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The impact of mobile-based digital technology adoption on livelihood diversification: evidence from Ethiopia

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ABSTRACT

The integration of mobile phones and associated services into the diversification of livelihoods has the potential for rural transformation in developing nations. However, mobile-based technology adoption for livelihood activities in the Hadiya Zone, Ethiopia, remains inadequate. This study aims to investigate the impact of mobile-based technology adoption on livelihood diversification in the study area. The results of the instrumental variable Tobit show that mobile-based digital technology adoption positively and significantly influences livelihood diversification. This is evident particularly among the educated, men, remittance recipients, active labourers, landowners, urban residents, and traders. This underscores that the adoption of mobile-based technologies for livelihood activities is uneven, particularly among marginalised populations. Therefore, government, telecom companies, and development agencies should prioritise expanding network coverage, implement inclusive digital policies, and foster skills development. Additionally, promoting mobile money services and addressing affordability barriers are crucial to encouraging the adoption of mobile-based digital services for livelihood activities.

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1. Introduction

The emergence of information and communication technology (ICT) technologies has changed the livelihoods of populations, particularly women and rural populations in developing countries. It is widely acknowledged that ICT holds immense potential in the modern era to achieve the Sustainable Development Goals (SDGs) by facilitating employment, financial inclusion, and overall societal progress (Aker and Mbiti 2010; Azmeh 2025; Fu, Avenyo, and Ghauri 2021). Nowadays, mobile phones are widely accessible, versatile, and portable tools, surpassing traditional channels such as radio, television, newspapers, and landline telephones in developing countries where there is an infrastructure deficiency (Aker, Ghosh, and Burrell 2016; Mothobi and Grzybowski 2017).

Mobile-based digital technology adoption is crucial for enhancing access to information, improving communication, and facilitating financial transactions in developing countries (Aker and Mbiti 2010; Baird and Hartter 2017; Pede et al. 2018). Adoption of mobile technology can be defined as the adoption and integration of mobile internet and mobile banking into livelihood activities. This enables individuals to strengthen their social and economic networks by improving various

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economic opportunities, managing risks, and promoting efficiency and social development (Aker, Ghosh, and Burrell 2016; Rajkhowa and Qaim 2022). Enhancing livelihood diversification through adoption of moble technology supports SDG 5 (gender equality) and SDG 8, which focuses on decent work and economic growth (UN 2023).

Africa is one of the regions where access to mobile-based digital technologies has recently increased (ITU 2023). Similarly, these technologies have expanded in Ethiopia due to government policy efforts focused on telecom reform and sector privatisation (GSMA 2024). Through these efforts, mobile-based digital technologies play a crucial role in supporting various livelihood activities across the country (Haile, Wossen, and Kalkuhl 2019). However, despite progress, the adoption of mobile-based digital technologies remains uneven across various livelihood activities, especially among marginalised populations (women and rural populations). Since Ethiopian policy is increasingly reliant on digital transformation policies (EDS 2020), understanding the integration of mobile-based digital technologies into livelihood activities in the Hadiya Zone, Ethiopia, would be useful for socio-economic transformation.

Several existing studies emphasise the various drivers that influence livelihood diversification in developing contexts. Access to finance is one of the factors commonly mentioned to have a significant impact on livelihood diversification (Alobo Loison 2019; Asfaw et al. 2017). Furthermore, factors such as environmental regulation, gender and geographical differences are identified as drivers that influence rural livelihood diversification (Alobo Loison 2019; Qiu, Su, and Tang 2022). Although these studies are insightful for improving the diversification of income of households or individuals, they overlook link between mobile-based digital technologies and livelihood diversification.

To date, studies have examined how mobile phones and ICT influence the livelihood diversification of households in Bangladesh (Matsuura-Kannari, Islam, and Tauseef 2024), India (Rajkhowa and Qaim 2022), Tanzania (Baird and Hartter 2017), Ghana (Shaibu, Hudu, and Israel 2018), and China (Leng et al. 2020) while other studies have emphasised the relationship between mobile money and livelihood diversification (Atta-Ankomah, Adjei-Mantey, and Amankwah 2024; Shaibu, Hudu, and Israel 2018; Wang et al. 2022). Although this progress reveals that there is growing interest in the areas of mobile-based digital technologies and livelihood diversification, no studies have been conducted linking mobile-based digital technologies and livelihood diversification in the Hadiya Zone, Ethiopia. In addition, existing studies have extensively focused on macro-level studies (Atta-Ankomah, Adjei-Mantey, and Amankwah 2024; Haile, Wossen, and Kalkuhl 2019) while micro-level perspectives and contexts are insightful. To fill the highlighted gaps, this study tries to analyse the relationship between mobile-based digital technologies and livelihood diversification in the Hadiya Zone, central Ethiopia.

