Gender differences in the adoption of agricultural technology in North Shewa Zone, Amhara Regional State, Ethiopia

Markew Mengiste Neway* and Mesele Belay Zegeye

Abstract: This paper aims to analyze gender differences in the adoption of agricultural technology in the North Shewa Zone, Amhara Region, Ethiopia. The data were collected in 2021 from 796 farm households and were analyzed using binary logit model. The results show that the adoption rate of agricultural technology in the zone by male-headed (87.3%) and female-headed households are significantly different, and adoption is lower for female-headed households (61.2%). The descriptive results reveal that female headed households had lower access to education, land size, and for that reason technology adoption. Moreover, the results show that the decision to adopt agricultural technology is significantly influenced by the gender of the household, the level of education of the householder, the marital status of the household, participation in saving, membership of an agricultural cooperative, distance from the market and access to extension visits, access to certain credit, total arable land and livestock asset. Therefore, the results suggest that policies and programs that aim at developing and disseminating agricultural technology adoption, food security, value-chain analysis, income diversification and livelihood analysis.

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PUBLIC INTEREST STATEMENT

The article provides insights into the current state of gender gap levels and their implications for the development agenda of the study area in particular and at the country level in general. Tackling gender inequality is crucial to achieving sustainability in agriculture, as women make up almost 50% of society. Currently, however, there is a high level of inequality between men and women in adopting technology, making it more difficult to increase productivity and reduce poverty in society. Therefore, the finding of this study will help government, policymakers, and other stakeholders who are working on gender equality and alleviating poverty by providing a number of policy options.
technology in the Zone should vigorously support economically less endowed but more gender-egalitarian, especially female-headed ones.

Subjects: Gender Studies - Soc Sci; Gender & Development; Economics

Keywords: agriculture; gender; technology adoption; logit model; Ethiopia

1. Introduction
In the world, adopting agricultural technologies is seen as an important tool to increase agricultural efficiency, reduce poverty, and improve food security (Akinyemi et al., 2019; Alvi et al., 2021; Gebre et al., 2019; Mishra et al., 2015). However, the performance of the agricultural sector in many developing countries including Ethiopia is rated as very poor and is the most vulnerable sector to climate change (Phiri et al., 2022). Furthermore, the underperformance of the agricultural sector has been partially attributed to women’s inability to access resources, despite their role as farmers being a crucial resource in agriculture and the rural economy (Alvi et al., 2021; Murage et al., 2015; Phiri et al., 2022). Agricultural development efforts that fail to address persistent gender disparities miss opportunities for greater sustainable development and impact implementation of gender-sensitive interventions will change this scenario (Kristjanson et al., 2017; Muriithi & Gichungi, 2018; Phiri et al., 2022). As a result, the poor and women in developing countries are affected most by lower agricultural productivity, because they have a lower adaptive capacity for agricultural technologies and inadequate access to alternate means of production (Fahad & Wang, 2018).

There is a general agreement that there are significant gender disparities around the world, which may be the result of multiple intersectional identities. The most common explanations for this gender difference are poverty and geographical distance (Van der Mark et al., 2019), lack of infrastructure (Huyer, 2016), and/or belonging to a minority language group (Olivius & Hedström, 2019). Besides, women face significant obstacles to achieving equal status with men in terms of land ownership (Bezner, 2017; Gebremariam & Wünscher, 2016), the farm household’s demand for agricultural technology may differ based on land ownership status (Fahad & Jing, 2017), and in terms of employment or income (Huyer, 2016). Women also have little representation in political power, and their interests are often marginalized in politics (Bezner, 2017), in access to credit (Gebremariam & Wünscher, 2016), access to education (Huyer, 2016), and access to health outcomes (Hammarström & Hensing, 2018).

In Ethiopia and particularly in the North Shewa Zone agriculture is the main sector of the economy despite its declining share of the national income. However, the productivity of the sector is very low due to the rain-fed agricultural system, traditional farming system, minimal application of agricultural technologies (M. Belay & Mengiste, 2021; Diriba, 2020), and climate change (M. Belay & Mengiste, 2021; Fahad & Wang, 2018). To this end, enhancing agricultural productivity cannot be sustained without the adoption of modern agricultural technologies. In the study region, discrimination against women is not only a women’s problem, but it is a problem for society as a whole. Without the inclusive economic, social, and political participation of women, there can be no development in a country (Buchy & Basaznew, 2005). Since the majority of the population in the study area is subsistence farmers, it is imperative to transform the backward agricultural system into a modernized agricultural system to alleviate poverty and improve people’s living conditions. However, sustainable development is not possible without giving equal opportunities to all citizens of a country. Agricultural productivity can only be improved by enabling all farmers to use modern technologies without any discrimination. Low agricultural productivity is still a challenge, which may be attributed to the limited adoption of agricultural technologies, especially by female farmers (M. Belay & Mengiste, 2021; Diriba, 2020; Gebre et al., 2019). Although the overall use of modern agricultural technology in the study area is very low, it is believed that women use less modern agricultural technology as compared with men. The possible reason

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behind the less use of modern farming methods or technology by women might be society’s attitude towards women, lack of proper education of women themselves, and lack of property rights. Overall, in Ethiopia and North Shewa Zone, women’s participation in agriculture is generally very low. In the Zone, there are no clear agricultural development programs that can help women to participate in the introduction and application of modern agricultural technologies. As a result, women’s welfare or livelihoods are not enhanced, not empowered, and earn very low incomes that induce gender inequalities (Meinzen-Dick et al., 2011; Rola-Rubzen et al., 2020). To increase agricultural production, it is necessary to change backward attitudes and economic and social factors towards women, and increase their participation in the adoption of agricultural technologies is needed.

