

Information and communication technology transform the agricultural extension practices in North Maluku, Indonesia

Chris Sugihono^{1,2}, Sunarru Samsi Hariadi¹, Sri Peni Wastutiningsih¹

¹Extension and Development Communication Study Program, Graduate School, Universitas Gadjah Mada, Yogyakarta, Indonesia

²Indonesian Agency for Agricultural Instrument Standardization, Ministry of Agriculture, Jakarta, Indonesia

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ABSTRACT

The world's swift digitization has profoundly transformed how farmers and extension workers operate, learn, and communicate. This study explores how information and communication technologies (ICT) adoption transforms agricultural extension practices in North Maluku, Indonesia. Using a qualitative approach, the study gathered and analyzed data from fifteen extension workers through interviews, observation, documentation, and focus group discussions from November 2022 to March 2023. The findings reveal ICT adoption has transformed the extension workers' strategies in five areas: i) coordination and collaboration, ii) digital learning, iii) virtual group dynamics, iv) promotion and mobilization, and v) online consultation and monitoring. However, ICT adoption has not replaced traditional extension methods, such as demonstration plots, field schools, and field trips. The use of ICT is not always in line with the deterministic view that technology automatically changes society. In contrast, recursive patterns in practice adaptation create complex dynamics in which extension workers' decisions continue to play a key role in the evolution of agricultural extension. These findings enrich practical and policy debates regarding harnessing ICT potential for enhanced agricultural extension in Indonesia. Additionally, they advance theoretical discussions on the merits of the technological determinism perspective in analyzing ICT utilization.

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Corresponding Author:

Sunarru Samsi Hariadi

Extension and Development Communication Study Program, Graduate School, Universitas Gadjah Mada

Daerah Istimewa Yogyakarta 55281, Indonesia

Email: sunarru_sh@ugm.ac.id

1. INTRODUCTION

Agricultural extension, a practice with roots in the late 19th century, has continuously evolved to address the changing needs of farmers [1]. Initially focused on disseminating research findings to rural communities, extension services have expanded to encompass a wider range of activities, including education, technology transfer, and community development [2]. This historical trajectory reflects the adaptive nature of agricultural extension, shifting from a unidirectional information model to a more participatory approach that engages farmers as active partners in knowledge-sharing [3]. Information and communication technology (ICT) has significantly influenced the agricultural landscape, marking a new era in agricultural development, particularly in developing countries [4]. This paradigm shift is characterized by an unwavering belief in technology's potential to drive progress, echoing the principles of technological determinism theory [5]. This theory posits that technology follows an internal logic of efficiency and innovation, with humans adapting to these advancements [6]. From early radio broadcasts to modern smartphones and data analytics, ICT has become deeply integrated into contemporary agricultural practices,

ranging from precision farming to digital platforms for climate information [7], nutrient recommendation [8], market access [4], and information exchange [8]. This technological evolution promises to enhance efficiency, productivity, and sustainability within agricultural systems [9].

Numerous studies have explored the impact of ICT on agricultural extension, revealing both positive and challenging outcomes. Studies have consistently demonstrated the transformative potential of ICT in enhancing access to timely and relevant information for farmers [10]–[12]. This includes real-time weather updates, market prices, and best practices for crop and livestock management, often delivered through mobile applications or online platforms. Moreover, ICT has proven instrumental in fostering communication and collaboration among farmers, extension workers, and other stakeholders [13]. Virtual forums, social media groups, and messaging apps enable knowledge sharing, peer-to-peer learning, and the formation of virtual communities of practice [14]. Furthermore, empirical evidence suggests a positive correlation between ICT adoption and increased agricultural productivity [15]. This can be attributed to factors such as improved decision-making based on timely information. However, challenges such as digital literacy barriers, infrastructure limitations, and the potential exclusion of certain farmer groups from the benefits of ICT interventions have also been identified [16].

