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Digital Readiness Map of Mango Farmers in Indonesia

Diana Andriani[1], Ai Musrifah[2], Windi Novianti[3], Dinar[4], Dony Susandi[5*], Hafidz Sanjaya[6], M. Yani Syafei[7]

[1] Department of Industrial Engineering, Universitas Komputer Indonesia, Bandung 40132, Indonesia
[2] Department of Informatics, Universitas Surya Kencana, Cianjur 43216, Indonesia
[3] Department of Management Science, Universitas Komputer Indonesia, Bandung 40132, Indonesia
[4] Department of Agribusiness, Universitas Majalengka, Majalengka 45418, Indonesia
[5] Doctoral Management Science, Universitas Komputer Indonesia, Bandung 40132, Indonesia
[6] Commanditaire Vennootschap J-Ensitec, Universitas Majalengka, Majalengka 45418, Indonesia
[7] Postgraduate Department of Management, Universitas Ekuitas Indonesia, Bandung 40124, Indonesia

Corresponding Author Email: dony.75422004@mahasiswa.unikom.ac.id

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ABSTRACT

Digitalization has become an essential means to drive productivity improvements and competitive advantage across agriculture. However, empirical evidence of farmers digital readiness in Indonesia is scarce. This research seeks to determine the extent of digital readiness among mango farmers and serves as a significant first step toward an inclusive Agriculture 4.0 transformation. The study adopted a mixed-methods research design, comprising surveys of 403 farmers and qualitative interviews, to examine three fundamental aspects: access to technology, data availability, and digital literacy. The findings suggest that despite fairly strong access to technology (mean = 3.7) and data availability (mean = 3.6), digital literacy is low (2.9). A regression analysis indicates that access to technology ($\beta = 0.501$, $p < 0.001$), data availability ($\beta = 0.343$, $p < 0.001$), and literacy ($\beta = 0.291$, $p < 0.01$) are significant predictors of readiness, with an R^2 value of 0.624. The Digital Readiness Map shows that farmers are highly ready (14%), moderately ready (32%), low (41%), and critically low (13%). This also reflects issues like the generational gap; qualitative evidence also suggests that young farmers serve as digital intermediaries, brokering access for older generations. The results indicate that readiness is multidimensional, encompassing not only technological but also socio-cultural and organizational factors. Policy recommendations include improving rural connectivity, promoting data literacy, and supporting youth-led projects. Strengthening digital skills, improving access to relevant data, and supporting locally grounded initiatives are therefore essential for fostering more inclusive and effective sustainable agriculture digitalization.

1. INTRODUCTION

Indonesia's agricultural sector faces increasing pressure to maintain productivity, competitiveness, and rural livelihoods in the digital era. Agriculture remains a fundamental pillar of national food security and economic stability; however, productivity disparities and unequal adoption of technological innovations continue to constrain its performance. In recent years, digitalization has been increasingly viewed as an important pathway for improving agricultural efficiency and strengthening farmers' participation in modern value chains. The use of digital technologies allows producers to manage resources more efficiently, improve product quality, and respond more effectively to market demands [1]. For farmers, digital technologies create value-added products [2-4], reduce their operating costs [5-7], and meet the safety and quality standards needed for export [8-10]. As a result, digital transformation technologies have become essential rather than optional, enabling data-driven decision making, efficient use of resources, and the optimization of complex agricultural systems even better [11-14]. Consequently, digitalization is no longer an optional innovation but a strategic benchmark for farmers operating within an increasingly competitive global environment.

In practice, Indonesia at this time is starting to move toward Agriculture 4.0 with pilot projects that use smart sensors, Internet of Things (IoT) apps, data analytics, and blockchain-based supply chains [15-21]. These kinds of tools can help make decisions, predict how much food will be produced, and improve how well different people in agricultural systems work together. Even if technology is available, this doesn't mean that farmers are ready to use digital tools efficiently. Many farmers still have structural problems, such as not being very good with computers, having uneven rural infrastructure, having different generations, and having different levels of Internet connection [6, 22-27]. These factors indicate that

evaluating farmers' readiness is as crucial as the implementation of new technologies.