The Hadiya Zone is well suited to conducting a study that integrates mobile-based digital technologies into livelihood diversification. First, most households in the area use mobile phones primarily to communicate with family members and relatives, both locally and abroad (Adugna 2019). Second, along with a variety of crops, including endemic crops such as *enset* (*Ensete ventricosum*) and *teff* (*Eragrostis tef*), the zone is also home to livestock and offers non-agricultural employment opportunities (Lefebo et al. 2016). Lastly, there are notable variations in mobile-based digital technologies across different livelihood activities (Adugna 2019). This is due to variations in demographic, socioeconomic, technological, and situational factors in Ethiopia, including the Hadiya Zone (Adugna 2019; Warner, Mekonnen, and Habte 2023). These conditions raise questions about how various factors of mobile-based digital technologies impact livelihood diversification. The study attempts t answer the question of how do socioeconomic, situational, and demographic factors impact livelihood diversification?

This study makes three contributions to the literature. First, the study examines the relationship between mobile-based digital technologies and livelihood diversification in the Hadiya Zone. It adds to the literature by employing an instrumental variable Tobit model to address the endogeneity issues, which are not addressed in the literature (Ahmed et al. 2018; Alemu 2023). Second, this study has enriched the literature by evaluating the different effects of gender and geographical location on mobile-based digital technologies, which influence livelihood diversification. Lastly, the government of Ethiopia is implementing various digital initiatives that enhance the adoption

of mobile-based digital technologies for various livelihood activities, underscoring the relevance of this study to current national development efforts. Similarly, the findings of this study are useful in other regions with circumstances comparable to the Hadiya Zone.

2. Review of the literature

2.1. Theoretical literature

Livelihood diversification is a continuous adaptive cycle in which households adopt new practices, maintain existing ones, or drop others, thereby retaining diverse and evolving livelihood portfolios (Ayana, Megento, and Kussa 2022). Recently, mobile-based digital platforms have been increasingly recognised as essential tools for improving household livelihoods by facilitating access to information, enhancing communication, and promoting financial inclusion (Ma et al. 2020; Wang et al. 2022). Fu, Avenyo, and Ghauri (2021) emphasise how digital platforms, including mobile tools, drive socio-economic transformation in developing countries through capability building, institutional transformation, and improved market access. Mobile tools are well-suited to bridge the gaps caused by infrastructural deficiencies in developing countries (Mothobi and Grzybowski 2017). The adoption of these platforms depends on ecosystem readiness, household or organisational characteristics, technological openness, and regulatory environment (Aurazo and Gasmi 2024; Leng et al. 2020; Park 2017; Turoń 2025). As part of ecosystem readiness, the expansion of broadband and internet access is one of the key gateways to increasing the uptake of mobile platforms among marginalised populations (Park 2017). Regulatory support that encourages wider service penetration is fundamental to driving adoption by facilitating sector privatisation, interoperability, and digital reforms (Aurazo and Gasmi 2024; EDS 2020). According to Warner, Mekonnen, and Habte (2023), the collaborative partnership among various stakeholders, including mobile tool manufacturers, telecommunication companies, financial institutions, and government organisations, can drive technology adoption.

2.2. Empirical review of the literature

The literature linking mobile-based digital technologies to livelihood diversification is limited but has been growing recently. Existing studies have primarily focused on China to analyse the relationship between mobile tools and livelihood diversification (Leng et al. 2020; Li et al. 2023), while neglecting countries like Ethiopia, where the use of mobile-based digital technologies has increased significantly(GSMA 2024). For instance, Leng et al. (2020) argue that the adoption of ICT helps diversify rural incomes and benefits low-income rural households in China.

