

Unlocking the Potential of Women Farmers in Indonesia Through Digital Technology

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ABSTRACT

Women play a strategic role in Indonesia's agricultural sector; however, their contribution to productivity and economic development remains constrained by limited access to land, capital, information, and technology. Advances in digital technology offer significant opportunities to improve production efficiency, expand market access, and strengthen the economic empowerment of women farmers. Nevertheless, empirical and conceptual studies that specifically examine the adoption of digital technology by women farmers in Indonesia are still limited and fragmented. This study aims to comprehensively review the types of digital technologies adopted by women farmers in Indonesia, the factors influencing such adoption, and its impacts on productivity, income, and welfare. The study employs a qualitative approach through a systematic literature review of 70 reputable scientific articles published between 2011 and 2023, analyzed using content analysis techniques. The findings indicate that the use of mobile phones, digital extension services, e-commerce platforms, and smart agricultural technologies contributes positively to reducing information asymmetry, improving production efficiency, expanding market access, and strengthening the role of women farmers in decision-making. However, the adoption of digital technology remains constrained by low digital literacy, limited infrastructure, restricted access to capital, and gender-based social norms. The implications of this review underscore the importance of gender-responsive digital inclusion policies to promote rural economic growth, food security, and sustainable agricultural development.

INTRODUCTION

The agricultural sector is one of the main pillars of Indonesia's economy and plays a strategic role in national economic development. Data from Statistics Indonesia (Badan Pusat Statistik) show that this sector contributes approximately 12.4 percent to the Gross Domestic Product and absorbs more than 30 percent of the national workforce (BPS, 2022). Within this employment structure, women play a significant role, not only as agricultural laborers and farm entrepreneurs, but also as actors involved in decision-making related to the management of agricultural resources (FAO, 2019). Women's contributions are reflected not only in production activities, but also in post-harvest processing and the distribution of agricultural products to markets.

Despite their substantial contribution to the agricultural sector, women's participation continues to face structural inequalities. Numerous studies indicate that female farmers have more limited access to land, capital, technology, and markets compared to male farmers (World Bank, 2014; Sujarto et al., 2022). This inequality directly affects productivity levels, which tend to be lower among female farmers, even though their workload and responsibilities are no lighter. Such conditions are closely linked to social and economic factors, including cultural norms, limited access to information, and fewer opportunities for women to obtain modern agricultural technologies (Agung, 2020).

The rapid development of digital technology over the past decades has brought significant changes across various economic sectors, including agriculture. The use of digital-based technologies—such as agricultural applications, e-commerce platforms, digital payment systems, and artificial intelligence-based data analytics—has been proven to improve production efficiency, reduce transaction costs, and expand market access for farmers (Anadozie et al., 2021; Krell et al., 2021; Abdulai et al., 2023). For female farmers, digital technology plays a strategic role in reducing gender gaps by enhancing access to information, strengthening bargaining power in markets, and expanding financial inclusion (Rahmat et al., 2023).

However, the adoption of digital technology among female farmers still faces numerous challenges, particularly in developing countries. Previous studies show that women farmers often experience limited access to digital devices, internet infrastructure, and adequate technology training (Neway & Zegeye, 2022; Akudugu et al., 2023). In addition, low levels of digital literacy and limited economic resources are major factors hindering women's use of digital technology (Javaid et al., 2023). These barriers become even more complex when combined with social and cultural factors that restrict women's participation in the ownership and use of technology (Chen et al., 2021; Liu & Zhou, 2023).

Several case-study-based studies in developing countries demonstrate that female

farmers who gain access to digital technology accompanied by adequate training are able to significantly increase agricultural productivity (Zapata et al., 2016; Ma et al., 2020; Li et al., 2021). For example, digital technology training programs for female farmers in Africa have reportedly increased agricultural efficiency by up to 40 percent over a five-year period (Neway & Zegeye, 2022). These findings indicate that digital technology has strong potential as an instrument for women's economic empowerment in the agricultural sector, provided it is supported by inclusive policies and ecosystems.

In Indonesia, studies on digital technology adoption in agriculture are still largely dominated by general approaches that do not specifically address the experiences and challenges of female farmers (Sujarto et al., 2022). In fact, women farmers face distinctive barriers related to access to resources, levels of digital literacy, and social norms that influence decision-making in technology utilization. The limited number of studies that position female farmers as the main subjects highlights a research gap in the literature on agriculture and digital transformation in Indonesia.