The Central Bureau of Statistics [28] states that Indonesia's mango production reached around 2.7 million tons, with West Java contributing as much as 31.8%. Within this province, the CIAYUMAJAKUNING region (Cirebon, Indramayu, Majalengka, Kuningan and Sumedang) plays a significant role and contributes more than 20% of Indonesian mango cultivars. However, digitalization in rural settings is only beginning to take hold: urban West Java households outnumbered rural ones by more than 50% in terms of reliable Internet access [29]. Initial findings from this study indicate that mango farmers have reasonably good access to technology and data, but their digital literacy is still low. This could make it harder for them to use technology effectively.

Since developing countries have less research on digital agriculture preparation, several global researchers have concentrated on it. Digital service deployment improves knowledge flow as part of preparation. Increased information improves farmers' decision-making in a changing agricultural environment [30]. Ideally, when well-designed agricultural extension services utilize information and communication technologies to bridge knowledge gaps, this ultimately translates into higher agricultural productivity and food security [7]. IoT applications can improve communication between farmers and other actors in the agricultural sector, leading to access to resources and information [5]. This suggests that mapping of digital agriculture and economics mapping approaches have gained attention as tools for identifying local bottlenecks and improving resource allocation strategies [31]. Particularly, for farmers in rural regions, training programs can aim at strengthening digital competencies, thereby increasingly supporting farmers as essential components of agricultural development strategies [32]. These developments highlight the importance of developing comprehensive digital readiness assessments to guide strategic planning and targeted interventions.

Despite growing research on digital agriculture in Indonesia, most studies focus on technological applications and the potential benefits of precision agriculture, IoT systems, or blockchain-enabled value chains. Much existing research in Indonesia mainly discusses technological applications and the potential benefits of precision agriculture [26, 33-37]. However, since each commodity operates within different production systems, value chains, and socio-cultural contexts, general assessments may not capture actual adoption constraints. Recent investigations in Indonesia have explored the application of IoT within digital agriculture [20, 38-40]; until now, those are all these studies have not yet assessed the preparedness of farmers' readiness to adopt digital technologies and key agricultural products, such as mangoes.

This study focuses on Digital Readiness Mapping specifically for Indonesian mango farmers, employing West Java as an appropriate setting for investigation due to its strategic role in national mango production and its diverse farming characteristics. A mixed-method qualitative and quantitative methodology is utilized to evaluate the level of digital transformation readiness among farmers. The results are expected to contribute to academic discussions and assist policymakers and stakeholders in improving digital capabilities within horticultural value chains. In this context, we aim to address how a Digital Readiness Map can be developed for Indonesian mango farmers. Specifically, the research addresses the following questions:

1) How high is the current digital readiness level of Indonesian mango farmers in the case of West Java?
2) What key challenges and gaps must farmers overcome to obtain and use technology and data effectively?

2. LITERATURE REVIEW

Digital readiness is widely recognized as the preparedness of individuals or communities to adopt and effectively use digital technologies. According to Eshet-Alkalai [22], digital literacy is a multidimensional competence involving technical, cognitive, and socio-emotional skills required in the digital era. In agriculture, readiness not only refers to access to devices or connectivity but also the ability to interpret and apply digital information for decision-making. Lioutas and Charatsari [23] argued that without adequate literacy, infrastructure alone cannot ensure meaningful adoption.

Theoretical frameworks provide important foundations for analyzing adoption in agriculture. The Technology Acceptance Model (TAM) (Davis, 1989) in Akpe et al.'s [24] study emphasizes the role of perceived usefulness and perceived ease of use in shaping technology adoption. Similarly, the Diffusion of Innovation theory [41] highlights innovation attributes, communication channels, and social systems. Both theories help explain why adoption varies across farmer groups and generations. However, their use in commodity-specific readiness mapping has been limited, suggesting opportunities for further application.

Globally, Agriculture 4.0 has received growing attention. Wolfert et al. [13] identified the potential of Big Data in smart farming, showing how digitalization could enhance efficiency and sustainability. More recent studies provide nuanced evidence of both opportunities and barriers. A systematic review in Malaysia identified costs, infrastructure, and digital literacy as decisive factors for precision agriculture adoption [35]. In Ghana, smallholder engagement with digital technologies was found to depend strongly on education, age, and access [42]. In Tanzania, digital platforms improved farmers' access to markets and information but infrastructural barriers persisted [6].

