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Mobile Phones and Climate Information Access Among Smallholders in East Java, Indonesia

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Abstract

Background: The increasing adoption of mobile phones among smallholder farmers in Indonesia presents new opportunities to access agrometeorological and climate change information, essential for climate adaptation in rural agricultural areas. **Aim:** This study examines the extent to which mobile phone ownership influences access to climate change adaptation information among smallholder farmers in East Java. **Methods:** A cross-sectional survey was conducted involving 7,850 smallholder households. The study assessed the relationship between mobile phone ownership and its use for accessing climate-related information, participating in farmer groups, and conducting agricultural transactions. Logistic regression was applied to identify key determinants of mobile phone utilization. **Results:** Of the total respondents, 54.4% reported owning a mobile phone. Among them, 46.4% used their phones to access climate change information, 41.4% engaged in buying and selling agricultural products, and 46.4% participated in farmer organizations. Mobile phone ownership and group membership were significantly associated with mobile phone use for agricultural purposes ($p < 0.001$). Conversely, age and household income were not statistically significant. Notable variations were also observed in relation to smartphone ownership, gender, and educational level, with higher education and female participation linked to increased utilization of phones for climate-related activities. **Conclusion:** Mobile phone ownership plays a critical role in enhancing access to climate adaptation information and agricultural engagement among smallholders. The findings highlight the potential of digital tools to strengthen resilience and support climate-smart practices. Promoting equitable access to mobile technology, particularly for women and less-educated farmers, is vital for inclusive agricultural adaptation strategies.

Keywords: climate change; mobile phone; productivity; small farmers

Introduction

At the end of 2022, the International Telecommunication Union reported that, as the world welcomed its 8 billion population, an estimated 5.3 billion people or 66% of the total global population were online, while 2.7 billion were still offline. At the same time, three-quarters of the population aged 10 years and above have a mobile phone. The average percentage of individuals who own a mobile phone is higher in almost all regions than the percentage of internet use, but the gap is narrowing (ITU, 2022). In the same year, the Central Statistics Agency reported that individual mobile phone service users in Indonesia increased by 5.85%, with 66.48% of internet users. The increase in internet penetration is driven by the need for quick and easy access to information, as well as the availability of broader internet infrastructure (BPS, 2022). In a study of 120 developing countries, including Indonesia, it was shown that the growth of mobile phone penetration coincided with economic growth (Nipo et al., 2023).

The increased growth of mobile phones has impacted the lives of hundreds of millions of people (Goel & Masurkar, 2024). In Indonesia, mobile phones are increasingly being used to provide a number of information services in the financial, energy, and agricultural sectors. (Rubanda et al., 2023). Mobile phones are essential for farmers in various types of farm management, serving as a tool for agricultural information exchange (Ding et al., 2022), social development and irrigation and innovation (Ayim et

al., 2022), technology adoption (Li et al., 2022), production (David & Wynand, 2019), product marketing (Han, H., 2022), climate information (Amarnath et al., 2018), income generation (Abubakari et al., 2023), and efficiency (Kusumaningsih, 2023).

The research by (Saridewi & Annisa, 2025) argues that mobile phones offer new opportunities for rural households to pursue better livelihoods. ICT has significantly contributed to socio-economic development in countries that have adopted it effectively (Luo et al., 2023), including through enhanced agricultural value chains in developed nations. However, the integration of ICT in Indonesia's agricultural sector remains limited and lacks transformation (Kayum, N., 2024). The use of mobile phones is not only for farmer communication, but also as a tool to access critical weather and climate information vital for farming success amid worsening climate change. Climate change has become a major threat to agriculture (UNESCO, 2023), significantly altering farming systems. Overland, (2024) revealed a surge of 3 million kilotons in carbon emissions in 2019, gradually raising global temperatures and disrupting agricultural productivity (Shang & Xie, 2024); (Fatkhullah et al., 2023). The Indonesian government has responded with a low-carbon development strategy targeting a 29% emission reduction by 2030 (Irma & Gusmira, 2024).