There is very little existing literature that has been conducted on the issue in different parts of the world (for instance, Alvi et al., 2021; Bezner, 2017; Huyer, 2016; Njuki et al., 2014). In recent times, several studies emerged that consider technology adoption decisions jointly made by men and women in the same household. There are inconsistencies regarding gender differences in farm technology adoptions. Some studies assert that there is no gender difference in technology adoption (for instance, Aryal et al., 2020), while others claim that there is gender differences in technology adoption (for instance, Quaye et al., 2021; Gebre et al., 2019; Massresha et al., 2021). This study, therefore, aims to fill the gap by adding empirical evidence about the gender differences in agricultural technology adoption. Moreover, regardless of the efforts made to examine gender difference and agricultural technology adoption in Ethiopia and North Shewa Zone is scanty. The study conducted by Gebre et al. (2019) tried to explore the role of gender-based decision-making in the adoption of improved maize varieties. They found that the intensity of improved maize varieties adopted on plots managed by male, female, and joint decision-making households are significantly different. Thus, evaluating gender differences and adoption of technologies through supporting less endowed farmers, especially female-headed ones is crucial to improving agricultural productivity. Based on the above-mentioned research gap, the study mainly aims to explore gender differences in agricultural technology adoption and investigate the determinants of the adoption decision of agricultural technology in the North Shewa Zone, particularly in the four districts located in the Zone, which are characterized by a lower level of agricultural technology adoption. Given this, we wish to form the following research question:

RQ1: Does gender differences determines the agricultural technology adoption decisions in North Shewa Zone, Ethiopia?

The remainder of this paper is organized as follows: part 2 provides a literature review, and part 3 presents the research methodology. The results are discussed in part 4, while part 5 concludes the study.

2. Literature reviews
Social attitudes toward women vary significantly across societies. The attitude of the society about gender roles or regarding the roles men and women should play in society division of labor between men and women, with men in the role of breadwinner and women in the role of homemaker is advisable, they are considered to have traditional gender role attitudes (Van der Mark et al., 2019). Gender relations are how a culture or society defines rights, responsibilities, and the identities of men and women to one another (Bravo-Baumann, 2009). According to socialization theories of gender development view, gender differences as a by-product of the differential treatment of girls and boys by the people in their lives and the pervasive gender-stereotyped messages children are exposed to in their environment (Miller, 2016). Empirical research on various historical determinants of contemporary differences in gender roles and gender gaps across societies, and how these differences are transmitted from parents to children and therefore persist is due to differences in female labor force participation, fertility, education, marriage arrangements, competitive attitudes, domestic violence, and other forms of difference in gender norms...
(Giuliano, 2017). Gender difference could influence agriculture and agricultural technology adoption in different ways, often determined by culturally defined gender roles and labour divisions (Gebre et al., 2019).

Since agriculture is the base of the Ethiopian economy, agriculture employs 85% of the labour force employment among whom about half are women (F. Belay & Olijira, 2016). The country is a multicultural country; the gender roles and division of labour in agriculture vary in terms of cultural settings, locations, and farming systems (Ogato et al., 2009). Moreover, in addition to the gender division of labour, other dimensions of gender such as social networks, asset ownership, landholding, and access to extension services also affect women’s decisions over agricultural technology adoption. For instance, women play important and varied roles in agriculture, but they are constrained by two important types of gender gaps: women have unequal access, relative to men, to productive resources, and there is insufficient information about the roles and resources of women and men (Huyer, 2016). Across the developing world including Ethiopia, rural women suffer widespread gender-based discrimination in laws, customs and practices causing severe inequalities in their ability to access, control, own and use physical assets like land, livestock and limiting their participation in decision-making at all levels of land governance. As a result, female-headed households operate smaller farms than their male counterparts (Daley et al., 2013; Addison et al., 2018; Quaye et al., 2021; Kieran et al., 2015; Mottaleb et al., 2019). Moreover, in most developing countries, studies showed that education was a priority for both men and women, but there was a difference of views between girls and boys that means boys got a better chance for education than girls (Njuki et al., 2014); and the level of education were found as the source of gender differences (Huyer, 2016).

Due to a combination of resources and other access disadvantages of female-headed households; they tend to harvest lower yields than male-headed households. Furthermore, women have lower access to financial and training services and are affected by pervasive inequality. For that reason, there are gender disparities in access to modern agricultural inputs, such as access to productive inputs and technologies that limit women’s contribution to agricultural productivity and economic development (Bezner, 2017; Garcia & Wanner, 2017; Mottaleb et al., 2019; Uduji & Okolo-Obasi, 2018; UNDP, 2012).

