadcasts.

Type of information	**N**	**%**
Feeding preparation and management	337	87.1
Animal health and disease preventive	312	80.6
Livestock housing and equipment	238	61.5
Selection of rams for fattening	186	48.1
Castration methods	109	28.2
Methods of ram identification	78	20.2
Record keeping	69	17.8
Business and entrepreneurship skills	133	34.4
Livestock marketing	200	51.7
Cooperative or group rules and regulations	102	26.4
Beekeeping	74	19.1

Preferred modalities as communication pathway

Innovations on livestock production can be communicated to smallholder farmers using various approaches. A significant majority (87%) of respondents indicated a

preference for acquiring information through structured lessons broadcasted in the mass media. Radio plays were also a popular medium, with 81% of those surveyed showing enthusiasm for learning about agricultural technologies in this format, as shown in Table 4. Additionally, about half of the participants found community dialogues or discussions to be an effective way of receiving information. However, the format of question-and-answer sessions was less favored, with only 28% of the respondents choosing it as their preferred method of communication.

According to the survey results, most respondents (71.4%) preferred receiving agricultural information once a week or two to three days a week. About 20% stated that they would be willing to receive information daily about improved husbandry practices. The preferred time of the day for media broadcasting is the evening. The survey showed that 72% of the study respondents preferred the evening as the appropriate time of day, while 17% chose opted for morning broadcasts. Midday was only appropriate for less than 5% of them.

Respondents also indicated their preferred lengths of media programs for learning about livestock production systems. The study shows that 37% of respondents found a duration of 1 to 2 hours per broadcast most acceptable, while the second most preferred duration was from 30 minutes to one hour. Less than 5% of the participants preferred receiving messages that lasted less than 15 minutes or very long broadcasts that extended beyond 3 hours.

Table 4: Preferred modalities to receive information on livestock production technologies using media.

Preferred type of modality	**N**	**%**	**Preferred type of modality**	**N**	**%**
Delivery method			*Time of day*		
In forms of formal lesson	337	87.1	Morning	64	16.5
Using dramas	312	80.6	Midday	16	4.1
Interview with model farmers	238	61.5	Late afternoon	25	6.5
Community dialogue or discussion	186	48.1	Evening	280	72.4
In form of questions and answers	109	28.2			
Frequency			***Lesson length***		
Every day	77	19.9	Up to 15 minutes	5	1.3
two to three days a week a	145	37.5	15 to 30 minutes	52	13.4

week					
Once a week	143	37.0	30 minutes to 1 hour	134	34.6
A few times a month	9	2.3	1-2 hours	142	36.7
A few times year	13	3.4	2-3 hours	41	10.6
			Above 3 hours	11	2.8

Main sources of knowledge on agricultural innovations

Participants were asked to share their experiences of receiving information about agricultural technologies through various communication channels. The results show that different sources of information were used (Table 5). For example, 70% of respondents mentioned that they get updates about livestock production technologies from radio broadcasts. Relatively more men (76%) listen to the radio than women (62%) to learn about improved farming methods. This difference in the use radio as a means of communication is statistically significant at the 1% level. There are also significant differences in the use of radio based on educational status. All study participants who have completed post-secondary education listen to the radio, while only about half of the respondents without formal education receive information from the radio. The proportion of use of radio as a communication medium varies from 60% in Wera and Basona Worena woredas to 88% in Limo woreda. The chi-square (χ^2) test shows that there is a significant difference in the distribution of the relative frequencies of using radio across the study sites.

Compared to radio, the use of television broadcasts as a source of agricultural information is limited in the study areas. Only 46.5% of the study participants received information about agricultural production innovations by watching television. It seems that the trend of attending television programs is more common among educated people. The study shows that 33% of people with no formal education watched television broadcasts, while 82% of people with post-secondary education did the same. In terms of income sources, relatively more people who engaged in dairy production (60%) use television as a communication medium than those involved in cash crops production (33%). Among the study sites, relatively more individuals in Silti Woreda use television as a source of innovation in livestock production techniques.

Table 5: The use of different media to obtain information about livestock production technologies.