Hübler and Hartje (2016) found a positive effect of smartphone ownership on the income of rural households in Southeast Asia. Ma et al. (2020) demonstrate that internet use significantly increases household income and expenditure in China. Munyegera and Matsumoto (2016) found that remittances received through mobile money improve the welfare of households in Uganda by smoothing the consumption of essentials such as food, medication, education, and other asset-building activities. Similarly, Kikulwe, Fischer, and Qaim (2014), reported that recipients of remittances were more likely to easily purchase farm inputs and realise profits compared to non-recipients.

In addition, various socioeconomic, demographic, and situational factors differently influence the adoption of mobile-based digital technologies, which in turn affects livelihood diversification in different countries, underscoring the necessity for context-specific studies (Ferritto 2024; Warner, Mekonnen, and Habte 2023). Park (2017) found a disparity in digital infrastructure between urban and rural areas of Australia, posing challenges that limit rural residents in adopting technology to enhance their livelihoods.

Warner, Mekonnen, and Habte (2023) found that women exhibited lower rates of adoption of mobile-based digital technologies, particularly in rural areas of Ethiopia, limiting the inclusive

development of households. C. Leng et al. (2020) argue that education is a crucial gateway to the use of mobile-based digital technologies, limiting individuals with little or no education. Li et al. (2023) emphasise that individuals with limited education often face challenges in adopting mobile-based digital technologies due to a lack of digital skills, which restricts the benefits they can derive from these platforms. Ma et al. (2020) indicate that those who have access to land have a higher likelihood of mobile-based digital technologies adoption for livelihood activities than those with no access to land. Banerjee, Bose, and Siddiqui (2022) argue that trade is one of the important factors contributing to the adoption of mobile-based digital technologies for the efficient operation of businesses in Asian countries. Furthermore, the literature predominantly emphasises macro perspectives on the mobile-based digital tools (Atta-Ankomah, Adjei-Mantey, and Amankwah 2024; Leng et al. 2020), while micro-level studies provide valuable insights, which this research aims to address. Given Ethiopia's unique demographic, socioeconomic, and situational factors, conducting a study on the relationship between mobile-based digital technologies (mobile internet and mobile money) and livelihood diversification in Ethiopia would provide a valuable addition to the literature.

2.3. Conceptual frameworks

As illustrated in Figure 1, various factors influence the decision to adopt or refrain from adopting mobile-based digital technologies for livelihood diversification. These factors include demographic elements (such as age, gender, education, and family size), socioeconomic factors (including land ownership, remittances, and trade), and situational factors (such as geographical location).

3. Research methodology

3.1. Area description

The study was conducted in the Hadiya Zone, central Ethiopia. It is the administrative hub of the Central Ethiopia Region and is situated 232 km from Ethiopia's capital, Addis Ababa. The zone shares borders with Kembata Tembaro (KT) to the South; the Dawro zone to the Southwest; the Omo River to the West, which separates it from the Yem zone and the Oromia region; Gurage to the North; Siltie to the Northeast; and the Halaba zone to the East. Land use in the zone is primarily

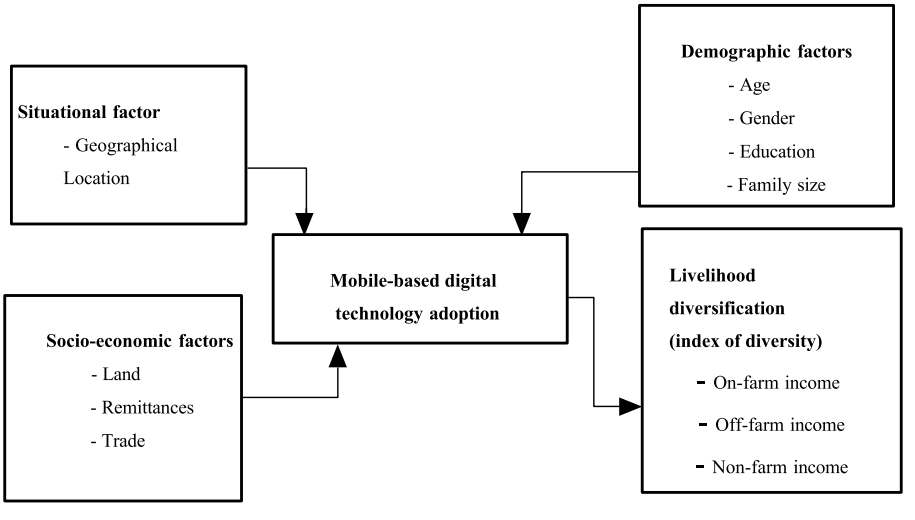

Figure 1. Conceptual framework of the study.
Source: Own design based on literature (2025).