Gender difference impacts the adoption decision of agricultural technology in different ways, often determined by culturally defined gender roles and labour divisions (Gebre et al., 2019). For instance, in most parts of Ethiopia, plowing with oxen and planting are primarily considered a man’s task, while women share other agricultural activities with men, such as weeding, harvesting, and collecting. The roles and decision-making power over agricultural activities of women vary across households, locations, and cultures or ethnicities in the country (Gebre et al., 2019). This holds, especially in the case of the North Shewa Zone of Ethiopia, where women are not considered equal to men and lack so many accesses to the community. As a result, gender roles in the division of labour and decision-making in agriculture retain a level of heterogeneity in the country, due to which women and men have different service needs (Alemu, 2016). Thus, from the policy perspective, this paper provides evidence of whether there are significant differences among men and female-headed households’ decision-making regarding the adoption of agricultural technologies in the study area. Table 1 provides a summary of the literature review that is relevant to this study.

This review of the literature highlights the fact that socio-cultural norms and practices, unequal division of labor, and access to and control over assets disadvantage women over men in accessing—induces gender differences. From the above literature review, the researcher understands that gender difference can be analyzed from a different perspective, such as difference in property ownership especially land, education status, and other accesses. As a result, gender differences might influence the adoption of agricultural technologies.
### Table 1. Summary of literature review

| Author and years of publication | Title of the research                                                                 | Methods          | Major findings                                           |
|---------------------------------|----------------------------------------------------------------------------------------|------------------|----------------------------------------------------------|
| Aryal et al., 2020              | Does women’s participation in agricultural technology adoption decisions affect the adoption of climate-smart agriculture? Insights from Indo-Gangetic Plains of India | probit           | Women have no role in technology adoption                |
| Quaye et al., 20212021          | Gender dimension of technology adoption: the case of technologies transferred in Ghana  | Binary model     | Discriminatory access to production resources             |
| Vernireddy & Choudhary, 2021    | A systematic review of labor-saving technologies: Implications for women in agriculture | Review           | Labor-displacement                                        |
| Muriithi & Gichungi, 2018       | Effect of Technology Innovation on Gender Roles: A case of Fruit Fly IPM Strategy on Women's Decision Making in Mango Production and Marketing in Kenya | Tobit difference-in-difference | Persistent gender disparities in access to productive resources |
| Addison et al., 2018            | Gender Effect on Adoption of Selected Improved Rice Technologies in Ghana               | multinomial probit | Child care and limited access to land inhibit female incidence of adoption |
| Rola-Rubzen et al., 2020        | Improving Gender Participation in Agricultural Technology Adoption in Asia: From Rhetoric to Practical Action | Review           | Large gender disparities in the adoption of technologies |
| Massresha et al., 2021          | Perception and determinants of agricultural technology adoption in North Shoa Zone, Amhara Regional State, Ethiopia | Binomial logistic | Female adoption is lower than male household             |
| Ojo et al., 2021                | Adoption of soil and water conservation technology and its effect on the productivity of smallholder rice farmers in Southwest Nigeria | Endogenous switching regression | Female adopt less than male                               |
| Temesgen et al., 2014           | Climate change adaptations of smallholder farmers in South Eastern Ethiopia             | Descriptive and inferential statistics | Female adopt less than male                               |
| Bezner, 2017                    | Gender and Agrarian Inequities                                                          | Review           | Women owned less resources                               |
| Gebremariam & Wünscher, 2016    | Combining Sustainable Agricultural Practices Pays Off: Evidence on Welfare Effects from Northern Ghana | Multinomial Endogenous Treatment Effect | Women owned less resources                               |
| Huyer, 2016                     | Closing the Gender Gap in Agriculture                                                 | Review           | Low access for education and low income                  |

As a final point, an extensive body of literature has examined the determinants of agricultural technology adoption in the world and Ethiopia (For instance; Aynalem et al., 2018; Workineh et al., 2020; Temesgen et al., 2014; Feyisa, 2020; Asfaw et al., 2011; Gebre et al., 2019; M. Belay & Mengiste, 2021). The findings of these studies showed that gender of the farmers, age, and education level of the farmers, access to credit, farm size, distance from input market, oxen ownership, livestock holding, extension visits, off-farm employment, and total farm income have a significant effect on adoption of agricultural technologies.

### 2.1. Working hypothesis

Gender equality is deeply rooted in social, economic, cultural, and political structures and is closely linked to every development challenge, from poverty alleviation to peace and democracy. Government officials in the study area also believed that the mainstreaming of women in
every activity reduces gender inequality and ensures gender equality by developing different instruments such as Women’s Machinery, Women’s Policy, a National Action Plan, constitutional measures, and decentralization policies (Biseswar, 2008). While the researcher hypothesized that even if there are efforts made by the government to achieve gender equality the problem of the gender gap is not yet filled. Therefore, this study attempted to distinguish and test the current status of women in the study area and to help answer whether government efforts are truly narrowing the gender gap and empowering women in the adoption of agricultural technology in the zone.