Socio-economic group		**Relative frequency of media use**			
		Radio	Television	Agricultural agent	Social network
Sex	Male	75.9	45.4	88.6	67.1
	Female	62.3	48.43	92.5	64.8
	Chi-square	8.3116***	0.3983	1.5732	0.2262
Age	Less than 21	60.8	45.1	80.4	68.6
	21-30	75.0	48.0	87.8	67.4
	31-40	65.5	45.5	98.2	60.9
	Above 40	72.4	41.4	93.1	72.4
	Chi-square	5.5728	0.5597	15.0182***	2.1187
Education	No education at all	52.4	33.3	97.6	54.8
	Primary	70.0	45.6	89.8	68.0
	Secondary	74.8	47.8	87.0	66.1
	Above secondary	100	81.8	100	72.7
	Other	75.0	66.7	91.7	66.7
	Chi-square	12.3906**	10.5413**	5.2224	2.9434
Income Source	Cash crop	66.7	33.3	86.7	51.1
	Food crop	69.1	47.9	91.8	69.6
	Dairy pro	66.0	60.0	98.0	86.0
	Sheep fat	87.0	39.1	87.0	52.2
	Other	67.3	46.2	82.7	59.6
	Chi-square	7.201	7.9666*	8.4543*	19.3718***
Woreda	Basona Worena	60.4	51.9	88.2	70.6
	Doyogena	82.0	49.0	91.0	66.0
	Limo	88.0	40.0	96.0	72.0
	Silti	84.0	76.0	100	68.0
	Tembaro	76.0	12.0	96.0	52.0
	Wera	60.0	8.0	80.0	40.0
	Chi-square	22.936***	38.4454***	8.4356	11.9365**
Total		70.3	46.5	90.2	66.2

*, ** and *** denote statistically significant differences in use of media across social groups at 10%, 5% and 1% level of statistical significance respectively.

The study shows that agricultural agents are the other important source of information about agricultural technologies in the sample districts. About 90% of the study respondents mentioned that they learned about improved livestock production systems through contact with agricultural extension workers. The chi-square test shows a significant relationship between the distribution of age groups and receiving farming information from agricultural agents. Relatively more individuals aged over 40 years of age received information from agricultural agents than those who are

under 21 years old. Similarly, among individuals who relied on various sources of income, those who produce food crops had closer contact with agricultural extension workers. According to a study, 66% of respondents obtained information about agricultural technologies through their participation in different social gatherings and networks such as Iquib, Idder, and Wonfel. Across all study sites, the proportion of individuals who accessed agricultural technologies through their network ranged from 40% in Wera woreda to 72% in Limo woredas.

Predictive factors for the main source of information on livestock production innovations

As shown in Table 5, the participants receiving information on agricultural production from various sources. However, the two main sources of technological transfer are radio broadcasts and contact with agricultural extension workers. Among the respondents, 32% use radio media as their main source of information, while 29% get advised about improved production methods mainly from agricultural extension workers. In contrast, only 9.7 % of the respondents learn about livestock technologies through television broadcasts and about 5% do the same from their social networks. Accordingly, multinominal logistic regression was used to assess factors explaining access to information from these two main sources, using others as the reference category. The results of the Hausman test support the validity of the MNL model used for the analysis assuming the independence of irrelevant alternatives. Removal of the agricultural agent category did not result in a significant change in the predictors of radio use as a primary source of innovation information. The chi-square statistic is 1.17, which is not statistically insignificant at the 5% level of significant. This implies that the estimated coefficients are independent of additional sources of information on agricultural innovation. Table 6 shows the relative risk ratios for accessing information about livestock production systems from radio and from agricultural agents using other sources as a reference category.

Men were found to be 2.5 times more likely than women to obtain information about animal production from radio than from other sources. There is no significant relationship between the age distribution of respondents and the sources of agricultural innovation. On the other hand, attending post-secondary education

increases the likelihood of using radio as a source of information by 7.2 times compared to other sources of information. Protestants are more likely to listen to radio programs about livestock production compared to Orthodox Christians. The frequency of using information sources also varied based depending on income sources. Households that depend on sheep fattening for their livelihood are 2.8 times more likely to seek information on livestock technologies from radio compared to those who rely on cash crop production. Additionally, individuals residing in Limo Woreda are 8.9 times more likely to use radio compared to other information sources. Apart from household size, demographic profiles do not predict the likelihood of obtaining information from agricultural agents. However, there are significant differences in receiving information about livestock technologies from extension agents based on the religious affiliations of the respondents. Protestants are 13.6 times more likely to access information on livestock technologies from agricultural agents compared to Orthodox Christians. It was found that households with larger family sizes are 63% less likely to get information from agricultural workers as compared to households with 1 -3 household members. Additionally, those who grow food crops are 2.5 times more likely to contact agricultural agents for information than those who grow cash crops. Based on place of residence, the frequency of accessing information from agricultural agents in Limo *woreda* is 6 times higher than in Doyogena *woreda*.