Mobile phones play a strategic role in delivering climate-related agricultural information. Services include market information, pest and disease alerts, weather consultations, crop and livestock updates, financial services, and decision support (Khan et al., 2022); (Anteneh & Melak, 2024). Yet, despite ICT introduction into agriculture over the past 30 years, structural barriers such as transparency, trust, and inefficient information flows still hamper its full potential (Mwenda et al., 2023). Compared to previous studies focusing on production, technology adoption, and market access, this research presents a distinct contribution by specifically examining mobile phone use for climate change adaptation among smallholders in Indonesia, a topic rarely explored in the national context. Thus, this study provides novel insights into whether and how mobile phones facilitate smallholder access to climate change information and related adaptive actions. To fill this gap, this study adopts a circuit-based approach to examine factors influencing mobile phone adoption among smallholders in East Java, particularly concerning access to climate change information, adaptation behavior, participation in farmer groups, and engagement in market transactions.

This study offers a novel contribution to the growing body of literature on information and communication technologies (ICTs) in agriculture by focusing specifically on the role of mobile phones in facilitating climate change adaptation among smallholder farmers in Indonesia, a country where such research remains limited and underexplored. While prior studies have extensively examined mobile phones in relation to productivity, technology adoption, and market access, few have investigated their potential to mediate access to climate, related information and adaptive decision-making in rural agricultural contexts. Moreover, the existing literature has largely concentrated on either infrastructure or socioeconomic barriers to ICT adoption without integrating the behavioral dimensions of adaptation in response to environmental stressors. This research bridges that gap by employing a comprehensive framework that considers not only technological access but also farmer engagement in group institutions, economic behavior (such as input-output transactions), and the socio-environmental context of farming communities facing climate risk. The novelty of this study lies in its empirical emphasis on climate information as a driver of adaptation, analyzed through the lens of mobile phone use a linkage that remains under-investigated, especially in Southeast Asian settings with highly diverse agrarian systems.

To address this research gap, the study formulates and investigates three core questions: (1) What are the factors influencing mobile phone adoption among smallholders in East Java? (2) Does mobile phone use influence agricultural productivity? and (3) How does mobile phone use affect farmers' decisions to adapt to climate change? These questions are answered using a large-scale household survey, allowing for robust statistical inference regarding the relationship between mobile technology use and adaptive behavior in agriculture. The findings aim to inform national and subnational policymakers on how mobile-based innovations can be leveraged to support the resilience of smallholder systems in the face of increasing climate volatility. Ultimately, the goal of this research is to generate context-specific policy recommendations and practical strategies to enhance agricultural productivity, promote inclusive access to climate information, and strengthen adaptive capacity among smallholder farmers in Indonesia.

Methods

Study Area

The East Java region is a place that is in accordance with the research recommendations to examine the problems in this research topic. The increase in mobile phone use is in line with the population growth rate in East Java which is increasingly dense. In addition, East Java is included in the 15 cities with the most people using mobile phones (Central Statistics Agency, 2020) and is the province that ranks first as an area with an area of agricultural land in Indonesia, which is 1,214,909 ha and is 25.41% of the area of East Java (Central Statistics Agency, 2021). So that from the area of agricultural land, East Java can contribute to the country's Gross Domestic Product (GDP) of 8.30% (subcategories of agriculture, livestock, hunting and agricultural services) (Agricultural Indicators of East Java Province, 2022). Based on the contribution of the agricultural sector in East Java, it is a very suitable recommendation to be used as a research location (Figure 1).