While prior research has explored the broad impact of ICT on agricultural extension, a critical gap remains in our understanding of how ICT is specifically utilized by extension workers and whether it complements or replaces traditional extension methods. Furthermore, the influence of local contexts on ICT adoption and use in agricultural extension has been under-explored. This study addresses these gaps by investigating the case of North Maluku, Indonesia, where ICT has been introduced into the agricultural extension system. Employing the technological determinism theory as a framework, we explore how ICT adoption has altered the working methods, learning approaches, and communication strategies of agricultural extension workers in this region. The findings will inform policy and practice recommendations aimed at enhancing the performance of agricultural extension workers in the digital era.

2. RESEARCH METHOD

This study adopts a qualitative research design to comprehensively explore the transformative impact of ICT on agricultural extension practices in North Maluku, Indonesia. Qualitative methods are particularly suited to uncover the nuanced contextual factors and multifaceted dynamics inherent in ICT integration within the agricultural sector. North Maluku, located in eastern Indonesia, presents a unique research setting due to its diverse socio-economic and geographical characteristics. The region encompasses a wide range of ecosystems, agricultural practices, and community structures, making it crucial to contextualize research findings within these localized realities. The agricultural landscape of North Maluku, characterized by its diverse crops, farming systems, and traditional practices, offers a compelling case for investigating the complex interplay between technological advancements and established agricultural traditions.

Fifteen agricultural extension workers from North Maluku were purposively selected for this study based on their experience, expertise, and active involvement in agricultural extension activities. Participants represented a cross-section of roles within the extension system, ensuring a diverse range of perspectives on ICT adoption and integration [17]. Data collection spanned from November 2022 to March 2023 and utilized a multi-method approach [18], including:

- i) In-depth interviews: to elicit detailed narratives of individual experiences and perceptions regarding ICT use in agricultural extension.
- ii) Observation: to gather contextual information about the workplace environments and practices of extension workers.
- iii) Documentation: to collect relevant documents, such as training materials, reports, and guidelines, related to ICT use in extension.
- iv) Focus group discussions (FGDs): to foster collective discussions and generate insights into shared perspectives and collaborative dynamics among extension workers.

Thematic analysis, a rigorous qualitative data analysis technique, was employed to identify, analyze, and report patterns (themes) within the data, adapted from Braun and Clarke's framework (Figure 1) [19]. The process encompassed several stages. Initially, a 'data corpus' was created by transcribing verbal data and selecting pertinent keywords. This corpus is then transformed into a 'data set' through meticulous reading, memoing, marking of significant text segments, and the removal of incomplete or irrelevant data. Next, 'codes' were generated, reviewed, and finalized to label meaningful data segments. These codes were subsequently clustered into 'themes' based on shared meanings, which were then evaluated and refined. The final stage involved organizing these themes into coherent groups and defining and naming each theme comprehensively.