3. Research method

3.1. Study area profile
North Shewa zone is one of the 11 zones under the Amhara Regional State with a total area of 17,697.64 square kilometers. The administrative structure is included in 22 districts and 5 city administrations and has a total population of 2,226,685. The zone is located at 8.38 – 10.42 North latitude and 38.4–40.3 East longitude at an altitude of 1500–4012 m above sea level. The mean annual temperature of the zone is ranging between 10°C and 25°C. Most of the areas of the zone experience mean annual rainfall ranging approximately between 800 mm and 1600 mm. Agriculture is the mainstay economic activity, in which more than 80% of the population makes their livelihood in agriculture. To improve the livelihood of farming households, the application of modern agricultural technologies was taken as a measure throughout the region (Office, 2019).

3.2. Data collection
Primary data were collected from four districts of Minjar Shenkor, Angolela Tera, Moretna Jiru, and Menz Gera the North Shewa Zone. This analysis is based on household-level cross-sectional data gathered from farm households. The data was collected through a semi-structured questionnaire. Before participation in the survey, the households were properly informed and guaranteed that the survey is purely for academic purposes, and that they didn’t need to respond to the questionnaires. For this survey total of 800 households were selected randomly from the last week of December 2020 through the end of April 2021 by four experienced and trained interviewers. Then, each household from the four districts was selected using simple random sampling. The questionnaire was designed to gather data about the demographic, socio-economic, institutional characteristics, and adoption practices of farm households in the zone.

3.3. Sampling method
In this study, samples were drawn by using a multi-stage sampling method. First, four districts of the zone, namely, Minjar Shenkor, Angolela Tera, Moretna Jiru, and Menz Gera were selected purposively due to their high potential for agricultural practices and their topographical similarity. According to (Office, 2019) in the selected districts there are a total of 117,149 households. Having this, (Vogel, 1986) and (Naresh, 2012) suggested that for a large homogenous population, between 35,001 and 150,000, the researcher can select a maximum sample of 800 respondents. Following this, in this study, a total of 800 sample households (200 households from each district) were drawn randomly selected. Second, simple random sampling was used to select each respondent from each selected district. Due to missing information, four observations were dropped. Thus, the final sample size of the study is determined to be 796 farms household.

3.4. Methods of data analysis
The data were analyzed using both descriptive and econometric methods of data analysis. The descriptive method uses statistical measures such as mean and t-test to analyze the gender differences in the adoption of agricultural technology adoption. In the econometric method, the binary logit model is applied to estimate the determinants of agricultural technology adoption in the study area.
3.5. Conceptual framework and estimation strategy

In the adoption setting, farmers’ choice of the technology is expected to be based on the farmers’ expected profit/gain from the adoption of a specific choice given his/her constraints (M. Belay & Mengiste, 2021; Kassie et al., 2018). The household decision for adoption may induce changes in the allocation of resources for improved agricultural technologies and other different uses and are the outcome of optimization by heterogeneous agents (in our case, male and female-headed households). This optimization takes place in the presence of constraints on the budget, information, credit access, and the availability of both the technology and other inputs. The differences in the access to these facilities between men and women might also affect the adoption of agricultural technologies (Gebre et al., 2019). The conceptual framework of the study is presented diagrammatically in Figure 1.

From a theoretical perspective, a household’s decision to adopt new or improved agricultural technologies will rely on the farmers’ expected profit/gain from adoption, the expected utility of adoption, and identified adoption constraints (Admassie & Ayele, 2010; Tefera et al., 2016; Amare & Simane, 2017; M. Belay & Mengiste, 2021). The theoretical model for agricultural technology adoption decision could be denoted as shown below:

\[ A = f(G, O, E, I) \]

where, \( A \) stands for adoption decision of agricultural technology adoption, \( G \) stands for household gender, \( O \) stands for other household-specific characteristics, \( E \) represents economic factors, and \( I \) represents institutional factors that have an influence over adoption decision.

Accordingly, the decision around the adoption of agricultural technology is modeled using binary logistic regression. This reason for using logistic regression is because it is easy to manipulate and simple to comprehend; and the decision to adopt is mainly categorized as adopter and non-adopter (Gujarati, 2004). Adoption in this study refers to a farm household, which used at least one technology (such as fertilizer, herbicide, pesticide, and improved seed, irrigation, and farm machinery) in any one of the crop fields and non-adoption refers to a farm household who did not adopt any of these technologies in any one of the crop fields. Accordingly, a household is an adopter (\( A = 1 \)) if the household adopts at least one of the agricultural technology in any of the crop fields and a non-adopter (\( A = 0 \)) if the household does not adopt any of the agricultural technology. Following Admassie and Ayele (2010), Challa and Tilahun (2014), and Gebre et al. (2019), the model is formulated as follows:

\[ A' = \beta_0 + \beta_1 S + \beta_2 AG + \beta_3 FS + \beta_4 Edu + \beta_5 Ms + \beta_6 SA + \beta_7 CS + \beta_8 TLU + \beta_9 DFM + \beta_{10} LS + \beta_{11} FCM + \beta_{12} ES + \beta_{13} OFP + \epsilon_i \]