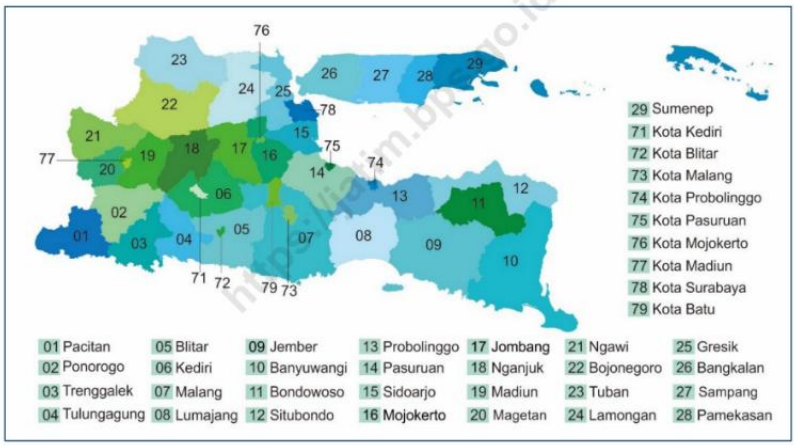

Figure 1. Map of Regency/City Administrative Areas in East Java Province

East Java Province has a population of around 41,416,407 people in 2023 (East Java Central Statistics Agency, 2023), around 6,578,237 people who carry out agricultural practices (BPS, National Labor Force Survey (Sakernas) as their main economic activity, have a population of at least 46.86% of the population who have completed elementary school and below, 20.74% and 23.98% of the population who have completed Junior High School and Senior High School Education, and as many as 8.42% of the population

has the highest education (East Java Provincial Education Statistics, 2022), and around 65.22% of households have a mobile phone (BPS, Susenas, 2022).

Data Collection

This study uses data from the Indonesia Family Life Survey (IFLS) 2022–2023. The survey provides comprehensive information on farmer households in East Java, including the ownership of mobile phones among farmers. A total of 7,850 individuals in East Java province were selected using a stratified random sampling method to ensure representation across various districts/cities, education levels, and farmer group participation. The main independent variable in this study is mobile phone ownership among farmers. The treatment group consists of farmers who own mobile phones, while the control group includes farmers who do not. Ethical clearance for this research has been obtained from the authorized ethics committee. All participants were provided with clear information regarding the study's objectives and benefits and gave their written informed consent prior to interviews and data collection.

Data Analysis

Variable Description

This study focuses on three dependent variables related to smartphone services: access to weather information, agricultural product transactions (buying and selling), and participation in institutional activities. These variables were measured based on farmers' perceptions of the usefulness of smartphone features (categorized as useful or not useful). The explanatory (independent) variables were drawn from the household survey and categorized into key demographic and socioeconomic factors, including mobile phone ownership, education level, gender, and household income, as presented in Table 1. The analysis explores the influence of these explanatory variables on the dependent variables, as shown in the next table.

Table 1. Summary of statistical variables of results and demographic characteristics of respondents

Kind	Variable	Level	N	%
DV	Weather Information	It's useless	4209	53.6
		Use	3641	46.4
	Buying and Selling	It's useless	4601	58.6
		Use	3249	41.4
	Institutional Activities	It's useless	4210	53.6
		Use	3640	46.4
IDV	Smartphones	Not	3581	45.6
		Yes	4269	54.4
	Participation of farmer groups	Not	2216	28.2
		Yes	5634	71.8
	Education	Not in school	1028	13.1
		Primary school	2971	37.8
		Junior High School	1817	23.5
		High School	2034	23.1
	RT Revenue Quartile	< IDR 800,000	3201	40.8
		>IDR 800,000	2013	25.6
		<IDR 1,000,000	1107	14.1
		>IDR 1,000,000	1529	19.5
	Gender	Woman	5210	66.4
		Man	2640	33.6

Note: DV stands for Dependent Variable and IDV stands for Independent Variable. [a] monthly income minus the number of income categories by calculating the income of the quartile 25%=Rp<800,000.-, 50%= Rp<1,000,000,-, and 75%= Rp>1,000,000,-.

Logistic Regression Analysis

Logistic regression analysis in this study was used to identify the motivation of farmers to adopt various services in mobile phones. In this analysis, Odds Ratio (OR) will be used for each dependent variable that uses or does not use weather information services, product purchases and sales, and institutional activities. However, in this study the same characteristics of the respondents, namely they are both members of the same agricultural institution, so in this study it is required that not all data at the household level is used as independent variables. Therefore, this study also uses ANOVA statistical analysis to test the differences between groups or types of treatment. Furthermore, the final stage uses logistic regression analysis through the STATA statistical tool (StataMP 17 – 64 bit).

Results and Discussion

Descriptive Statistics

On this occasion, the researchers began to collect respondents with phone ownership levels (Smartphones, basic phones, feature phones) by gender. It aims to identify the extent to which the lack of internet-enabled phone access can underlie gender-based differences in the use of messaging services. Based on the presentation of table 3, around 38% of respondents have smartphones, more men have smartphones than women. Basic phones are owned by 56.27% of women than men. Given that access to smartphones is very important for access to messaging services, the researchers investigated differences in age, education, and participation of farmers in farmer groups between smartphone owners and non-smartphone owners. As presented in table 4, the average education and organization of farmers is greater in smartphone owners, the statistical difference is similar between basic and non-smartphone phone owners.