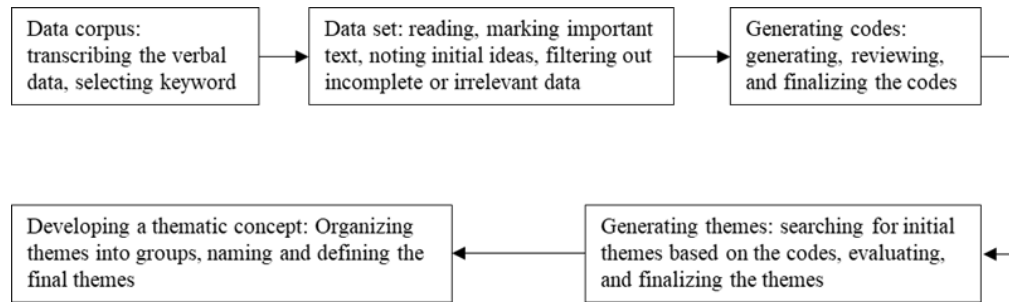


Figure 1. The procedure of thematic analysis in this research

3. RESULTS AND DISCUSSION

3.1. ICT in agricultural extension practices

The integration of ICT is reshaping agricultural extension practices in North Maluku, as evidenced by the diverse tools utilized by extension workers (Table 1). Our findings reveal a strong correlation between the multifaceted capabilities of smartphones and WhatsApp and their high usage intensity (*****) among extension workers in North Maluku. This suggests that these tools' potential for real-time communication, field documentation, and AI-powered decision support directly translates into their widespread adoption and critical role in modernizing extension practices [20], [21]. Furthermore, we observed that Facebook, with its capacity for knowledge sharing and community building, also enjoys high usage intensity (****) among extension workers. This indicates its effectiveness in fostering collaborative learning environments and facilitating communication between extension workers and farmers [22]. YouTube's moderate usage (***) aligns with its role as a repository for in-depth agricultural knowledge and training resources [23]. In contrast, the relatively lower usage intensity of websites, Instagram, and TikTok (** or *) indicates untapped potential for these platforms in agricultural extension. Their unique features for visual storytelling and engagement could be strategically leveraged to reach specific audiences or address particular extension needs. The diverse range of ICT tools used and their varying levels of intensity reflect the adaptability of extension workers in leveraging technology to enhance their work. However, the underutilization of certain platforms highlights the necessity for capacity building and strategic planning to fully harness the potential of ICT in agricultural extension.

Table 1. ICT tools utilized in agricultural extension and their applications

ICT Tools	Key Features	Agricultural Extension Practices Supported	Usage intensity
Smartphone	Camera, audio/video recording, video editing, GPS tagging, internet access, mobile hotspot, m-banking, agricultural apps, AI	Field activity documentation and reporting, real-time information dissemination, crop/field monitoring, access to up-to-date agricultural information, and AI-powered tools for analysis and prediction.	*****
WhatsApp	Instant messaging, voice and video calls, group chats	Real-time communication, team coordination and collaboration, sharing multimedia resources (videos, images, documents), and formation of farmer discussion groups.	*****
Facebook	Sharing posts, stories, live broadcasts, Marketplace, agricultural communities, messages, likes and comments	Knowledge sharing, joining and interacting with agricultural communities, disseminating agricultural information, and promoting events.	****
YouTube	Video hosting & sharing, channels and playlists, comments and live streaming	Creating cultivation tutorials, sharing success stories, delivering in-depth agricultural knowledge, and building a comprehensive agricultural video library.	***
Website (cyber-extension)	Text-based information, images, videos, infographics	Dissemination of information on technologies, crop varieties, pests and diseases, fertilizers, market prices, planting calendars, and Q&A forums.	**
Instagram	Sharing photos and short videos, hashtags & location tagging, music	Visual storytelling, showcasing agricultural products, providing glimpses into farming life, and promoting agritourism.	*
TikTok	Creating short videos, trending challenges, music and effects, likes and comments	Creating engaging agricultural educational content, and raising awareness about agricultural issues.	*

Source: Primary data (observation, in-depth interview, and FGD)

Note: The number of asterisks (*) indicates the relative frequency and extent of adoption among agricultural extension workers.

3.2. Impact of ICT on agricultural extension practices

Agricultural extension has evolved significantly, driven by the need to address global food challenges and promote sustainable agriculture [24], [25]. Traditionally, extension services in North Maluku relied heavily on conventional methods, such as face-to-face interactions, demonstration plots, farmer field schools, and training courses to disseminate knowledge and technologies to farmers (Figure 2). Field visits enable extension workers to observe, diagnose, and advise on farmers' needs. Demonstration plots offer visual evidence of innovation results, allowing farmers to compare practices [26]. Farmer field schools, employing participatory methods, enhance knowledge, and decision-making, and foster social learning [27]. While mass media reaches a broad audience, creating awareness, it has limitations in interactivity and feedback mechanisms [28]. These approaches, while effective in building trust and providing personalized guidance, often face limitations in terms of reach, time, and resources [29].