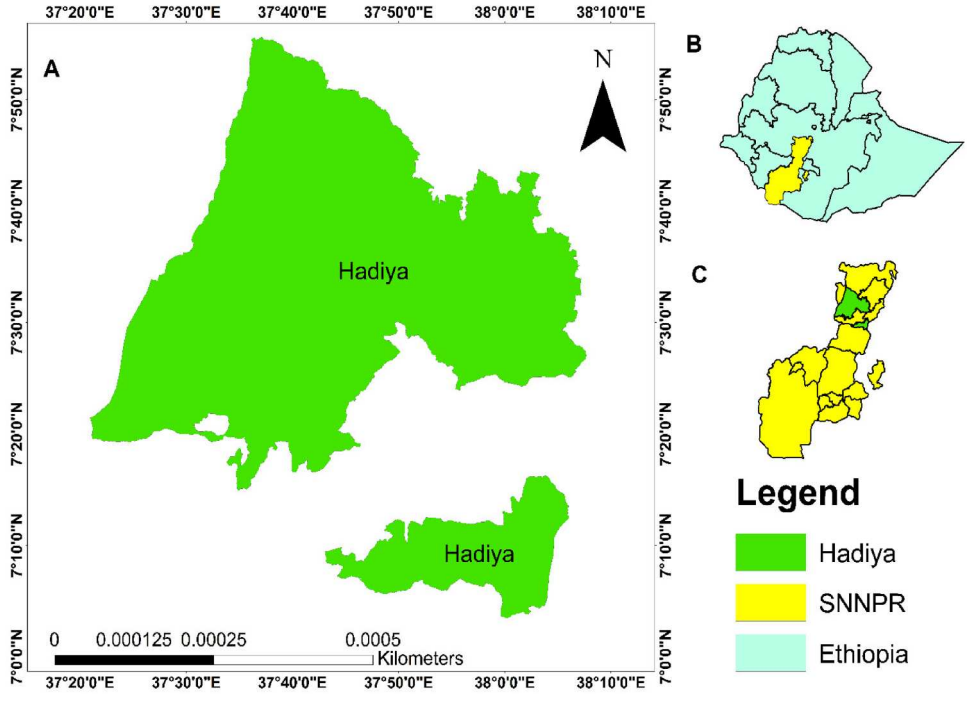

Figure 2. Map of the study area.

agricultural, with significant areas allocated for crop cultivation. This includes staple crops such as maize, *teff*, and wheat, as well as cash crops such as coffee and *khat*. According to the Hadiya Zone Plan and Development Department, the zone is home to 1,969,866 residents (as of fiscal year 2021–2022). Of these, 990,271 are women and 979,595 are men. A total of 346,958.5 hectares of land is covered by the 316 kebeles that comprise the zone's rural districts. Of this area, 12.9 per cent of the land is classified as low altitude (*Kola*), 68.1 per cent as moderately undulating land (*Woyinadega*), and 19 per cent as high altitude (*Dega*). The annual rainfall distribution varies between 801 and 1,400 millimetres, while the altitudinal variation ranges from 800 to 2,970 metres. Livelihoods in the zone depend on on-farm (crop production and livestock rearing), off-farm (agricultural employment), and non-farm employment (trade, construction work, civil servants, and other professions) (Figure 2).

3.2. Research design, data, and data sources

The present study used data from a household survey collected from respondents in the study area. We used a mixed-methods research approach that involved both qualitative and quantitative data from primary and secondary sources. The primary data collected include variables related to access to digital devices, the necessary infrastructure for digital activities, household characteristics, access to and utilisation of digital services, and geographical location. Primary data were collected through face-to-face interviews using tablets equipped with Kobo Toolbox software. Structured survey instruments were administered by trained enumerators to ensure consistency and data quality. Relevant secondary data were sourced from original articles, reports, and reviews.