Table 2. Types of mobile phones the respondents own

Gender	Phone Type	Proportion
Woman	Basic Phone	56.27
	Phone Features	12.84
	Smartphone	30.89
Man	Basic Phone	48.40
	Phone Features	13.60
	Smartphone	38.00

Table 3. Descriptive statistics of non-owners and smartphone owners in farmer groups, age and education

Variable	Statistics	Non-owner	Owner
Farmer Group	Mean	1.13	1.54
	S.D.	0.823	0.780
Age	Mean	52.6	47.8
	S.D.	12.0	12.1
Education	Mean	2.13	2.76
	S.D.	0.839	0.918

Note: SD=Standard Deviation

To distinguish whether education, age, and membership in farmer groups affect access to messaging services, we compared differences in socioeconomic factors between male and female users and non-messaging service users. As shown in table 5, the average age and level of education of messaging service users is lower than that of men. Similarly,

women, on average, are only members of smaller farmer organizations. The statistical variation is generally similar between men and women. Therefore, researchers used differences between men and women to contextualize the importance of socioeconomic factors in regulating the use of messaging services, although these factors were not always significant in the logistic regression model.

Table 4. Summary of statistics on the usefulness of smartphones for weather information, buying and selling information, and agricultural information

Variable	Weather Information				Buying and selling information				Farm information			
	Not		Yes		Not		Yes		Not		Yes	
	W	M	W	M	W	M	W	M	W	M	W	M
Age												
Mean	50.4	52.7	45.8	52.2	50.1	52.6	48.1	52.5	50.6	52.7	46.7	52.4
S.D.	12.22	11.98	10.39	13.74	12.57	14.40	9.67	12.38	12.42	12.30	10.18	12.63
Farmer Group												
Mean	1.17	1.25	1.44	1.71	1.14	1.25	1.48	1.64	1.11	1.18	1.56	1.78
S.D.	0,82	0,815	0,769	0,803	0,835	0,838	0,731	0,753	0,800	0,810	0,828	0,736
Education												
Mean	2.20	2.44	2.35	2.68	2.23	2.48	2.23	2.55	2.17	2.37	2.43	2.82
S.D.	0,939	0,933	0,635	0,811	0,938	0,907	0,745	0,926	0,941	0,887	0,714	0,893

Note: W= Woman, M= Man, SD= Standard Deviation

Logistic Regression Results

Smartphone Ownership

In simple terms, the ownership of a personal smartphone can be defined as the ownership of a mobile phone with internet access and the ability to download applications, increasing the likelihood of using messaging services in all three models as shown in table 6. Smartphone owners are between 1.83 and 2.72 times more likely than non-smartphone owners to use messaging services ($p<0.05$ for weather information and $p<0.001$ for buying and selling information and agricultural information).

We found that owning a *Smartphone* is a significant determinant in the use of mobile services. However, the distribution of smartphone ownership across study sites remained uneven, with ownership rates of 31% among women and 38% among men (Table 3). According to data from DataReportal, the number of active smartphone users in Indonesia has increased consistently every year. In 2015, there were around 54 million active users. This figure jumped dramatically to 209.3 million in 2023. Although there was a decline in 2022, the overall trend showed a significant increase. Currently, about three-quarters of Indonesia's population is an active smartphone user, and this is reflected most strongly in the mobile market, including Central Java, West Java, and outside the island of Java (Balinusra).

The prevalence of smartphone ownership as a predictor of mobile service usage may be due to the nature of how mobile services tend to be designed, technology developers generally design for smartphones rather than basic phones or feature phones. In addition, this rapid growth is also driven by several other factors, including increased internet accessibility, increasingly affordable smartphone prices, and the development of better digital infrastructure (Goodstats), this also represents that smartphone ownership will affirm the important role of these devices in the daily lives of the Indonesian people. The results of our research, show that the development of mobile services facilitated in smartphone applications, has successfully reached segments of the population that do not have a smartphone. However, given that the majority of respondents use basic phones or feature phones (as shown in Table 3), mobile services designed specifically for

smartphone-based applications may not be able to reach low-income customers and basic phone users.