Our findings reveal a recursive adaptation in agricultural extension practices in North Maluku, driven by the integration of ICT. Initially, extension workers embraced ICT tools like smartphones and social media to enhance communication, information dissemination, and knowledge sharing (Arrow 1, Figure 2). This led to improved efficiency and expanded reach. The rapid advancement of ICT is catalyzing a significant shift in agricultural extension, transitioning from traditional face-to-face interactions to a virtual paradigm mediated by online platforms such as webinars, video conferences, and social media [30]. This shift allows extension workers to transcend geographical limitations and reach a wider audience of farmers, potentially enhancing the efficiency and reach of extension services [31]. The initial phase of ICT adoption in North Maluku, where extension workers supplemented their conventional approaches with virtual visits, online consultations, and multimedia content dissemination via platforms like WhatsApp, aligns with findings from Alam and Shaba [12], where extension workers often begin by integrating digital tools into their existing practices [32].

However, feedback from farmers (Arrow 2, Figure 2) revealed that while ICT offered advantages in terms of reach and efficiency, it could not fully replace the nuanced understanding and trust fostered through face-to-face interactions. This observation echoes concerns raised in Simelton and McCampbel's study [33] regarding the potential for digital technologies to create a digital divide and exclude farmers who lack access or digital literacy skills. In response, extension workers adopted a hybrid model, strategically combining conventional and ICT-based methods (Arrow 3, Figure 2). This recursive adaptation challenges the notion of technological determinism, demonstrating that ICT adoption in agricultural extension is not a linear or inevitable process. This finding is consistent with research emphasizing the importance of human agency and social context in shaping technology adoption and use [34].

The hybrid model adopted by extension workers in North Maluku represents a pragmatic response to the "innovation paradox" [35]. While ICT expands access to information and training opportunities, it also risks excluding certain segments of the farming community. The study's findings suggest that this hybrid approach may benefit from further refinement, ensuring that the strengths of both ICT and traditional methods are leveraged to promote inclusivity and equitable access to extension services. Furthermore, the study's findings emphasize the interplay of technological capabilities, social norms, and individual agency in shaping ICT use in agricultural extension [20]. This aligns with theoretical frameworks emphasizing the complex interplay between technology and society, such as those proposed by Lee *et al.* [36]. Understanding these factors is crucial for designing effective ICT interventions in agricultural extension.

3.4. Limitations and future research

This study offers valuable insights into ICT's impact on agricultural extension in North Maluku, but its context-specific nature limits generalizability. Additionally, while acknowledging cultural influences on ICT adoption, the complex interplay between culture and technological determinism warrants further exploration. The extent to which extension workers and farmers actively shape technology use also requires deeper investigation. Future research should conduct comparative analyses across diverse regions, examining variations in ICT's impact and how cultural dynamics influence its adoption. A more in-depth exploration of human agency within the technological determinism framework is also crucial to understanding how individuals negotiate and potentially resist technological influences. This will contribute to a more comprehensive understanding of the complex relationship between ICT, agricultural extension, and socio-cultural contexts.