Based on these conditions, the novelty of this study lies in its analytical focus that explicitly positions female farmers as the main actors in the adoption of digital technology in Indonesia's agricultural sector. This study identifies the types of digital technologies most widely adopted by female farmers, analyzes the factors influencing adoption levels, and assesses their impact on productivity and welfare. In addition, it examines the structural and social barriers faced by female farmers in utilizing digital technology. This approach enriches the literature by integrating a gender perspective into the study of digital transformation in the agricultural sector in developing countries.

In line with this focus, the objectives of this study are to: (1) identify the digital technologies most widely adopted by female farmers in Indonesia; (2) analyze the factors influencing digital technology adoption among female farmers; (3) evaluate the impact of digital technology adoption on the productivity and welfare of female farmers; and (4) examine the main barriers to the use of digital technology among female farmers. The findings of this study are expected to serve as a basis for formulating evidence-based policy recommendations to promote digital inclusion and women's economic empowerment in Indonesia's agricultural sector.

This study integrates several theoretical frameworks to analyze the role of digital technology in strengthening the capabilities of women farmers in Indonesia, as well as the barriers that influence its level of adoption. First, the capability approach proposed by Sen (1993) is employed to explain how digital technology can expand choices, freedoms, and economic opportunities for women farmers. This approach emphasizes that improvements in capabilities are determined not only by the availability of technology, but also by the removal of structural barriers that limit women's roles in the agricultural sector, including discriminatory social norms, limited access to productive resources, and

low levels of digital literacy. Inclusive access to digital technology has the potential to strengthen the position of women farmers by enhancing productivity and competitiveness in the agricultural sector.

Second, studies on gender and technology (Koinig et al., 2020; Qazi et al., 2022) provide an analytical foundation for understanding the relationship between digital innovation and gender inequality in the agricultural sector. This body of literature indicates that digital technology can support women's empowerment by improving access to agricultural information, markets, and financial services. However, the utilization of such technology remains constrained by various factors, including unequal ownership of digital devices, limited technological skills, and social norms that restrict women's mobility and decision-making power. These conditions contribute to unequal levels of digital technology adoption between male and female farmers.

Third, the concept of the digital divide proposed by Norris (2001) is used to understand the impact of unequal distribution of digital technology on women farmers. The digital divide encompasses not only disparities in access to digital devices and internet infrastructure, but also differences in digital skills, readiness to adopt innovation, and social exclusion experienced by vulnerable groups, including women in the agricultural sector. This framework provides an analytical basis for identifying factors that hinder digital inclusion and women's participation in the use of technology.

Fourth, the institutional economics perspective (Nelson, 1985) is applied to explain the role of formal and informal institutions in influencing the adoption of digital technology by women farmers. Government policies, regulatory frameworks, institutional support, as well as social and cultural norms have a significant influence on access to and utilization of digital technology in agricultural activities. This perspective underscores the importance of public policies oriented toward women's empowerment, including capacity building through digital training, the provision of economic incentives, and the development of inclusive digital infrastructure.

Women farmers in rural areas of Indonesia face a range of structural and interrelated challenges. The main problems are reflected in limited access to productive resources, such as land, capital, and agricultural technology (Akter et al., 2017; Chrisendo et al., 2020; FAO, 2019). These conditions are further exacerbated by limited access to agricultural education and training, which play a crucial role in improving the knowledge and skills of women farmers (FAO, 2019; Agung, 2020; Chrisendo et al., 2020). Additional barriers arise in the marketing aspect, as narrow market access makes it difficult for women farmers to sell their harvests at fair prices (Lee et al., 2022). Limited social networks also restrict women's access to relevant and up-to-date agricultural information (Alvi et al., 2021).

Strong patriarchal norms in rural areas further shape gender-based power

inequalities in the agricultural sector. These inequalities are evident in limited land rights, restricted ownership of productive resources, the dominance of unpaid labor, low levels of job security, and minimal involvement of women in decision-making processes at both household and community levels (Botreau & Cohen, 2020; Qanti et al., 2022).