3.3. Sampling technique and sample size

For this study, multistage sampling techniques were used to select sample respondents among adults at least 18 years or older in the study area. In the first stage, three rural districts –

Ameka, Gombora, and Lemo – were randomly selected, while Hossana Town was purposively selected to represent the urban settings of the study zone. In the second stage, three local administrations, or kebeles, from each district were randomly selected from a list of local administrations (subdivisions of district or town). Finally, a total of 394 respondents was selected using a simple random sampling technique, with the sample size determined based on Yamane's (1967) formula:

$$n = \frac{N}{1 + N\,(e)^2} \tag{2.1}$$

$$n = \frac{31500}{1 + 31500\,(0.05)^2} = \frac{31500}{79.75} = 394$$

Here, *n* is the sample size, *N* is the population size, and *e* is the level of precision that takes 5 per cent.

3.4. Method of data analysis

3.4.1. Definition of variables

Table 1 presents the relationship between the explanatory and dependent variables that describe how mobile-based digital technology influences livelihood diversification.

3.4.2. Empirical model specification of the instrumental variable Tobit model

To answer the specific objective of the present study, which is beyond the scope of descriptive analysis, an appropriate empirical model is formulated: the instrumental variable Tobit model.

The Simpson index (livelihood diversification index) was used due to its computational simplicity, robustness, and wider applicability compared to alternative indices (Ahmed et al. 2018). In line with Khatun and Roy (2012), we employed non-farm, off-farm, and on-farm incomes as indicators of livelihood diversification. Following the methodological guidance of Khatun and Roy (2012) and Shiyani

Table 1. Description of dependent and explanatory variables used for the study.

No.	Variable	Variable definition	Variable description	Expected sign	Sources
1	LDI	Livelihood diversification index	Livelihood diversification index calculated using on-farm, off-farm, and non-farm income		
2	MBDTA	Mobile-based digital technology adoption	1 = adopters of mobile internet and mobile money, 0 = otherwise	+	(Atta-Ankomah, Adjei-Mantey, and Amankwah 2024)
3	Age	Age of the respondent	Continuous	+	(Ma et al. 2020)
4	Gender	Gender of the respondent	1 = men, 0 = women	+/-	(Shaibu, Hudu, and Israel 2018)
5	Education	Education level of respondent	0 = no education, 1 = primary, 2 = secondary, 3 = diploma, and 4 = degree and above	+	(Wang et al. 2022)
6	Family size	Number of family members	Number of family members excluding child and elders	+	(Li et al. 2023)
7	Geographical Location	Geographical location	1 = urban residents and 0 = rural residents	+	(Park 2017)
8	Remittances	Remittances	1 = have access to remittance and 0 = no	+	(Ali et al. 2024)
9	Land	Land	1 = have access to land and 0 = no	+	(Ma et al. 2020)
10	Trade	Trade access	1 = have access, 0 = have no access	+	(Banerjee, Bose, and Siddiqui 2022)

and Pandya (1998), the livelihood diversification index is expressed as follows:

$$\mathrm{LDI} = 1 - \sum_{i=1}^{N}\left(\frac{A}{Ti}\right) + \left(\frac{B}{Ti}\right)^2 + \left(\frac{C}{Ti}\right)^2 + \left(\frac{D}{Ti}\right)^2 + \left(\frac{E}{Ti}\right)^2 \tag{2.2}$$

Where, LDI is the index of livelihood diversity; N is the total income sources; A = farm income; B = off-farm employment income; C = non-farm employment income; D = remittances; E = other income sources; and Ti = total income.

The range of values would be 0–1. The index value is zero when there is a full specialisation and reaches one as the level of diversification increases. An LDI of 0 indicates no diversification; values between 0.01 and 0.38 indicate low diversification; 0.39–0.63 indicate medium diversification; and values above 0.63 indicate high diversification (Amevenku et al. 2019).