Table 5. Predictor of the use of weather information, buying and selling information, and agricultural information through mobile messaging services

Predictor	Weather Information		Buying and Selling Information		Farm Information	
	Odds ratio	C.I.	Odds ratio	C.I.	Odds ratio	C.I.
Smartphone	2.19***	1.39-3.45	1.83*	1.14-2.91	2.72***	1.62-4.55
Participating farmers	2.06***	1.56-2.72	1.64***	1.24-2.17	1.83***	1.33-2.52
Non-participating farms	1.38	0.94-2.03	1.95	1.32-290	1.48	0.95-2.30
Livestock assets	0.80	0.64-1.01	0.65**	0.50-0.85	0.51***	0.37-0.70
Income quartile (Level 2)	1.10	0.58-2.08	1.65	0.86-3.16	1.75	0.84-3.63
Income quartile (Level 3)	1.03	0.56-1.92	1.63	0.87-3.16	1.02	0.48-2.17
Income quartile (Level 4)	1.48	0.79-2.74	1.70	0.89-3.25	2.30*	1.11-4.77
Age	0.99	0.97-1.01	1.00	0.98-1.02	0.99	0.97-1.01
Education (Level 2)	3.16**	1.44-6.92	1.56	0.82-2.95	4.55**	1.69-12.29
Education (Level 3)	3.46**	1.54-7.77	1.13	0.56-2.26	3.53*	1.27-9.80
Education (Level 4)	2.58*	1.02-6.51	0.67	0.28-1.60	1.52	0.46-5.04
Sex (Male)	1.11	0.98-1.27	1.20**	1.05-1.38	1.35***	1.15-1.58
(Intercept)	0.05***	0.01-0.20	0.08***	0.02-0.30	0.05***	0.01-0.26
Observations	7850		7850		7850	

Note: C.I., Confidence Interval, *$p<0.05$; **$p<0.01$; ***$p<0.001$

As suggested by several previous studies (Ayim et al., 2022); (Amarnath et al., 2018); (Anteneh & Melak, 2024), designing mobile services that take into account the needs of basic phone users is an effective approach to expand the accessibility of mobile services beyond smartphone users. In this context, developers not only need to adapt the design for the base phone, but also take into account the various obstacles that are common in developing countries. In addition, other considerations to consider are the focus on the use of the USSD protocol as well as voice calling services designed for basic phones that are simpler and more affordable, compared to the functions on smartphones that tend to consume more power and are less widely used (Retnaningsih et al., 2023). The intersection between these aspects needs to be a concern in the implementation of Information and Communication Technology (ICT) for development programs. For example, the tools developed by USAID for survey data collection demonstrate the importance of this approach in ensuring more effective dissemination of information.

Membership of Organizations and Non-Membership of Farmers' Organizations

Based on the results of the analysis conducted, we found the fact that the participation of farmers in farmer groups had a positive effect on the use of messaging services. As shown in table 6. When we sorted by membership participation, farmers who participated in farmer groups were 1.82 and 2.87 times more likely to use weather information services ($p<0.01$), trade information ($p<0.01$), and agricultural information services ($p<0.001$).

Participation in farmer groups increased the likelihood of utilizing mobile services for various purposes compared to those who did not participate. Participating farmers are more flexible and open to anyone who wants to learn to gain access to information services and dedicated networks in smartphone features. This means that farmers who are tied to farmer groups can more easily obtain exclusive agricultural information that can only be accessed by their members (Campenhout et al., 2020). On the other hand,

participating farmers tend to have easier access to agricultural information that is freely available to the public, which means that its use by one individual does not reduce access for other individuals (Campenhout et al., 2020). Most mobile service platforms do not charge a membership fee to access information, so farmers who participate in farmer groups have a greater incentive to utilize and search for agricultural information through mobile services. Farmers who did not participate had a lower tendency to seek information through freely available mobile services. Rather than taking advantage of the features of buying and selling, weather information, and agricultural information in mobile services, they are more likely to take advantage of watching and playing games while they are busy farming (Ma, 2023); (Mdoda et al., 2024).