A number of studies propose policy recommendations and interventions to address these challenges. Alvi et al. (2022) emphasize the importance of training and empowering women farmers who play active roles in their communities, as this group has the potential to become sources of knowledge and mentoring for other farmers. Efforts to strengthen market access through community-based marketing schemes are also considered effective in helping small-scale women farmers overcome barriers in the distribution of agricultural products (Lee et al., 2021). Meanwhile, changing social norms that limit women's roles in the agricultural sector requires the involvement of the government and relevant stakeholders through policies that support gender equality (Qanti et al., 2022). The role of the government is also reflected in the provision of training programs focused on climate resilience and the adoption of agricultural technologies for women farmers (Utami, 2022).

Various empowerment programs have demonstrated tangible contributions to improving the capacity of women farmers in Indonesia. The Women-Headed Household Empowerment Program (PEKKA) is designed to strengthen women's economic capacity through a community-based approach (World Bank, 2012). The Better Life Farming program provides integrated support through training in health, self-care, and family well-being for women farmers (BLF, 2023). The government's commitment to women's empowerment is also reflected in the 2030 Sustainable Development Goals (SDGs) agenda. From a regulatory perspective, Village Law No. 6 of 2014 explicitly places women's empowerment and gender equality as important components of village development (FAO, 2019). Other programs contributing to the strengthening of women farmers' roles include the Empowerment Program for Women Farmer Groups through the Optimization of Home Garden Land with the SFHA System (Prayudi et al., 2020), as well as the HARA program, which supports the strengthening of women farmers' positions through data-driven approaches and digital inclusion (Hara, 2021).

Factors Influencing the Adoption of Digital Technology among Women Farmers in Indonesia; The adoption of digital technology among women farmers in Indonesia is influenced by a variety of factors that differ across regions and are shaped by demographic characteristics. Key determinants of digital technology adoption behavior include age, gender, level of education, degree of economic dependency, access to capital, availability of infrastructure, technological accessibility, and the characteristics of the agricultural enterprises being managed (Ahmad Rizal & Md Nordin, 2022; Akundu et al., 2023). Smallholder farmers generally manage limited land areas, have low access to

capital and agricultural inputs, and operate seasonal farming systems with diverse commodities (Agussabti et al., 2022).

The main barriers to the utilization of smart agricultural technologies in food commodities, particularly among smallholder farmers, include the impacts of global climate change, relatively low human resource quality, and constraints related to land and capital availability (Agussabti et al., 2022). Therefore, increasing the adoption of digital technology among women farmers is regarded as an important strategy to reduce gender-based productivity gaps in the agricultural sector (Theis et al., 2018).

The digital transformation of the agricultural sector in developing countries, including Indonesia, is driven by the growth of AgriTech, which leverages digital technologies to enhance productivity and profitability for smallholder farmers (Goh, 2022). This situation has important implications for policy formulation and field-level practices. Policymakers need to consider the factors influencing digital technology adoption across different regions and demographic groups, and to design policies capable of addressing the key constraints faced by smallholder farmers, such as limited access to capital, agricultural inputs, and the pressures of global climate change on the sustainability of the agricultural sector.

On the other hand, practitioners are expected to focus on providing education and training programs for farmers—especially women farmers—to improve their readiness to adopt digital technologies and to reduce the complexity associated with implementing agricultural innovations. In addition, it is necessary to identify types of digital technologies that are appropriate to local conditions and to strengthen supporting infrastructure so that technology adoption can deliver optimal benefits to farmers (Agussabti et al., 2022).

Barriers to Digital Inclusion among Women Farmers in Indonesia; Women farmers in Indonesia face various barriers in accessing and utilizing digital technology. These barriers include limited ownership of devices and access to internet connectivity, low levels of digital literacy, deeply rooted cultural norms, and language constraints (OECD, 2018; Coggins et al., 2022). These conditions are further exacerbated by limited digital infrastructure, particularly in rural areas, as well as concerns over data privacy and security, which also restrict the use of digital technology among women farmers (Chen et al., 2021; Zhao et al., 2022; Liu & Zhou, 2023).

A number of studies indicate that cultural and social norms, such as gender expectations and the division of roles within households, contribute to the low rate of digital technology adoption among women farmers. Such norms often create psychosocial barriers that negatively affect women's confidence in using new technologies (Ankrah et al., 2020; Lopez et al., 2022; Qanti et al., 2022).