The Tobit model takes into consideration the censored nature of households' livelihood diversification, as well as the correlation of error terms between the various bundle activities (Li et al. 2023; Qiu, Su, and Tang 2022). An instrumental variable Tobit model was employed to analyse the impact of mobile-based digital technology adoption (MBDTA) on livelihood diversification, as the livelihood diversification index (LDI) is censored. In the presence of a latent or censored sample in the variable, it is more appropriate to find the parameter estimates using a Tobit model (Ahmed et al. 2018; Gujarati 2004; Li et al. 2023).

$$\begin{aligned}\mathrm{LD}_i = {} & \alpha_0 + \beta_1 MBDTA + \beta_2 \mathrm{Age} + \beta_3 Agesquared_i + \beta_4 Gender + \beta_5 \mathrm{Education}_i \\ & + \beta_6 Farmilysize + \beta_7 \mathrm{Geographical\ location}_i + \beta_8 \mathrm{Remittances}_i + \beta_9 \mathrm{Land}_i + \beta_{10} \mathrm{Trade}_i \\ & + \varepsilon_i\end{aligned} \tag{2.3}$$

An instrumental variable was chosen to deal with endogeneity, considering the potential reverse causality between dependent and independent variables. Social networks were included as an instrumental variable to solve the endogeneity problem, considering the reverse causality between mobile-based digital technology adoption and livelihood diversification. To assess the validity of the instrument, we employed the logit model to analyse social networks and mobile-based digital technology adoption, as well as the ordinary least squares model to examine the relationship of social network with livelihood diversification index (measured using on-farm, non-farm, and off-farm income). The results indicate that the social network has a positive and significant influence on the adoption of mobile-based digital technology; however, it has no significant effect on the livelihood diversification index. These results validate the decision to use the social network variable as a valid instrument.

4. Results and discussion

This section discusses the specified variables included in the model through descriptive statistics and econometric analysis. The descriptive statistics provide a brief overview of the results related to demographic, socio-economic, technological, and situational factors, including averages, percentages, standard deviations, minimums, and maximums. An econometric model, the instrumental variable Tobit model, was employed to analyse the impact of mobile-based digital technology adoption on livelihood diversification.

4.1. Descriptive statistics

The results in Table 2 indicate that the mean age of the respondents is 43 years, with a standard deviation of 11.284. This reveals that there are more respondents in the active age groups than older respondents. The gender statistics of this study reveal that about 77.16 per cent (or more than two-thirds) of the respondents were men. The data regarding the education levels of the

Table 2. Descriptive analysis of continuous, dummy, and categorical variables

Variable	Mean	Std. Dev.	Min	Max
LDI	0.246	0.0921	0	0.48
Age	43.495	11.284	22	69
Age squared	2018.81	1045.701	484	4761
Family size	5.44	1.67	1	13
Variable	**Description**	**Per cent**		
MBDTA	Adopters	70.56		
	Non-adopters	29.44		
Gender	Men	77.16		
	Women	22.84		
Education	No Education	21.57		
	Primary	30.96		
	Secondary	27.41		
	Diploma	9.39		
	Degree and above	10.66		
Social network	No network	33.25		
	One networks	40.10		
	Two networks	20.81		
	Three networks	5.84		
Remittances	Have access	59.90		
	Have no access	40.10		
Land	Have access	77.16		
	Have no access	22.84		
Trade	Have access	13.75		
	Have no access	86.25		

Source: Survey data (2025).

respondents reveals that more than 50 per cent fall into the categories of primary education and no formal education. This highlights the need to improve educational engagement within the broader society, allowing individuals to harness the potential benefits of mobile-based digital technology. The mean value of the family size was about 5.44 persons per family, with a range of 1–13 and a standard deviation of 1.67.

The distribution of social networks indicates that 73.35 per cent of respondents have limited social networks, restricting their ability to share experiences related to the adoption of mobile-based digital technology. This situation reveals that, although there are social networks that could improve mobile-based digital technology adoption, a significant number of respondents are restricted to single or no networks, hindering their ability to grasp digital experiences and access essential services. Statistics reveal that 59.9 per cent of respondents have access to remittances, while the remaining 40.1 per cent do not. This demonstrates that more people have used accessible mobile-based digital technology to supplement their income. About 77.16 per cent of the respondents own their own farmland to perform various agricultural activities, while 22.84 per cent do not own farmland. This gap highlights the need for awareness campaigns to help those in need leverage mobile services for their daily activities. Lastly, about 13.75 per cent of respondents are traders, while 86.25 per cent are non-traders.