**Figure 1. Conceptual framework of the study.**
Where $A_i^{1}$ the latent variable that represents the agricultural technology adoption-equal to one (1) when a choice is made to adopt and zero (0) otherwise, $\beta_i$ is a column vector of parameters to be estimated, $SK$ stands for the gender of the household, $AG$ represents the age of the household head, $FS$ stands for a family size of the household head, $Edu$ stands for the education level of the household head, $Ms$ stands for the marital status of the household head, $SA$ stands for saving of the household head, $CS$ stands for access to credit, $TLU$ stands for tropical livestock unit, $DFM$ represents the distance from the market, $LS$ stands for total land size, $FCM$ stands for cooperative memberships of the household, $ES$ stands for access to extension services, $OFP$ represents off-farm work participation, and $\epsilon_i$ is the stochastic error term, and $\beta_i$ is a column vector of parameters to be estimated.

Using the logistic regression model, the probability of adopting agricultural technologies can be estimated and evaluated as:

$$P_i = \operatorname{prob}(A_i = 1|X_i) = \frac{\exp X_i^\beta_i}{1 + \exp X_i^\beta_i} \quad (3)$$

And, the probability of non-adopters, that is, the farmer does not adopt any agricultural technology is evaluated as:

$$1 - p_i = \operatorname{prob}(A_i = 0|X_i) = \frac{1}{1 + \exp - (X_i^\beta_i)} \quad (4)$$

Since the model is non-linear, the parameters are not necessarily the marginal effects of the various independent variables. In order to estimate the logit model, the maximum likelihood estimation technique is applied, and the marginal effect is applied to interpret the results of the study correctly. The empirical model for the logit model estimation is specified as follows:

If we let $X_i$ be the $k^{th}$ element of the vector-independent variables $X$, and $\beta_k$ be the $k^{th}$ element of $\beta$, then the marginal effect of a particular independent variable, $X_i$, on the probability of the occurrence of the response is given by (Maddala, 1983):

$$\frac{dA_i}{dX_i} = \left( \frac{\exp X_i^\beta_i}{1 + \exp X_i^\beta_i} \right) \times \beta_k \quad (5)$$

### 3.6. Description, measurement and hypothesis of variables

To estimate the parameters of the model, a set of explanatory variables are considered. The selection of these variables is based on previous empirical studies on agricultural technology adoption. They are expected to influence farm household decisions on agricultural technology adoption. The detail of those variables is given as follows.

Gender, which is a dummy variable, represents the gender of the household head. Since male dominance in agricultural production is seen markedly in Ethiopia, we include these variables to examine the gender effects on the adoption of agricultural technology. We expected that if the sex of the farmer is male-headed then the probability of adoption will increase because male-headed farmers have better access to resources like land, labor, and other inputs than female-headed farmers (Hailu et al., 2014). The age of the farmer is one of the factors in adoption decisions. As the age of the farmer increases, their adoption will decreases or increases because old farmers are risk-averse and conservative to adopting the new or improved technology (Admassie & Ayele, 2010), or old farmers could have more experience and knowledge than the young farmers, so they will adopt the technology (Mohammed, 2014). The marital status of the household is one of the considered explanatory variables of adoption decisions. The reason is that unmarried farmers have few responsibilities and channel their financial resources to agricultural technology adoption contrary to their counterfactuals. Besides, marriage could result in a large family size, which would consequently put pressure on the financial resources, and limit the adoption capacity of the farm households (Ojo & Baiyegunhi, 2020; Ojo et al., 2021). Education could have a positive effect on the probability of agricultural technology
adoption because more educated farmers are likely to be better informed of the advantages and disadvantages of alternative technologies (M. Belay & Mengiste, 2021). Family size in the farm household affects the probability of adoption through; family size positively affects adoption because adoption requires and attracts more family labour (Kassie et al., 2010). Conversely, family size also negatively affects adoption because the more family member within the household may weaken their economic status, and in turn, adoption decreases (Sahu & Das, 2016).

Saving participation and credit access by the farmer could have a positive effect on the probability of adoption since saving money and having the access to credit solves liquidity constraints that the farmer could face, while they want to buy agricultural technology packages (M. Belay & Mengiste, 2021). Off-farm activities could have a positive effect of the adoption decision because participating in off-farm activities can generate income and solve the liquidity constraints of the farmers (Mulugeta & Hundie, 2012). Livestock assets have a positive effect on the adoption decisions for the reason that farmers who possess a flock of livestock will help to adopt as the asset becomes a source of income and inputs of organic fertilizer (Admassie & Ayele, 2010). Moreover, Farmland size determines positively the decision of adoption for the reason that as operated farm size increases, the likelihood of farmers considering farming activity as full time or way of life increases: and hence more likely motivated towards adopting agricultural technologies. This implies that greater land size serves as a security against the risk of crop failure (Feyisa, 2020).