Evidence from South Africa further reveals systemic constraints. Von Maltitz et al. [43] found that even agricultural extension professionals lack sufficient readiness, underscoring that barriers are not confined to farmers but extend across institutions. These studies collectively show that readiness is context-dependent, shaped by socio-economic and institutional environments, and cannot be generalized across regions. In Indonesia, research on agricultural digitalization has begun to explore smart farming ecosystems, IoT, and blockchain-enabled value chains. Scholars have emphasized that digital transformation is a socio-technical process shaped by infrastructure, institutions, and farmer capacity [21, 44]. These works highlight important innovations but remain broad, focusing largely on sectoral potential rather than readiness assessments.

Commodity-specific research is still rare. For example, Susandi et al. [20] examined blockchain for traceability and transparency, while other researchers analyzed IoT applications in mango farming [21, 45]. Both provide valuable insights but stop short of systematically evaluating how prepared farmers are to adopt these innovations. Thus, there remains a lack of empirical evidence that maps readiness

across different dimensions such as access, literacy, and generational gaps. From this body of literature, it becomes evident that global studies document readiness challenges and contextual variations, while Indonesian research has mostly explored technological potential without systematic readiness mapping. This gap is critical because readiness determines whether innovations can be effectively adopted at the farmer level. Mango farming, as a strategic horticultural commodity with high domestic and export value, has not been studied in this regard. This study therefore positions itself as the first systematic attempt to map the digital readiness of Indonesian mango farmers, contributing to theory by linking readiness with adoption models and to practice by informing targeted interventions in agricultural policy and capacity building. Therefore, understanding readiness at the commodity level becomes essential before large-scale digital agriculture policies are implemented.

3. METHODOLOGY

3.1 Research design

The present study was designed as a multi-method study combining quantitative surveys, qualitative interviews, and observations. This holistic approach was adopted to capture both measurable indicators and contextual dimensions of digital readiness among mango farmers. Through this mixed-method, the quantitative survey established numeric benchmarks for accessibility metrics and data access/literacy, while qualitative data informed cultural and generational obstacles and farmers conceptions of technology, allowing a comprehensive assessment of technological access, digital literacy, and socio-cultural factors influencing digital adoption in agriculture.

3.2 Study area and research context

The study was conducted in West Java, Indonesia, especially in the CIAYUMAJAKUNING regions (Cirebon Regency, Indramayu Regency, Majalengka Regency, and Kuningan Regency) and Sumedang Regency. The areas were chosen because they are the central mango-producing regions of Indonesia, especially for the premium variety Gedong Gincu, which is financially valuable and has good export opportunities. Beyond production volume, the regions reflect structural characteristics commonly observed in Indonesian mango farming systems, including smallholder dominance, heterogeneous farm scales, generational diversity, and varying levels of access to digital infrastructure. Therefore, the selected regions provide an analytically representative case for examining digital readiness patterns while acknowledging contextual limitations for nationwide statistical generalization.

3.3 Sampling strategy and participants

Stratified purposive sampling was employed to select from 403 mango farmers, with strata defined based on age, production scale, and subregional location. Farmers were classified into digital readiness categories based on a composite index derived from three key dimensions: technology access, data availability, and digital literacy. The classification thresholds were determined using distribution-based grouping to reflect the distribution of responses within the sample. This approach enables relative comparison across farmers and highlights disparities in readiness levels, rather than establishing fixed or universal benchmarks. The index scores were grouped into four categories (high, moderate, low, and critical) using predefined threshold ranges to ensure consistent and systematic classification across respondents.

Furthermore, in-depth interviews were used to supplement the survey results with experience-based and context-driven insights from young farmers, senior farmers, extension workers, and small and medium enterprise (SME) players. The sample size was considered adequate for regression-based statistical analysis and comparative classification of digital readiness levels. The stratification with in-depth interviews was to ensure proportional representation across demographic and production characteristics.

3.4 Data collection procedures

To complement quantitative findings, qualitative data were collected through in-depth semi-structured interviews involving 15 key informants, consisting of young farmers (2), senior farmers (5), extension officers (5) and SME actors (3). Interviews followed a standardized interview protocol containing predefined thematic questions addressing digital adoption experiences, perceived barriers, intergenerational knowledge transfer, institutional support, and infrastructure challenges. Each interview lasted approximately 45–60 minutes and was conducted in Bahasa Indonesia to ensure clarity and participant comfort. With participant consent, interviews were audio-recorded and subsequently transcribed for analysis.