Efforts to address these barriers require comprehensive and integrated strategies. Possible approaches include the provision of structured digital skills training, the implementation of awareness-raising campaigns, and the development of user-friendly applications available in local languages. In addition, the establishment of digital community centers and the strengthening of collaboration with local organizations are considered important in promoting changes to cultural norms that have traditionally limited women farmers' access to digital technologies (FAO, 2018).

METHOD

This study employs a qualitative approach through a literature review method to systematically examine various scholarly works discussing women farmers, digital technology, and gender. The data used are secondary data derived from books, scientific journal articles, and relevant websites (Snyder, 2019). The data collection process was conducted through a structured search of academic databases using the keywords “women farmers,” “gender and technology,” and other related terms within the time span from 2011 to 2023.

The initial search stage yielded 158 articles, which were subsequently screened based on topic relevance and academic quality. The screening results indicated that 133 articles met the criteria as scientific publications, and from this number, 70 articles were selected because they specifically addressed issues related to women farmers in connection with digital technology and gender. To ensure data credibility, this study applied source triangulation by comparing information obtained from various references to maintain data consistency (Patton, 2014).

Reference management was carried out using the Mendeley citation management application to organize selected articles, manage citations, and systematically compile the bibliography (Gusenbauer & Haddaway, 2020). Data analysis was conducted using content analysis techniques, which encompassed four main stages: first, data collection through the identification and extraction of information from relevant sources; second, data reduction by selecting and organizing information to sharpen the focus of the study; third, data presentation by grouping analysis results based on the main themes emerging in the literature; and fourth, drawing conclusions through the process of interpretation and synthesis of the analytical findings (Krippendorff, 2018).

Through this approach, the study is able to provide a comprehensive overview of the dynamics, challenges, and opportunities faced by women farmers in utilizing digital technology to support productivity and welfare in Indonesia.

RESULTS AND DISCUSSION

Digital Technologies Most Widely Adopted by Women Farmers in Indonesia

Mobile Phones

Mobile phones have evolved into a primary device for farmers in Indonesia and many other countries, particularly as a means of communication, access to information, and economic transactions (Goh, 2022). Numerous studies indicate a strong relationship between mobile phone use and increased agricultural productivity (Quandt et al., 2020; Anadozie et al., 2021; Agussabti et al., 2022). Through mobile phones, farmers obtain information on cultivation practices, weather conditions, market prices, and pest control, which supports better decision-making and leads to improved crop yields.

Mobile phone use is also associated with increased farmer income. Access to market information enables farmers to sell their produce at more competitive prices and reduces dependence on intermediaries. Information on agricultural input prices, such as seeds, fertilizers, and pesticides, also helps farmers control production costs. In addition, digital banking services facilitate direct financial transactions and reduce reliance on cash-based transactions (Anadozie et al., 2021).

Krell et al. (2022) report that mobile phone ownership among smallholder farmers is widespread and is utilized to obtain agricultural information and purchase production inputs. This condition underscores the strategic role of mobile phones in encouraging more adaptive farming practices in line with technological developments.

Kumar (2023) notes that farmers use mobile phones not only for personal communication but also to support agricultural activities. Platforms such as WhatsApp and YouTube are utilized as sources of agricultural information. The majority of farmers perceive mobile phones as an important tool for expanding knowledge and learning about new agricultural technologies. However, language barriers and limited network connectivity remain obstacles to the optimal use of mobile phones.

The use of mobile phones has been shown to save farmers time and labor, contributing to increased income (Razaque & Sallah, 2013). Mobile applications, short message services (SMS), and social media are also used to reach women farmers in rural and remote areas (Mishra et al., 2023). These technologies support production management, crop data archiving, and monitoring of crop conditions and quality (Contreras-Medina et al., 2021).

Digital Extension Tools

Digital Extension Tools (DET) are digital-based instruments used for the exchange and dissemination of agricultural information between farmers and extension agents. Smallholder farmers utilize various forms of DET, including phone calls, WhatsApp groups, and smartphone applications designed as media for delivering agricultural knowledge (Coggins et al., 2022; Mishra et al., 2023). The presence of DET expands the reach of extension services and accelerates the distribution of technical information to

women farmers.