Extension services and farm cooperative membership provided to the farmers by the local and national government affects the decision to adopt positively because extension service and farm cooperatives provide information, training, and advisory services about the sources and contribution of the technologies to the farmers and participating in input distribution (Gebre et al., 2019). Distance from home to the nearest market negatively affects the adoption of agricultural technology because farmers who live away from market places have less access to market information and to buy (sell) agricultural inputs (outputs) on time and at a reasonable price (Feyisa, 2020). The

| Variable                              | Code   | Measurement                                      | Expected sign |
|---------------------------------------|--------|--------------------------------------------------|---------------|
| Adoption Status                       | Adopt  | =1 if adopter, 0 otherwise                        |               |
| Gender of the household head          | SX     | =1 if male, 0 otherwise                           | ±             |
| Age of the household head             | AG     | In lifetime years                                 | -             |
| Family size of the household          | FS     | In number                                         | ±             |
| Education level of the household head | $Ed_{u1}$ | Illiterate                                         | -             |
|                                       | $Ed_{u2}$ | Grade 1–8                                         | +             |
|                                       | $Ed_{u3}$ | Grade 9–10                                        | +             |
|                                       | $Ed_{u4}$ | Above grade 10                                    | +             |
| Marital status of the household head  | Ms     | =1 if married, 0 otherwise                        | -             |
| Saving participation                  | Sa     | =1 if have saved, 0 otherwise                     | +             |
| Access to credit service              | CS     | =1 if have access, 0 otherwise                    | +             |
| Livestock ownership                   | TLU    | Amounts of livestock herd                         | +             |
| Distance from the market              | DFM    | In kilometer                                      | -             |
| Total land size of household          | LS     | In hectare                                        | +             |
| Farm cooperative member               | FCM    | =1 if they are member, 0 otherwise                | +             |
| Extension service                     | Es     | =1 if have access, 0 otherwise                    | +             |
| Off farm participation                | OFP    | =1 if participated, 0 otherwise                   | +             |
sign of the variable is determined based on the previous finding of different research conducted on the determinant of agricultural technology adoption and summarized below in Table 2.

4. Result and discussion

4.1. Descriptive analysis

Table 3 provides the summary statistics of the socio-demographic characteristics of sampled respondents.

A mean comparison test is used to compare the means of explanatory variables between male-headed and female-headed households. The result as presented in Table 3 shows that the mean comparison test between male-headed and female-headed households is significantly different and larger for male-headed households. Table 3 shows that, out of all the surveyed households, 87.3% of adopters were male-headed while 61.2% were female-headed households. In terms of gender difference, 38.0% of male-headed were illiterate while 45.5% were female-headed; 48.6% of male-headed have primary education level, while 45.5% were female-headed; 11.5% of male-headed have secondary education level, while 7.6% were female-headed and 1.5% of male-headed have preparatory and above education level, while 1.2% were female-headed households. This shows a significant difference in education between male and female-headed households. The average size of the family in the male-headed sampled household is 5.04. However, it is lower in female-headed households. With regard to access to credit, off-farm employment, and saving; 54.2% of male-headed have got credit while 45.5% were female-headed; 62.6% of male-headed were engaged in off-farm work while 55.6% were female-headed and 78.2% of male-headed have saved money while 68.3% were female-headed. This shows that female-headed households have lower access to credit, off-farm work, and participation in saving than their counterparts. Moreover, male-headed households have more land size (1.982 ha) and livestock asset (6.261 TLU) than female-headed. This indicates that female-headed households have a significantly lower land size and livestock assets that are very important in the adoption of agricultural technologies than the male-headed households.

| Categorical Variables       | Category     | Male Headed | Female Headed | Difference |
|-----------------------------|--------------|-------------|---------------|------------|
| Adoption status             | Adopt        | .873        | .612          | 0.261***   |
| Marital status              | Married      | 1.145       | 1.168         | -0.023     |
| Education level of the household | Illiterate | 0.380       | 0.455         | -0.075**   |
|                             | 1–8 grade    | 0.486       | 0.455         | 0.031***   |
|                             | 9–10 grade   | 0.117       | 0.076         | 0.041***   |
|                             | above 10 grade | 0.015       | 0.012         | 0.003*     |
| Access to credit            | Yes          | .542        | .655          | 0.087***   |
| Off-farm Employment         | Yes          | .626        | .556          | 0.07***    |
| Saving                      | Yes          | .782        | .683          | 0.099***   |
| Extension visit             | Yes          | .933        | .636          | 0.297***   |
| Farm cooperative            | Yes          | .850        | .759          | 0.091***   |
| Age of the household        |              | 43.41       | 42.64         | 0.77       |
| Family size                 |              | 5.04        | 4.43          | 0.61***    |
| TLU                         |              | 6.261       | 5.278         | 0.983***   |
| Land size                   |              | 1.982       | 1.568         | 0.414***   |
| Distance from the market    |              | 9.592       | 9.614         | -0.022     |
With regard to extension visits and farm cooperatives, 93.3% of male-headed got access to extension visits during agricultural practices while 63.6% were female-headed and 85.0% of male-headed were a member of farm cooperatives while only 75.9% were female-headed households. This indicates that female-headed households have significantly lower access to extension visits and lower access to farm cooperatives in the study area as compared to the male-headed households. The result shows that significant gender differences in terms of the access to education, family-sized land, livestock, credit, off-farm activities, saving, extension, and farm cooperatives among male-headed and female-headed households in the study area, which induces a lower adoption rate of agricultural technology by female-headed households in the study area. This implies that male-headed households have better access than female-headed and the result is consistent with (Gebre et al., 2019).