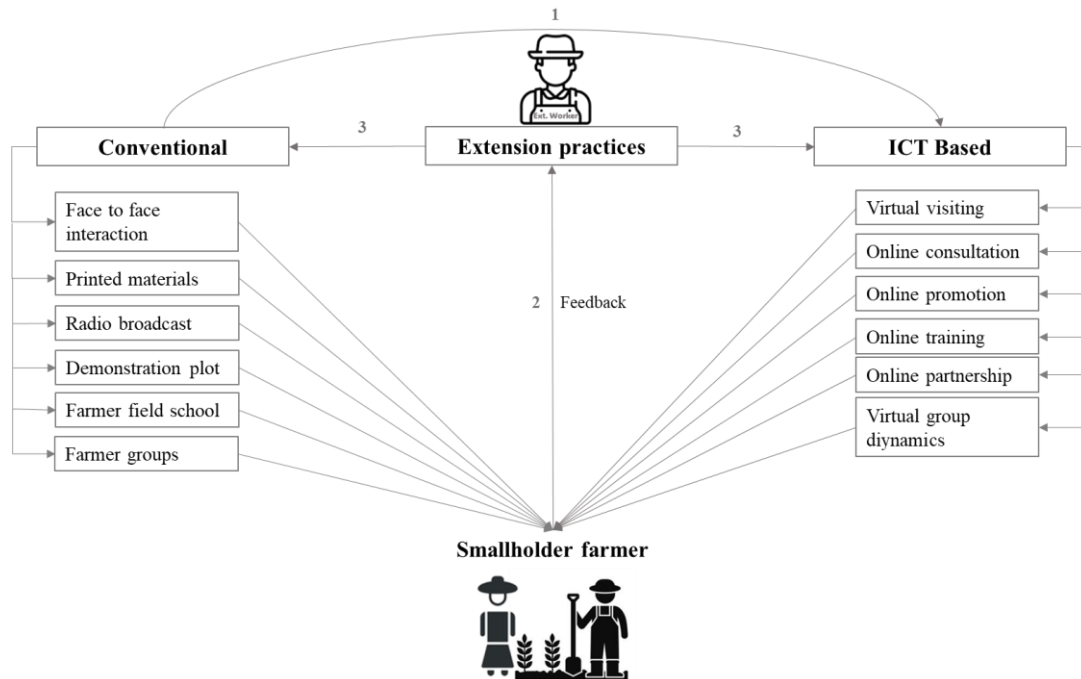


Figure 2. The transformative impact of ICT on agricultural extension practices: a recursive shift from conventional to digital and the coexistence of both
(Source: interview, FGD, Observation, 2023)

4. CONCLUSION

This study provides compelling evidence of ICT's transformative impact on agricultural extension in North Maluku, Indonesia. We observed increased communication frequency and interactivity between extension workers and farmers, fostering innovation and empowerment. Access to diverse information through digital platforms also enabled personalized learning opportunities. Importantly, our findings challenge a purely technologically deterministic perspective. ICT adoption in agricultural extension is a recursive and selective adaptation shaped by local needs and contexts, demonstrating the agency of extension workers in integrating ICT alongside traditional methods. This hybrid approach maximizes benefits while addressing challenges like limited digital literacy and access.

These findings underscore the need for context-specific and adaptive ICT implementation strategies. Successful integration requires investment not only in technology but also in digital literacy, infrastructure, and a culture of innovation. Recognizing the interplay of technology, human agency, and local context is crucial to harnessing ICT's full potential for empowering farmers and promoting sustainable agricultural development.

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
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BIOGRAPHIES OF AUTHORS

Chris Sugihono     is a PhD student in the Extension and Development Communication Study Program at the Graduate School, Universitas Gadjah Mada (UGM). He currently works at the Indonesian Agency for Agricultural Instrument Standardization, Ministry of Agriculture. His research interests focus on the utilization of digital technology in agricultural extension and community empowerment. He can be contacted at chrissugihono@mail.ugm.ac.id.



Sunarru Samsi Hariadi     is a Professor of Agricultural Extension at the Faculty of Agriculture, Universitas Gadjah Mada (UGM). He obtained his doctorate from UGM's Graduate School in 2004. He currently teaches in the Extension and Development Communication Study Program at UGM's Graduate School. His research interests include Agricultural Extension and Development Communication, Agricultural Institutions, and Socio-Cultural Studies. He can be contacted at sunarru_sh@ugm.ac.id.



Sri Peni Wastutingingsih     is a lecturer in the Department of Socio-Economics, Faculty of Agriculture, Universitas Gadjah Mada (UGM). She received her doctoral degree in Agricultural Sociology and Extension from Justus Liebig University, Germany, in 1999. She teaches agricultural extension topics, such as Introduction to Agricultural Extension and Communication, Adult Education, and Group Dynamics. She also teaches some courses in the postgraduate program on Extension and Development Communication. She has a strong research interest in empowerment, educational approaches for community development, and local resource development. Her research has been published in various publications. She can be contacted at peni@ugm.ac.id.