E-commerce and Marketplace Platforms

Ma et al. (2020) demonstrate that internet use has a significant effect on farmers' adoption of e-commerce. Farmers with higher intensity of internet use tend to have higher levels of e-commerce adoption. Consistent with this, Li et al. (2021) and Su et al. (2021) report that farmers who use e-commerce earn higher incomes than non-users, primarily through increased sales volume and higher prices for agricultural products.

Jin et al. (2020) argue that the presence of Rural E-commerce Service Centers (RESC) contributes to improving farmer welfare by providing access to information, reducing transaction costs, and increasing income.

In addition to e-commerce, various other digital technologies—such as drones, sensors, robots, and online applications—are increasingly being applied in agricultural activities in Indonesia (Agussabti et al., 2022). Digital business models such as MarketMaker help farmers reach new customers and suppliers and increase sales volume and value (Zapata et al., 2016). The digitalization of marketing expands market access and strengthens farmers' bargaining positions.

One marketplace that supports farmers is Halmahera, which functions as a platform for selling agricultural products and facilitates consumer access (Gustati, 2023). Omulo and Kumeh (2020) highlight the role of the Wefarm platform in supporting farmers' livelihoods by providing mobile-based agricultural information tailored to users' needs, enabling farmers to receive relevant and timely information to improve farming practices and productivity.

Agricultural Technology

Khatri-Chhetri et al. (2020) show that the adoption of Climate-Smart Agriculture (CSA) technologies and practices—such as direct-seeded rice, no-till machinery, laser land leveling, and green manure application—contributes to reducing women's workload in the agricultural sector. Other CSA technologies, including harvesting machines, weeding tools, solar-powered irrigation, and post-harvest innovations, also enhance the work efficiency of women farmers.

The benefits of CSA technologies are not limited to labor aspects but also include improved women's access to agricultural resources, strengthened roles in decision-making, and expanded market connectivity.

In addition to CSA, Smart Farming Technology (SFT) is increasingly being adopted by farmers. Studies indicate that SFT helps control input costs, provides more accurate information for decision-making, reduces agricultural pollution, increases productivity, and enhances farm income (Kerneck et al., 2020; Agussabti et al., 2022).

The Contribution of Technology to Enhancing Productivity, Income, and Decision-Making among Women Farmers

Digital technology plays a crucial role in reducing information asymmetry throughout the agricultural cycle, particularly in developing countries (Cheng et al., 2021). The adoption of data-driven agriculture has the potential to improve various aspects of food systems, including crop yields, profitability, environmental sustainability, and food security (Mehrabi et al., 2021). Nevertheless, the implementation of such technologies continues to face gaps caused by limited access to digital devices, low levels of digital literacy, and inadequate supporting infrastructure (Mehrabi et al., 2021).

Women's access to digital technology contributes to the expansion of development opportunities across regions (Kwakwa, 2023). The utilization of smart agriculture technologies based on the Internet of Things (IoT) offers benefits such as real-time monitoring of agricultural conditions, optimization of irrigation systems, and control of pests and plant diseases (Dhanaraju et al., 2022). In line with this, recent studies indicate that artificial intelligence (AI) contributes to improvements in agricultural management by accelerating plant disease identification and enabling more efficient management of chemical inputs (Javaid et al., 2023).

Research by Sidibé et al. (2021) demonstrates that the use of digital technology in the agricultural sector has the potential to enhance food security and support sustainable agricultural development, although it still faces various structural barriers. Information and Communication Technology (ICT) has been proven to increase the productivity of women farmers by facilitating access to agricultural information, markets, and technological innovations (Subramanian, 2021). The productivity of women farmers is influenced by several factors, including land availability, fertilizer use, seed quantity, and the level of mechanization in agricultural production processes (Utami, 2022; Saleh & Riyadi, 2023).

Beyond productivity and efficiency, the use of digital technology also affects farmers' welfare. Rahman et al. (2023) show that internet access significantly contributes to increased happiness and life satisfaction among farmers. On the other hand, the adoption of digital technology in agriculture also faces various challenges, such as unequal access to technology, risks to data privacy, and the potential for environmental degradation resulting from unsustainable technology use (Bahn et al., 2021).