3.5 Measurement and instruments

Quantitative data were collected through a structured questionnaire and measured by a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). Developed from previous studies on digitalization in agriculture [26, 43] as well as contextualized in the context of mango planting in Indonesia, the instrument concentrated upon three most salient constructs – access to technology, availability of data and digital literacy. The qualitative study included semi-structured interviews and participatory observation, with a focus on themes such as adoption behavior in the digital sphere, intergenerational interaction, and infrastructure difficulties.

3.6 Data analysis techniques

The quantitative instrument was pilot-tested with 30 farmers prior to the survey to ensure reliability and validity. Factor analysis was conducted to demonstrate construct validity, and Cronbach's alpha also demonstrated internal consistency > 0.70. Triangulation between interview transcripts and field observations contributed to the credibility and confirmability of the qualitative data. Analysis of narratives was thematically inductive supported by NVivo software, with patterns identified across farmer accounts. Quantitative summaries and regression analysis were conducted to determine the significant factors of digital readiness, along with farmers classification into high, moderate, low, and critical gap categories. Accordingly, the findings are intended to offer analytical transferability rather than strict statistical generalization to all mango-producing regions in Indonesia.

4. RESULTS AND DISCUSSION

4.1 Digital readiness dimensions of mango farmers

This subsection presents descriptive results illustrating the current profile of digital readiness among mango farmers. Based on a comprehensive survey of 403 mango farmers, this unique and seminal research examines three key aspects: access to technology, data availability, and digital training. The technology access mean score (3.7) in this study suggests that farmers had a substantial exposure to technologies. In contrast, the average for data access is 3.6, indicating that, despite some bare sufficiency, there are opportunities to improve data retrieval. Digital literacy – here referring to the ability to make good use of digital tools and technologies – was in fact rated as the least valued element (2.9) among all the producers examined, signaling substantial unease or a gap when operating between cultural and digital environments. This imbalance highlights the need for literacy and infrastructure-oriented responses. Therefore, although there is growing infrastructure to support them, many farmers still face difficulties adopting digital technologies for farm management and decision-making (Table 1). These descriptive findings indicate that digital readiness disparities are not merely technological but also behavioral and generational in nature.

Table 1. Mean scores of digital readiness dimensions

Dimension	Mean	Std. Dev.	Category
Access to Technology	3.7	0.82	Moderate-High
Availability of Data	3.6	0.77	Moderate
Digital Literacy	2.9	0.91	Low

Source: Authors

The disparities between the dimensions are displayed in a spider chart (Figure 1). The chart makes clear the gap between infrastructure and literacy, showing that while access and data are moderately good, digital literacy is remarkably low. Though technology and data are relatively balanced in their representation on the chart, the axis shrinks to the point of literacy, suggesting an area for intervention: one where a structural vulnerability becomes clear. In other developing-country settings, the 'ability of farmers to turn access into active use appears to be limited by poor skills'.

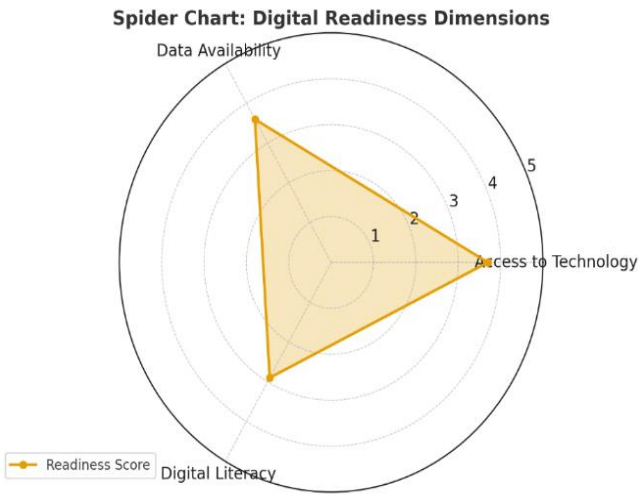

Figure 1. Digital readiness dimensions
Source: Authors

The dominance of technology access as the strongest predictor suggests that digital transformation in smallholder agriculture remains infrastructure-driven rather than capability-driven. In developing-country contexts, access functions as an enabling condition that determines whether farmers can even enter the digital ecosystem. However, consistent with socio-technical transition theory, access alone does not guarantee effective adoption unless supported by cognitive readiness and institutional facilitation.