4.2. Instrumental variable Tobit results for the effects of the adoption of mobile-based digital technologies on livelihood diversification

The instrumental variable Tobit model indicates a strong positive association between mobile-based digital technology and livelihood diversification. As presented in Table 3, the F-statistic exceeds 10, highlighting that there are no issues with weak instrumental variables. The result of the exogeneity of the Wald test ($\chi = 15.71$, $p < 0.001$) demonstrates that the null hypothesis that the instrument is weak is rejected. The coefficients of mobile-based digital technology adoption and the control variables positively and significantly influence livelihood diversification. The greater the adoption of mobile-based digital technologies, the higher the livelihood diversification. This reveals that

Table 3. The impact of mobile-based digital technology adoption on livelihood diversification.

	IV Tobit model	
LD index	Coef.	Std. Err.
MBDTA	0.083***	0.014
Age	−0.004	0.0032
Age squared	0.000626*	0.000335
Education	0.0169**	0.0068
Family size	0.0107***	0.00343
Gender	0.075***	0.0177
Remittances	0.0265**	0.0126
Land	0.0228*	0.0127
Trade	0.0218*	0.012
Geographical location	0.0123**	0.00547
_cons	−0.0148	0.0764
Wald test of exogeneity	15.71***	
First stage F test	134.36***	
Social network (instrument)	0.65***	0.056

Source: Survey data (2025); *, **, and *** mean significant at levels of 0.1, 0.05, and 0.01, respectively.

mobile-based digital technology adoption for livelihood diversification is not an isolated phenomenon but part of a broader digital ecosystem. Similar findings show that mobile-based digital technologies, such as mobile internet and mobile money, are crucial tools for reshaping how rural communities access resources and services (Atta-Ankomah, Adjei-Mantey, and Amankwah 2024; Baird and Hartter 2017; Ma et al. 2020).

Factors such as age, education, family size, gender, remittances, land, trade, and geographical location have a positive and significant impact on livelihood diversification. The coefficient of education positively and significantly influences livelihood diversification. More educated individuals are more likely to use mobile-based digital technologies than individuals with less education or no education, enabling them to engage in a wider range of income-generating activities. This underscores that individuals with higher levels of education can easily access and navigate various mobile-based digital platforms, underscoring the necessity of education in fostering digital inclusion and seamless livelihood activities (Fu, Avenyo, and Ghauri 2021; Wang et al. 2022).

Our findings show that there are gender-based differences in the adoption of mobile-based digital technology. Men were more likely than women to frequently use mobile devices for various livelihood activities, as per prior expectation. This variation is attributed to family commitments of women, such as childcare, housekeeping, food preparation, and related tasks. In addition, women have less control over the economic resources that limit them from accessing mobile phones and associated services. This disparity creates a systemic barrier that structurally excludes women from technology-based livelihood activities, highlighting the need for an inclusive digital transformation framework. Similar results have been reported by Shaibu, Hudu, and Israel (2018) and Warner, Mekonnen, and Habte (2023)

As expected, the coefficient of geographical location has a positive and significant influence on livelihood diversification. It is implied that as we travel farther from urban (Hossana Town) to rural areas (Ameka, Gombora, and Lemo districts), the infrastructure required to enable people to use mobile-based digital tools for a variety of livelihood activities is lacking. A study conducted by Park (2017) in Australia, reveals that weak broadband and internet connectivity limit the adoption of mobile tools in rural areas, which parallels the context of rural Ethiopia. The results on remittances reveal that the more remittances people receive, the greater their ability to save and participate in livelihood diversification. This indicates that households with relatives in large towns and abroad receive financial support that drives mobile-based digital technology adoption for various livelihood activities more than for those without remittances. Existing studies provide evidence that remittances facilitate participation in digital innovation, enabling wider rural communities to overcome entry barriers and engage in a variety of technology-supported livelihood activities (Ali et al.