Main Challenges Faced by Women Farmers in Accessing and Using Digital Technology in Indonesia

Limited Access to Land, Infrastructure, Capital, and Connectivity

Indonesia is widely recognized as an agrarian country; however, the agricultural sector continues to face various structural challenges, such as land conversion, limited

quality of human resources, and inadequate access to agricultural inputs (Chrisendo et al., 2021; Rozaki, 2021; Miranti et al., 2022; Pilgeram et al., 2022). The reduction in agricultural land area has a direct impact on the decline in farmers' household welfare (Moeis et al., 2020).

Women farmers in Indonesia experience more complex constraints, including limited access to land, capital, marketing opportunities, and decision-making rights (FAO, 2019). Restricted access to productive resources—such as land, credit, and extension services—negatively affects productivity and income levels among women farmers (Dev, 2012; Ankrah et al., 2020; Alvi et al., 2021). At the same time, the availability of communication infrastructure and access to information and communication technology (ICT) remain uneven, hindering the utilization of technology in agricultural activities (Seminar & Sarwoprasodjo, 2019). Major barriers to the adoption of digital technology include limited ownership of smartphones and inadequate internet connectivity quality (Theis et al., 2018; Coggins et al., 2022). In addition, landholding size and capital constraints are key determinants influencing the use of digital technology in the agricultural sector (Kerneckner et al., 2020; Nyang'au et al., 2021; Agussabti et al., 2022).

Digital Literacy

Digital literacy plays a crucial role in expanding women farmers' access to financing sources and financial services (Wulandari et al., 2017). Adequate literacy levels also help farmers better understand the proper use of agricultural production inputs, including pesticides (Dewi et al., 2022). Research by Suu et al. (2021) indicates that digital financial literacy mediates the relationship between online transaction activities and farmers' participation in digital financial markets. This effect is stronger among individuals with higher education levels, involvement in skills training, and membership in professional cooperatives or family farming enterprises.

Other studies show that financial information literacy contributes to agribusiness actors' ability to make strategic decisions that have implications for business sustainability and growth (Obi-Anike et al., 2023). Young farmers with higher levels of education, access to irrigation, packaging equipment, and storage facilities tend to participate more actively in modern supply chains, which is associated with increased income (Slamet et al., 2017; Toumbourou et al., 2023).

Liu and Zhou (2023) find that digital literacy plays an important role in household-level decision-making, influencing income and farmers' engagement in various economic activities. Improved digital literacy also enables women farmers to optimize the use of agricultural technologies, enhance household productivity, and access information at lower costs, including information related to selecting more sustainable energy sources for household needs (Contreras-Medina et al., 2021; Zhao et al., 2022).

Food Security

Household food security faces multiple challenges, including climate change, land degradation, and limited access to credit and markets (Inbouf, 2011). Climate change places significant pressure on agricultural production and increases the vulnerability of the sector (Lybbert & Sumner, 2012). Farmers' vulnerability to disruptions in agricultural systems is influenced by high dependence on agriculture as a livelihood, chronic food insecurity conditions, geographic isolation, and limited access to social safety nets (Harvey et al., 2014). Under such circumstances, women farmers face greater risks due to gender inequalities that restrict their access to productive resources and their roles in agricultural decision-making.

Conversely, Schmidt et al. (2021) show that women are more likely to serve as primary managers of farming enterprises that apply direct-to-consumer sales systems and organic farming practices compared to conventional farming models. These findings indicate that women-inclusive agricultural approaches contribute to strengthening food security and improving the welfare of women farmers.

Gender and Social Norms

Social norms and societal perceptions influence the level of women's participation in decision-making within the agricultural sector. In many cases, women are not actively involved in these processes due to cultural and social norms that limit their roles (Gebre et al., 2019; Badstue et al., 2020; Huijsmans et al., 2021; Lopez et al., 2022; Qanti et al., 2022).

Research by Neway and Zegeye (2022) indicates that male-headed households tend to adopt agricultural technologies more rapidly than female-headed households. This disparity reflects the existence of a gender gap in agricultural technology adoption. Therefore, gender-sensitive approaches to knowledge transfer and ICT-based agricultural technology development are necessary to ensure that women gain equitable access to the utilization of agricultural technologies (Abidin & Prasetyani, 2021; Das et al., 2021).