4.2. Econometrics analysis

4.2.1. Factors affecting adoption decision of agricultural technology

Table 4 presents the binary logistic estimation results that determine the factors influencing the probability of agricultural technology adoption. The empirical results show that the Wald Chi-square is statistically significant at a 1% level, suggesting that the explanatory variables jointly determine the adoption of agricultural technology. The result shows that the gender of the household head positively and significantly determines the adoption of agricultural technology at a 5% level of significance. As hypothesized, in the study also, male-headed households are more likely to adopt agricultural technologies than their counterparts because male-headed households are more likely to get information about new technologies, have more resources that help to adopt, have more education level, land, livestock, credit access, extension visits, and farm cooperative membership than female-headed households. The marginal effect shows that the probability of men-headed households adopting agricultural technology is about 12.38% than women-headed, keeping other things remain constant. This is consistent with the previous studies of (Gebre et al., 2019; Kerr, 2017; Gebremariam & Wünscher, 2016; Huyer, 2016; Temesgen et al., 2014).

The education level of the household head is positively associated with the adoption decision of agricultural technology, indicating that educated farmers are more likely to adopt the row planting

| Variable              | dy/dx  | Std. Err. | z     | P > z   |
|-----------------------|--------|-----------|-------|---------|
| SX                    | 0.123  | 0.049     | 2.53**| 0.012   |
| Age                   | 0.001  | 0.001     | 0.93  | 0.353   |
| Family size           | 0.0001 | 0.006     | 0.03  | 0.979   |
| Educ_02               | 0.081  | 0.029     | 2.75***| 0.006   |
| Educ_03               | 0.082  | 0.022     | 3.74***| 0.000   |
| Educ_04               | 0.129  | 0.018     | 7.17***| 0.000   |
| Marit~01              | -0.041 | 0.024     | -1.67*| 0.095   |
| Saving                | 0.065  | 0.032     | 2.05**| 0.04    |
| Farm cooperative      | 0.058  | 0.035     | 1.65* | 0.098   |
| Distance from market  | -0.002 | 0.001     | -1.93*| 0.053   |
| Credit access         | 0.049  | 0.022     | 2.19**| 0.028   |
| Extension visit       | 0.229  | 0.074     | 3.06***| 0.002   |
| Off-farm work         | -0.024 | 0.021     | -1.15 | 0.248   |
| Total land size       | 0.022  | 0.008     | 2.69***| 0.007   |
| TLU                   | 0.005  | 0.003     | 1.85* | 0.064   |

dy/dx – is for discrete change of dummy variable from 0 to 1
* , **, *** denotes significance level at 10%, 5%, and 1% respectively.
technology that their counterparts. This result is consistent with our prior expectations as education improves the ability to obtain, process, and use information that is relevant for adoption decisions. The marginal effect shows that being in the category of primary, secondary, and preparatory education levels increases the probability of the household adopting the agricultural technology by 8.12%, 8.30%, and 12.91% as compared to the illiterate group. The result is consistent with the findings of (Abay et al., 2016; Amare & Simane, 2017; Challa & Tilahun, 2014; Feyisa, 2020; Gebre et al., 2019).

The marital status of the household is negatively associated with the decision of agricultural technology adoption, indicating that married households are less likely to adopt than their counterparts. The marginal effect shows that being married has less probability of adopting agricultural technology by 4.12% as compared to unmarried one, keeping other things unchanged. The reason is that unmarried farmers have few responsibilities and channel their financial resources to agricultural technology adoption contrary to their counterfactuals. Besides, marriage could result in a large family size, which would consequently put pressure on the financial resources, and limit the adoption capacity of the farm households. This is consistent with the previous study (Ojo & Baiyegunhi, 2020; Ojo et al., 2021).

Distance from the market is negatively associated with the adoption decision of agricultural technology in the study area, suggesting that the probability of farmer who is far from the input market have less probability of adopting the agricultural technology than their counterparts. The marginal effect shows that a 1 km increase in distance from home to the nearest market decreases the probability of adopting agricultural technology by 0.21%. The possible reason for this is farmers in remote areas could have less access to information on agricultural input and output markets, high production costs, and could have fewer options to take off-farm jobs, and are less likely to adopt productivity-enhancing technologies that finally increase farm income. The result is also consistent with the previous studies (Aynalem et al., 2018; Feyisa, 2020; Workineh et al., 2020).