Table 6: Factors associated with the main source of information for livestock production systems (relative risk ratios after Multinomial logistic regression)

Variables	Radio	Agricultural agent
Male	2.468***	1.129
	(0.776)	(0.347)
Age group (ref: Less than 21)		
21-30	0.965	0.605
	(0.431)	(0.260)
31-40	0.706	0.546
	(0.365)	(0.271)
Above 40	2.361	2.606
	(1.955)	(2.024)
Education (ref: No education)		
Primary	1.152	0.635
	(0.686)	(0.306)

Secondary	2.101	0.988
	(1.305)	(0.516)
Above secondary	7.180*	0.637
	(7.347)	(0.855)
Other	1.844	0.524
	(1.733)	(0.449)
Religion (ref: Orthodox)		
Muslim	6.312	2.435
	(11.37)	(4.600)
Protestant	7.796*	13.64*
	(9.210)	(21.03)
Household size (ref: 1-3)		
4-6	1.102	0.812
	(0.412)	(0.280)
Above 6	0.922	0.369**
	(0.413)	(0.169)
Main income source (ref: cash crop)		
Food crop	1.924	2.246*
	(0.917)	(1.099)
Dairy production	1.461	0.596
	(0.845)	(0.370)
Sheep fatting	2.774*	0.810
	(1.568)	(0.545)
Other	1.118	0.989
	(0.638)	(0.581)
Woreda (ref: Doyogena)		
Basona Worena	4.243	9.942
	(5.136)	(15.60)
Limo	8.913**	6.010*
	(9.109)	(6.167)
Silti	3.312	6.045
	(6.321)	(12.56)
Tembaro	1.927	1.867
	(1.103)	(1.215)
Wera	0.855	2.743
	(1.646)	(5.803)
Constant	0.0293**	0.120
	(0.0446)	(0.211)
Observations	367	367

Discussion

Improving agricultural productivity through appropriate agricultural technologies is an important pathway to reduce poverty and improve the livelihoods of smallholder farmers in Sub-Saharan African Countries (Roseboom et al., 2016; Damba et al, 2020). To ensure the adoption and use of technologies, it is crucial to identify viable ways to disseminate information that address the needs of the target population. The current study demonstrates the potential of using radio as a tool to disseminate information on livestock technologies in the Amhara and SNNP regions of Ethiopia. Overall, most study participants are convinced that radio can be used as an important communication medium for informing small farmers about agricultural innovations. According to various assessments, despite the increasing influence of social media over time, radio remains one of the most trusted and widely used means of communication worldwide, with many people, especially in rural areas, having greater trust in radio than in other forms of media (Grbesa and Volarevic 2021; UNESCO, 2023). This suggests the importance of using radio as a technological transmission channel to promote agricultural development in Ethiopia and other sub-Saharan countries with similar contexts.

The most common aspects of livestock production that respondents most wanted to learn about through the media included feed formulation and management, animal health and disease prevention techniques, improved livestock husbandry and livestock marketing. Previous studies in Ethiopia have also identified information gaps in these aspects of livestock production. A study conducted in Wolayeta Zone of SNNP region shows that farmers have limited knowledge about forage species with high nutritional value and ways to improve animal feeds (Mengistu et al., 2021). Furthermore, the lack of reliable information on livestock production inputs and marketing strategies is reported to be a barrier to the development of livestock production in Ethiopia (Kebede, 2019).