4.2 Classification of farmer readiness levels

To learn more about these findings, farmers were classified into four readiness categories. Figure 2 presents this stratification as a pyramid, indicating that most farmers remain in the lower tiers. The chart distribution shows that 14% of respondents were in the "high readiness" group, 32% in the "moderate readiness" group, 41% in the "low readiness" group, and 13% in the "critical readiness gap" group. Beyond aggregate scores, readiness varies substantially across farmer groups, requiring classification analysis. Targeted interventions and different strategies are necessary to build digital capacity.

The digital readiness map for mango farmers and SMEs in Indonesia shows a tiered adoption system. Few young farmers and SMEs possess digital processing skills and high readiness; most have medium or low assurance, indicating they have access to digital tools but do not use them. A significant gap exists between older farmers and traditional SMEs, both of which lack access to digital resources and the necessary literacy skills. This mapping provides evidence that agriculture digital readiness in Indonesia is uneven, generationally stratified, and based on infrastructure, which warrants targeted policy responses tailored to each level of readiness.

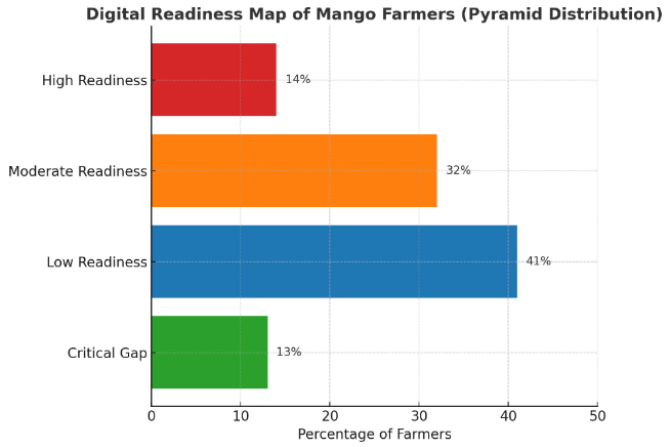

Figure 2. Distribution of farmers digital readiness categories
Source: Authors

The use of the pyramid structure emphasizes the necessity of differentiated strategies for each of these groups. That map shows that readiness is not homogeneous but rather layered. High-readiness farmers can be early adopters who might become digital champions within their communities. Farmers with moderate readiness have access to digital tools but lack the skills to use them effectively. Farmers with low readiness face challenges related to literacy and infrastructure, while those in the critical gap require intensive support, including access to basic connectivity and individualized literacy

support.

There are twofold implications; first, readiness requires infrastructure and well-designed programs to achieve greater efficiency. Second, policy measures should leverage the potential of young farmers as digital champions, ensuring older farmers remain included. Tailored capacity-building efforts that address a range of readiness states, along with strengthened extension and open data services, are necessary to tackle this demand. Combining evidence from statistics, descriptive findings, and theoretical underpinnings, the Digital Readiness Map contributes to readiness theory in academia and guides the promotion of inclusive digital transformation in Indonesian agriculture.

4.3 Determinants of digital readiness: Regression analysis

To further explain these disparities, regression analysis was conducted to identify the relative contribution of each readiness dimension. Regression analysis was performed to explore the correlates of digital readiness. Table 2 shows that all three — access to technology, data availability, and digital literacy — impact readiness. Technology access was the strongest determinant (ß = 0.501, $p < 0.001$), followed by data availability (ß = 0.343, $p < 0.001$) and digital literacy (ß = 0.291, $p < 0.01$), indicating that improved technological access substantially increases farmers readiness to engage in digital agriculture practices. The model explains 62.4% of the variance in readiness, suggesting potent explanatory ability. These results confirm that readiness is not due to a single factor, but instead requires a balance or integration of infrastructure, data resources, and data literacy.