Policies and Programs to Enhance Digital Inclusion among Women Farmers in Indonesia and Their Impact on Gender Inequality in the Agricultural Sector

Improving farmers' welfare requires policies that expand access to credit, markets, technology, as well as infrastructure support and productivity enhancement (Dev, 2012). Capacity-building programs and training are also necessary to improve the skills and digital literacy of women farmers (Lybbert & Sumner, 2012; Das et al., 2021). Women's empowerment through digital literacy and access to learning resources is a key factor in reducing gender inequality in the agricultural sector (Sujarwo et al., 2022). Education and health services play an important role in enhancing human capital, which affects labor quality and accelerates economic growth (Anas, 2019). Women with higher levels of

education have greater opportunities for labor force participation (Setyowati, 2009).

International efforts in agricultural research for development need to be strengthened, with a renewed emphasis on data sharing rather than the distribution of improved seeds. Closing the global data-driven agricultural gap is a prerequisite for creating sustainable and equitable food systems (Mehrabi et al., 2021). Women's access to agricultural resources and services also contributes to strengthening household food security (Ibnouf, 2011).

Technical, financial, and institutional support is required to enhance agricultural productivity and food security, particularly in the face of climate change (Harvey et al., 2014). Kwakwa (2023) emphasizes that reducing gender-based gaps in access to technology requires strategic measures, including the provision of affordable and inclusive internet access, the implementation of innovative pricing schemes, device subsidies for women, expansion of internet networks in remote areas, and the establishment of safe and women-friendly public access centers. Integrating a gender perspective into information and communication technology policies is also essential, whether through the formulation of gender-based objectives, the involvement of gender advocates, or the creation of opportunities for women's participation in the technology sector.

Strengthening access to information and communication technology infrastructure and encouraging its adoption among smallholder farmers aligns with OECD recommendations that emphasize women's participation in the digital economy. These efforts are aimed at reducing gender gaps in access to and use of technology, as well as strengthening global financial inclusion (OECD, 2018). Changes in social norms and societal perceptions are also needed to promote gender equality and increase women's involvement in decision-making processes within the agricultural sector (Qanti et al., 2022).

Governments and relevant institutions need to design appropriate strategies to reach farmers and provide accurate and timely information on seeds, weather conditions, and market prices, accompanied by guaranteed fair prices for agricultural outputs (Razaque & Sallah, 2013). Training and capacity building in the use of digital tools contribute to strengthening women's position in the agricultural sector through improved access to information, financial services, market connections, skills development, networking, and the design of technologies that are responsive to gender needs (Mishra et al., 2023). One initiative that has been implemented is the Women-Headed Household Empowerment Program (PEKKA) (World Bank, 2012).

CONCLUSION, LIMITATIONS, AND RECOMMENDATIONS

This study examines the issue of the low level of digital inclusion among women farmers in Indonesia, which has implications for their limited productivity, income, and contribution to rural economic development. Although digital technology has significant potential to support efficiency in agricultural activities and strengthen women's economic roles, its utilization has not yet been optimal due to various structural and social barriers.

The findings indicate that the use of digital technologies—such as mobile phones, digital-based extension services, online trading platforms, and smart agriculture technologies—plays an important role in expanding access to information, improving production efficiency, broadening market reach, and strengthening the decision-making capacity of women farmers. However, these achievements remain constrained by low levels of digital literacy, limited infrastructure and access to capital, as well as gender-based social norms that restrict women's involvement in agricultural innovation.

The implications of this study highlight the urgency of formulating agricultural development policies oriented toward digital inclusion with a gender-sensitive perspective. Strengthening digital literacy among women farmers, ensuring equitable development of technological infrastructure in rural areas, and mainstreaming gender perspectives in agricultural and technology policies are essential prerequisites for promoting inclusive and sustainable rural economic development.

This study has limitations as it relies on a literature review approach and therefore has not been able to fully represent empirical dynamics at the household or regional levels. Accordingly, future research is recommended to adopt quantitative empirical approaches or mixed methods to examine the impact of digital technology on the welfare of women farmers across various regions in Indonesia.

Overall, strengthening digital inclusion for women farmers is a crucial strategy to accelerate agricultural sector development, reduce gender inequality, and reinforce food security as well as national economic development in the long term.

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