Credit is positively associated with the adoption decision of agricultural technology, indicating that farm households who get access to credit are more likely to adopt it than their counterparts. The likelihood of adopting agricultural technology is higher for households with access to credit by 4.95% as compared to those who don’t have access to credit. This is because providing access to credit can raise the likelihood of adopting agricultural technologies for households in a shortfall of finance to purchase and possess new agricultural technologies. The result is consistent with the works of (Feyisa, 2020; Temesgen et al., 2014; Workineh et al., 2020).

Total farmland size is positively associated with the decision to adopt agricultural technology in the study area. The marginal effect suggests that when the amount of cultivable land size increased by one hectare, the likelihood of individual respondents adopting new agricultural technology increased by 2.24%. Since farmer with large farm size are interested in adopting agricultural technology because the likelihood of farmers considering farming activity as a full-time way of life increases: and hence more likely motivated towards adopting agricultural technologies and thereby increases their total production. This implies that greater land size serves as a security against the risk of crop failure. This is consistent with previous works (Feyisa, 2020; Workineh et al., 2020).

Livestock asset measured in the tropical livestock unit (TLU) is positively associated with the decision to adopt agricultural technology. The marginal effect shows that when the TLU increased by one unit, then the probability of the farmer adopting the agricultural technology increases by 0.6%. The study conducted by (Abay et al., 2016; Feyisa, 2020) have also found a similar result that households having large livestock units will have a better financial stand to afford and possess new agricultural technologies.
The result shows that there is a positive and significant relation between extension visits and agricultural technology adoption decisions at a 1% level of significance. Adequate access to extension services has a higher probability of adoption of agricultural technology because it helps to fill the information gap about the new agricultural technology and farmers learn about the benefits and applications of improved technologies through extension contacts. The marginal effect suggests that an improvement in the extension services will increases the probability of adoption by 22.9%. The result is consistent with a priori expectation as extension agents are the primary means by which smallholders receive information on modern agricultural technology and the previous research (Anang et al., 2020; Emmanuel et al., 2016; Feyisa, 2020; Workineh et al., 2020). Finally, participation in farm cooperatives has been found to be also the other important variable influencing the decision to the adoption of agricultural technologies. According to the result, households participating in farm cooperatives have about 5.83% more chance of adopting agricultural technology as compared to households that do not participate in farm cooperative memberships. This is because farm cooperatives serve the farmer in different ways, such as experience sharing, farmer’s training, and access to technology with affordable prices for their members and serving as a source of funds. The result is similar to the works of (Zhang et al., 2020). In general, in many developing countries, agricultural cooperatives constitute a major vehicle that can be used to enhance the adoption of new agricultural technologies and output marketing among smallholder farmers (Ma & Abdulai, 2016).

To conclude, we found that gender of the household head, education level of the head, marital status of the head, saving, farm-cooperative memberships, distance from the market, credit access, extension visits, total land size, and TLU have a significant effect on the adoption decisions of agricultural technologies. Similarly, we found that the female-headed households have significantly lower access in terms of education, saving, membership in farm cooperatives, access to credit, extension visits, land size, and livestock assets than the male-headed households. Therefore, this suggests that the adoption of agricultural technologies in the study area is highly influenced by the existence of gender differences and the adoption rate is quite lower for female-headed households than their counterparts. The result is consistent with the previous works (Gebre et al., 2019; Quaye et al., 2021; Addison et al., 2018; Rola-Rubzen et al., 2020).

5. Conclusion and recommendation
This study explored gender differences in agricultural technology adoption decisions in North Shewa Zone, Amhara region, Ethiopia. The results show that gender, education level, marital status of the household head; savings, credit access, farm cooperative, extension services, land size, TLU, and distance from the market are significant factors in agricultural technology adoption decisions in the study area. Moreover, we found that the gender of the household head is positively associated with the decision to adopt agricultural technologies, and a statistically significant gender difference in the rate of agricultural technology adoption in the study area, suggests that male-headed households are more adopters than female-headed. The differences are prevalent in that female-headed households have significantly lower access in terms of education, saving, membership in farm cooperatives, access to credit, extension visits, land size, and livestock assets than the male-headed households. We conclude that the probability of male-headed household is more than the probability of female-headed household in a technology adoption decision. Therefore, the results suggest that the government should strengthen the policy interventions and expand access to credit, promoting savings and agricultural extension services. The government should also make the market for buying or selling agricultural inputs or outputs near to the farm households. Moreover, policies and programs should be directed at developing and disseminating agricultural technology adoptions in the study area, most importantly for supporting female-headed households but should be more gender-egalitarian. Specifically, female-headed education, training, farm cooperatives, extension visits, access to saving and credit, and ownership of assets should be there to promote the adoption of agricultural technology by female-headed households. Furthermore, it is essential to take into consideration to help improve agricultural technology adoption for heterogeneous farm households (male and female-headed) in the study area.
area. This study was only limited to four districts of the North Shewa Zone of Ethiopia; therefore, this study endorses that such studies need to be conducted in other parts of the zone. Thus, the concerned body should implement certain policies in context to facilitate and encourage female-headed farm households to adopt agricultural technologies.

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Data Availability
The data that support the findings of this study are available from the corresponding author upon reasonable request.

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