Table 2. Regression results: Determinants of digital readiness

Variable	β (Coefficient)	T-Value	P-Value	Sig.
Access to Technology	0.501	6.23	0.000	***
Data Availability	0.343	4.87	0.000	***
Digital Literacy	0.291	3.94	0.001	**
Constant	1.102	2.11	0.036	*

Source: Authors

While technological access emerges as the strongest predictor, the qualitative evidence demonstrates that access alone does not guarantee meaningful utilization, highlighting the mediating role of digital literacy. The dominance of technology access as the strongest predictor suggests that digital transformation in smallholder agriculture remains infrastructure-driven. Access functions as an enabling condition allowing farmers to enter digital ecosystems; however, consistent with socio-technical adoption theory, access alone does not ensure effective utilization without sufficient digital capability and institutional support.

4.4 Generational dynamics and digital intermediaries

The regression analysis verifies that access remains the primary pathway to readiness, but qualitative interviewing reminds us that access is not equivalent to utilization alone. Younger farmers (aged 35 or younger) were also significantly higher on all dimensions than older comparison farmers (aged 50 or older). The remarks showed that smartphones, when owned, were primarily used for communication rather than for agricultural decision-making. Older farmers distrusted online information and had trouble using mobile phone apps. This situation means the practical benefits of digitalization was eroded by a general lack of confidence in interpreting data from weather apps or online market platforms, often resulting in farmers going back to square one, doing what they have been doing for centuries.

Younger farmers often served as "digital intermediaries" in their communities, helping older members with mobile apps for weather reports and price information, as well as WhatsApp trading platforms. This underscores the importance of digital literacy, which correlates less strongly with access but is an enabling factor for the successful use of Information and Communication Technology (ICT). Extension officers noted that the uptake patterns largely hinged on youth leadership in farmer groups, emphasizing generational readiness. Farmers from remote villages also shared problems with unreliable Internet access and expensive data plans, in line with the finding that just 62% of rural households in West Java can access the Internet reliably. This lack of infrastructure impedes the success of access measures and underscores the need for increased investment in the digital infrastructure of the countryside. The coexistence of infrastructure and literacy challenges explains why readiness scores vary, even as access to technology grows.

The emergence of younger farmers as digital intermediaries indicates that digital adoption follows a socially mediated pathway rather than an individual adoption process. Younger farmers act as knowledge brokers who translate digital information into locally applicable practices, accelerating diffusion through trust-based social networks. This finding extends diffusion theory by highlighting intergenerational mediation as a critical mechanism in smallholder digital transformation.

Low digital literacy affects decision-making by increasing perceived complexity and uncertainty associated with digital tools. Older farmers often rely on experiential knowledge accumulated through long-term farming practices, leading to lower perceived usefulness and ease of use—two central constructs of the TAM, which emphasize education and access as influential factors in determining technology adoption across contexts. Farmers in younger age categories who find mobile apps and online platforms more valuable report higher readiness, whereas older farmers encounter barriers to perceived ease of use. This finding aligns with the TAM, where perceived usefulness and perceived ease of use shape adoption behavior. Older farmers hesitation reflects lower perceived ease of use, whereas younger farmers demonstrate higher perceived usefulness through practical experimentation with digital tools.

These findings are also in line with reflecting global patterns, such as: in Malaysia, cost and literacy are barriers; while the key factors influencing adoption in Ghana and Tanzania are education and access; likewise, institutional preparedness among extension officers is still low in South Africa. However, the Indonesian mango business is unique in that it has an extreme generational gap, driven by a very cultural adherence to heritage processes. This can offset the projected gains from agricultural innovations. Adoption of technology should not be limited to tools; it is needed in activities to ensure the availability of all threats. As a result, digital information is frequently viewed as supplementary rather than authoritative, causing farmers to revert to conventional decision-making despite technological availability.

4.5 Policy implications and digital agriculture roadmap

Combining the quantitative and qualitative results emphasizes that digital readiness is multifaceted. It might look like infrastructure and access are enough; they are not if there are no literacy and behavioral adaptation. Initiatives that only provide devices or Internet access are at risk of having a limited effect unless they are accompanied by proper training and support. Adult literacy-focused interventions for older farmers can be effective, particularly when they involve younger generations as agents of change. Institutional interventions, such as open data initiatives and improved extension services, are also needed to narrow the readiness gap. Typically, the findings (Table 3) emphasize that, even as access to technology and data coverage has improved, digital literacy is lagging. This study, by offering an initial structured readiness map for mango farmers, demonstrates that effective digital transformation in agriculture requires addressing infrastructure, skills, and socio-cultural aspects alike. The readiness map, therefore, not only helps to inform theoretical debates but also provides practical relevance for policymakers, extension services and agribusiness actors to develop specific strategies for inclusive agricultural digitalization in Indonesia.