In addition, based on the results of a survey conducted in East Java, farmers who participate in farmer groups interact more regularly through weekly or monthly meetings in the context of maintaining irrigation infrastructure and discussions about water resource management, this interaction provides opportunities for members to obtain agricultural information. The conclusion that can be drawn is that, participating in farmer groups is the main factor driving the use of mobile services, this is due to their greater need for freely available information, compared to non-participating farmers who choose the tendency to utilize smartphones as a service for communication, watching and play.

Table 6. Results of a model that separates participation and non-farmer groups

Predictor	Weather Information		Buying and Selling Information		Farm Information	
	Odds ratio	I.C.	Odds ratio	I.C.	Odds ratio	I.C.
Smartphone	2.25***	1.42-3.58	1.71*	1.06-2.75	2.69***	1.59-4.56
Participating farmers	1.98**	1.29-3.04	1.82**	1.18-2.83	2.87***	1.73-4.76
Non-participating farms	2.54	1.44-4.47	0.78	0.41-1.47	0.97	0.48-1.96
Livestock assets	0.78*	0.62-0.99	0.66**	0.51-0.86	0.50***	0.37-0.69
Income quartile (Level 2)	1.11	0.59-2.12	1.64	0.85-3.17	1.81	0.86-3.80
Income quartile (Level 3)	1.10	0.59-2.05	1.59	0.84-3.02	1.01	0.47-2.16
Income quartile (Level 4)	1.56	0.84-2.91	1.80	0.94-3.45	2.38*	1.13-2.16
Age	0.99	0.98-1.01	1.00	0.98-1.02	0.99	0.97-1.01
Education (Level 2)	3.04**	1.39-6.68	1.55	0.82-2.96	4.80**	1.77-13.03
Education (Level 3)	3.37**	1.50-7.57	1.11	0.55-2.22	3.59*	1.29-10.01
Education (Level 4)	2.54*	1.00-6.42	0.67	0.28-1.61	1.48	0.44-4.98
Sex (Male)	1.11	0.97-1.26	1.19*	1.04-1.37	1.35***	1.15-1.58
(Intercept)	0.06***	0.01-0.24	0.06***	0.01-0.24	0.04***	0.01-0.22
Observations	7850		7850		7850	

Note: C.I., Confidence Interval, *<0.05; **p<0.01; p<0.001.

Household level characteristics based on livestock assets (e.g. household assets and livestock assets), as well as Income quartile levels, age, Education Levels, sex (male) characteristics are also associated with the use of messaging services. We did not find that age had a significant relationship with messaging services using any model (p>0.1, tables 6 and 7). Income is significantly related to one use of messaging services in tables 6 and 7. Meanwhile, livestock assets owned by farmers are significantly related to the possibility of using messaging services, including in table 6 it shows that livestock assets are significantly related to buying and selling information services (p<0.01) and agricultural information (p<0.001), while in table 7, livestock assets are significantly related to three services at once which include weather information services (p<0.05). Buying and selling information (p<0.01), and agricultural information (p<0.001). Even if the coefficient on livestock assets is more than one, or the interaction term is greater than one, the results

of the analysis indicate that there is a complex relationship between various forms of wealth and the application of messaging services. As explained in tables 6 and 7, the researcher did not find any income cluster to have a significant effect on access to buying and selling information and access to weather information, but in access to agricultural information we found that Income quartile Level 4 had a significant effect on access to agricultural information.

Furthermore, in the analysis, we found the fact that several Education Levels correlated significantly with the use of messaging services (table 6). Respondents at Education Level 2 who completed junior high school were 3.16 and 4.55 times more likely to use access to weather information ($p<0.01$) and agricultural information ($p<0.01$). Similarly, respondents who completed high school (Education (Level 3) were 3.46 and 3.53 times more likely to use weather information services ($p<0.01$) and agricultural information ($p<0.05$). Respondents who completed high school or vocational high school were 2.58 times more likely to use weather information messaging services than the reference group ($p<0.05$). Furthermore, the results of the analysis that we have described in table 7 also explain the same thing regarding the Education Levels.