The study highlights the importance of considering community preferences when designing technological transfer modalities to ensure the uptake and use of improved farming practices. Most study participants prefer broadcasts during the evening rather than at midday. This is because farmers are busy with their agricultural activities during the day, and it would be difficult to follow the media and absorb the

information carefully. In the study areas, radio and agricultural agents are the two main sources of information about agricultural technologies. The survey shows that 29% of the respondents use agricultural extension workers as their main source of information, while 32% rely on radio. In contrast, only 9.7% of the respondents learn about livestock technologies mainly through watching television broadcast. This is because television sets are less common in rural areas as compared to radio receivers. Consistent with this result, Yakubu et al. (2019) and Mtega (2018) found that most farmers in Nigeria and Tanzania listen to radio programs regularly, while only some of them watch television daily. Accordingly, the authors concluded that television cannot be considered a reliable pathway to disseminate agricultural information to smallholder farmers due to the limited accessibility of television sets and electricity supply.

Since radio and agricultural extension workers are the two main sources of information about livestock production systems, it would be beneficial to use these modes of communication simultaneously to reach the majority of the populations in the Amhara and SNNP regions. Similar to the implications of this study, Damba et al. (2020) report that a properly designed and implemented mix of approaches to technology diffusion is more effective than using a single method for technology transfer in Ghana.

Multinomial logistic regression analysis shows that the probability of receiving livestock technology information from radio is significantly higher among men than among women. The result suggests that women have comparatively fewer opportunities to listen to the radio and obtain information about improved agricultural production methods. In the context of patriarchal societies in Africa, women tend to work more hours in productive and reproductive domestic work, which limits the time they devote personal development and leisure activities (Adisa et al., 2019; Marter-Kenyon et al., 2023). It also shows that people who have completed higher education are 7.1 times more likely to use radio to learn about improved agricultural technologies than those with no education at all. This is because educated farmers are more inclined to learn using media and apply productivity-enhancing agricultural technologies (Makate et al., 2019).

While most study respondents have a positive attitude and interest in learning about

improved livestock production systems through radio broadcasts, there are different challenges that affect the effective use of the media in the study area. Participants argued that there are few radio stations broadcasting programs on livestock production and that existing programs do not provide solutions to locally specific problems in livestock production. Over the past two decades, the number of public and private owned radio stations in Ethiopia has increased enormously. However, most of them focus on disseminating information related on current political issues and entrainment programs and they are not contributing considerably as development tools (Mohammed, 2016; Bayable,2020; Jira, 2020). The other challenge is the lack of power supply to recharge radio receivers, which leads to long travel to the power sources and costs of purchasing dry cell batteries. Access to reliable electric supply is considerably lower in rural Ethiopia as compared to urban areas. For instance, in 2019, about 96% of urban households were connected to the electric grid, while only 27% of rural households had access to electricity, mainly through off-grid methods (Veritas, 2020). Recently, the government has sought to expand access to electricity in geographically disadvantageous areas through rural electrification projects, including the increasing use of solar photovoltaic systems (Wassie and Adaramola, 2021).

Respondents also stated a gap in radio stations' efforts to collect and incorporate feedback from their audiences. Therefore, they do not broadcast programs that meet the needs and expectations of the rural population. In order to communicate agricultural technologies through radio and increase animal production productivity among smallholder farmers, radio stations and concerned governmental and non-governmental agencies should prioritize and address such challenges.

Conclusion

Overall, the study suggests that radio can serve as an important communication medium to impart knowledge about livestock production technologies to smallholder farmers, thereby increasing the productivity of the sector in Ethiopia. However, to effectively reach the target audience through radio broadcasts, it is necessary to use appropriate communication modalities that take into account the needs of the target audience in terms of the type of information provided and the timing of broadcasting. Interventions through radio broadcasts must focus on providing solutions to locally specific problems in animal production. Radio stations must obtain feedback from the audience and consider the needs of the community when preparing and broadcasting livestock programs using various methods such as email, polls and surveys. This will help prepare and broadcast more relevant programs that meet the needs of their listeners (Lekshmi et al., 2015; Mtega et al., 2018; Oswald, 2018). Poor access to electricity, leading to a lack of power to charge radio receivers, is one of the major challenges that could limit the effectiveness of using radio as a medium to transmit agricultural technologies to smallholder farmers. Therefore, it is necessary to make efforts to increase electricity supply in rural areas through cost-effective alternative options, including the development of off-grid small hydro, biomass, wind and solar energy sources (Tucho and Non-Hebel, 2017; Wassie and Adaramola, 2021; Benti et al., 2021).

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