The implication is that readiness is not something you can buy by simply throwing money at infrastructure. Moreover, access without capability development leads to unsustainable adoption outcomes; if its comfort is not established correctly, or its use is nonexistent, the reins will eventually slip. Policy interventions should be implemented through coordinated efforts involving local agricultural extension services, farmer cooperatives, and government agencies, particularly by developing youth-led digital training programs and subsidizing rural Internet infrastructure.

Table 3. Findings to implications map of digital readiness among mango farmers

Findings (Data Evidence)	Analysis (Interpretation)	Implications (Policy/Practice)
Mean (SD) of access to technology and data availability were 3.7 and 3.6, respectively, which is appropriate in general terms.	Progress has been made in both infrastructure and the availability of data, but these developments have not occurred consistently across rural areas.	Enabling rural expansion of Internet infrastructure and establishing equal access to that infrastructure throughout the country should be a policy priority.
Digital literacy is quite poor (average = 2.9), especially among elderly farmers.	There are cognitive and generational gaps making it hard to leverage the digital as a tool.	As such, targeted literacy development programs, particularly in addressing senior farmers are warranted.
Regression results: access (β = 0.501), data (β = 0.343), literacy (β = 0.291), all significant.	All dimensions are significant predictors of readiness and infrastructure is the best predictor although literacy is also important.	There needs to be a balanced response: building infrastructure, data, and literacy while you pay those medical students.
Based on the Digital Readiness Map, 41% of farmers are low readiness and 13% land in a critical gap (Digital Readiness Map).	Most of the farmers are not ready, it is also determined that there exists gradient and heterogeneity among different populations in the level of readiness.	Differentiated strategies are needed: high-ready farmers can be used as digital champions; low-ready ones need a great deal of hand-holding.
Qualitative evidence shows that younger farmers work as digital intermediaries and older ones are more reluctant to use technologies.	Adoption paths are influenced significantly by generational behavior; diffusion of technology is based on traditional social roles.	Programs should prioritize preparing young farmers as peer trainers or change agents, while integrating older and younger farmers through hybrid engagement models.

Source: Authors

The findings contribute theoretically by integrating digital readiness assessment with technology adoption theories, demonstrating that readiness in smallholder agriculture is shaped not only by technological availability but also by intergenerational social dynamics. Practically, the study provides an evidence-based framework for designing differentiated digitalization policies tailored to heterogeneous farmer readiness levels.

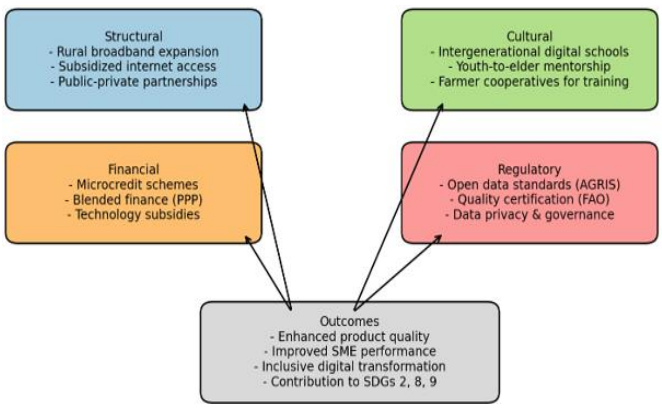

Figure 3. Policy roadmap for inclusive digital agriculture
Source: Authors

Based on these findings, the paper develops a policy roadmap that explains to both scholars and practitioners which structural, cultural, financial, and regulatory strategies are required to improve digital readiness. This roadmap outlines pathways to translate the evidence into specific channels, ensuring contributions from academia are squarely focused on feasible interventions for farmers, SMEs, and decision-makers (Figure 3). Policy Roadmap for Inclusive Digital Agriculture outlines four areas of intervention (structural, cultural, financial and regulatory), to strengthen digital readiness and uptake among farmers. The roadmap outlines ways to address these issues, thereby improving product quality, SMEs performance, and inclusive digital transformation. It also provides a general blueprint for a range of structural, cultural, financial, and normative interventions tailored to address the identified awareness gaps and stimulate acceptance among mango growers and SMEs. By framing its recommendations in this way, the roadmap supports translating evidence into timely, relevant interventions for policymakers, extension agencies, and agribusiness interests.