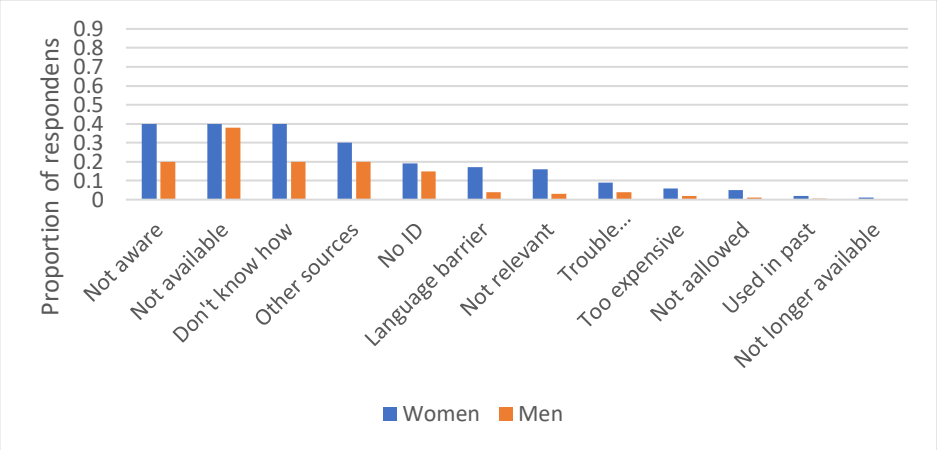

Figure 2. Reasons why respondents do not use messaging services to access weather information, buying and selling information and agricultural information

The coefficient of male respondents was positive in all iterations of the model (tables 6 and 7). In table 6, the relationship between gender and messaging service use is significant for trading information messaging services ($p<0.01$) and agricultural information ($p<0.001$). This means that the iteration of the gender model in table 6 is 1.20 and 1.35 times more likely to use messaging services in the iterations of buying and selling information and agricultural information. Next, we asked respondents who did not choose to use messaging services to access weather information to respond to a list describing the barriers that factors them to not using messaging services (figure 2). When compared to men, more women feel obstacles in the use of weather information services. But regardless of gender, the main barriers that limit farmers to accessing the use of messaging services are a lack of awareness, a lack of availability, and a lack of understanding of how messaging services work. Through these three categories, women are less aware and knowledgeable about how to use messaging services compared to men.

As presented in figure 2 about the trunk plot which explains the barriers to using message services based on gender. We found specific reasons why farmers don't use mobile services in answer to questions, for example; what are the reasons you don't

access the weather information; I am not aware of this service; This type of service is not available in my region/network; I don't know how to use this type of service; I get information from other sources (e.g. organizational groups); my phone doesn't have internet access; I don't have the required IDs or documents; the content is not in a language I understand; the content is irrelevant to me; I had trouble reading the contents; I had trouble understanding the content; it was too expensive if I wanted to use a mobile phone that provided messaging services; I have used it but have not felt the benefit and/or do not like using it; I have used it in the past but it is no longer available.

Conclusion

This study aimed to identify the factors influencing mobile phone adoption among smallholders in East Java, evaluate its impact on agricultural productivity, and examine its role in shaping farmers' adaptation decisions to climate change. Our findings show that participation in farmer organizations, higher levels of education, and smartphone ownership significantly increase the likelihood of mobile phone adoption, while age and income are not significant predictors. These factors interact with gender, revealing persistent inequalities in access particularly for women which adds nuance to the digital gender gap discourse. Furthermore, mobile phone use is positively associated with access to agricultural information, market data, and climate change knowledge, suggesting its potential to enhance productivity and support climate adaptation strategies. However, the continued reliance on basic and feature phones among rural farmers underscores the importance of designing mobile services that are compatible with less advanced devices. Although smartphone ownership serves as a proxy for wealth, its limited distribution may reinforce existing disparities in digital access and information use. These findings imply that equitable and inclusive mobile service development is essential to harness the full potential of digital tools for rural agricultural development and climate resilience.

Smartphones offer broader access to services related to climate information, market transactions, and agricultural knowledge. As climate change continues to pose serious risks, the role of mobile technology in supporting farmers' resilience will become increasingly critical. Therefore, future climate adaptation policies should prioritize the affordability and accessibility of both mobile devices and digital services. Special attention is needed for underserved groups particularly women and farmers not affiliated with agricultural organizations so that the dissemination of agrometeorological information becomes more inclusive, targeted, and effective in reaching those most vulnerable.

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