2024; Kikulwe, Fischer, and Qaim 2014; Munyegera and Matsumoto 2016). Excluding children and older people, as the number of family members increases, the livelihood diversification would increase. The implication is that families with larger labour forces are more likely to adopt mobile-based digital technologies. This can be important for managing numerous household activities more efficiently than cohorts with a smaller number of active labour forces. This result coincides with the study conducted by Li et al. (2023). The land serves as a foundation for the diverse agricultural activities that allow them to work on more than one activity for their livelihoods. Farmers with access to more land have greater opportunities to invest in agricultural enterprises that improve their income. Increased income enables them to own and use mobile phones, which can support to supplement various non-agricultural activities and further improve their livelihoods. This is supported by existing studies that emphasise the positive relationship between land and mobile technologies, which allows communication with various stakeholders and improves productivity (Ma et al. 2020; Wang et al. 2022).

5. Conclusion and recommendations

This study demonstrates that the adoption of mobile-based digital technology significantly enhances livelihood diversification among households in the Hadiya Zone, Ethiopia. Despite the low average livelihood diversification index (mean = 0.246), there is a positive association between mobile-based digital technology adoption and livelihood diversification, underscoring its potential to drive socio-economic transformation in rural communities. Our findings show that the adoption of mobile technologies for livelihood activities is more common among men, members of more educated groups, remittance recipients, and those with greater access to social networks and trade. The findings also show that individuals living in urban areas are more likely to adopt mobile-based technologies compared to those in rural regions, underscoring the need to address the factors influencing mobile-based digital technology adoption in rural areas. Women were less likely to adopt mobile-based digital technologies, particularly in rural areas, which limits the inclusive development of households. Having active working-age family members with land access is crucial to improving a variety of livelihood options. The number of family members and land access were found to be positive and significant predictors of livelihood diversification. The implication is that mobile-based digital technology adoption to enhance livelihood opportunities is significantly lower among marginalised populations. This is due to disparities in socio-economic, demographic, technological, and situational factors that influence the adoption of technologies in varying ways. Given Ethiopia's national digital strategy, which emphasises digital inclusion as a key driver of socioeconomic transformation, these results are highly relevant. The findings also align with SDG 5 (gender equality) and SDG 8 (decent work and economic growth), highlighting inclusive digital adoption in enhancing socio-economic transformation. The findings by Munyegera and Matsumoto (2016) emphasise how the adoption of mobile tools could enhance financial inclusion; however, disparities exist in adoption for livelihood activities, driven by several socioeconomic factors similar to those in Ethiopia. Furthermore, Rajkhowa and Qaim (2022) show that mobile phone adoption is higher among individuals who are more educated, men, have larger families, and possess greater land size, which parallels the Ethiopian context.

Given the results of the study, the following policy recommendations were made. Expanding network coverage, implementing inclusive digital policies, fostering skills development, promoting mobile money services, and addressing affordability barriers requires urgent action. First, gender-sensitive and inclusive digital policy initiatives are crucial, particularly for women and rural populations, to improve digital competency and bridge digital skill gaps. Second, promoting mobile-enabled financial services can improve access to socio-economic opportunities. Third, integrating emerging technologies into education and promoting user-friendly mobile tools in local languages can achieve long-term digital transformation goals. Collaborative efforts among governments,

telecommunications companies, and development agencies are essential for these initiatives. Fourth, expanding the coverage of the 4G and 5G networks in rural areas can bridge the rural–urban digital divide and promote livelihood activities. Fifth, increasing the productivity of land and labour by extending the number of production seasons is crucial. Sixth, encouraging trading activities would enhance market efficiency and foster innovation. Lastly, the government should emphasise the development of complementary infrastructure as part of the existing digital policy, which aims to enhance the adoption of mobile tools, such as electricity.

It is important to acknowledge the limitations of this paper. First, this study used cross-sectional data to analyse factors affecting the adoption of mobile-based digital technologies. Future research should use time series data for in-depth analysis, which can provide more comprehensive analysis, thereby facilitating better policy decisions. Another limitation is that it focuses on three districts and one town, which limits the generalisability of the findings throughout the nation. Future research should be conducted in other areas with various influences on device usage; this could significantly contribute to the literature.

Author contributions

CRediT: **Degineh Lagiso Bule:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft; **Herbert Ntuli:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Validation, Writing – review & editing; **Colleta Gandidzanwa:** Conceptualization, Formal analysis, Methodology, Project administration, Supervision, Validation, Writing – review & editing.

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Data availability statement

The data used in this article can be obtained upon request.

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