Structurally, investing in rural broadband infrastructure, subsidizing Internet access, and fostering public-private partnerships are necessary to achieve proper inclusive connectivity. These interventions are the strategic responses to address the access divides identified by the survey, especially

in areas where producers from remote communities suffer irregular connectivity. Cultural aspects are just as important, particularly given the generation gap identified in this research. The potential of young farmers, both as digital intermediaries and in mechanisms for avoiding the marginalization of older farmers, e.g., intergenerational digital schools, youth-to-elder mentorship programs, or farmer cooperatives for capacity building, can be mobilized by such interventions.

Regulatory frameworks are needed to build trust and enable interoperability. To succeed, it will require adhering to international open data guidelines such as AGRIS, complying with Food and Agriculture Organization (FAO)-provided international quality certification processes, and creating robust privacy and data governance instruments. Without these components, digital tools might not take off or be used by farmers. The expected path will contribute to enhanced product quality, increased performance of participating SMEs, and prompt an inclusive digital transformation that directly aligns with SDGs 2 (Zero Hunger), 8 (Decent Work & Economic Growth), and 9 (Industry, Innovation & Infrastructure). These results highlight the academic importance of this research and the pressing need for change in Indonesian agricultural policy.

Implementation of the proposed roadmap requires multi-level collaboration involving local agricultural extension agencies, regional governments, farmer cooperatives, and private agriculture technology providers. Extension officers may act as facilitators of literacy programs, while younger farmers can function as peer-based digital intermediaries supporting knowledge diffusion within farmer communities. Overall, the findings demonstrate that digital readiness is a multidimensional socio-technical condition shaped by infrastructure, literacy, and intergenerational dynamics, providing both theoretical advancement and practical guidance for inclusive agricultural digital transformation.

5. CONCLUSIONS

Digital readiness is formed by numerous factors, with access to technology being one, however not the sole factor. The findings indicate that the digital readiness level of mango farmers in West Java can be categorized as moderate, with relatively good access to technology emerging as the strongest predictor. However, its impact depends on farmers' ability to interpret and use digital information. In many cases, digital skills, access to data and farmers' backgrounds also play an important role. At the same time, although access to technology can be met, it doesn't mean that anything will be used effectively. Many farmers, especially older ones, still have trouble using digital tools, which means they can't get all the benefits that new technologies can offer.

Another key discovery is that younger farmers often help others learn how to use digital tools in real life. This means that adopting digital technology is not purely individual; it also happens to groups of people who work together on farms. At the same time, we need to take a more balanced approach to digital transformation. Infrastructure expansion is still necessary, but it needs to be paired with training and support that is useful and realistic for farmers. Bringing farmers, extension services, and local institutions closer together could help address this gap.

The results also suggest that being digitally ready can improve product quality and performance for SMEs, demonstrating its importance to the economy in agricultural value chains. In this scenario, the research suggests that digital transformation in agriculture goes beyond just adopting new technologies. It depends on how prepared farmers are to use them in practice. Agriculture productivity and competitiveness depend on improving digital skills, infrastructure, and finances.

This study is based on data from 403 farmers in West Java and should be interpreted within this context. While the results provide a reliable picture of digital readiness patterns in the study area, they are not intended for direct national generalization. Even so, the findings remain relevant for similar farming systems, as the region reflects many of the structural characteristics found in Indonesian mango production. For digital transformation to work in agriculture, it is not enough for technology to be available; farmers must also be ready to use it correctly in their work.

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NOMENCLATURE

AGRIS	International System for the Agricultural Science and Technology
FAO	Food and Agriculture Organization
ICT	Information and Communication Technology
IoT	Internet of Things
SDG	Sustainable Development Goals
SME	Small and Medium-sized Enterprises
R^2	Coefficient of Determination
TAM	Technology Acceptance Model

Greek symbols

β	Thermal Expansion Coefficient