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EFFECTIVENESS OF WHATSAPP IN FACILITATING FARMER GROUP COMMUNICATION IN NORTH SUMATRA'S WONOSARI VILLAGE

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Abstrak

Teknologi komunikasi digital semakin mengubah pola pertukaran informasi di sektor pertanian, namun tingkat adopsinya pada kelompok tani di wilayah perdesaan masih berbeda antar-generasi dan tingkat literasi digital. Penelitian ini menganalisis penggunaan WhatsApp dalam komunikasi kelompok tani di Desa Wonosari, Kecamatan Tanjung Morawa, Sumatera Utara, dengan menitikberatkan pada manfaat komunikasi dan hambatan adopsi teknologi. Penelitian menggunakan pendekatan kualitatif deskriptif dengan fokus pada kelompok tani yang beranggotakan 68 orang. Data dikumpulkan melalui wawancara mendalam dengan pengurus kelompok tani, observasi langsung, dokumentasi, dan kajian pustaka yang relevan. Hasil penelitian menunjukkan bahwa WhatsApp telah mengubah pola komunikasi yang sebelumnya didominasi penyampaian informasi dari rumah ke rumah dan dari mulut ke mulut menjadi pertukaran informasi yang lebih cepat dan mudah diakses. WhatsApp mempermudah koordinasi antarpetani, penyebaran informasi pertanian, komunikasi dengan Penyuluh Pertanian Lapangan (PPL), serta interaksi antaranggota. Namun, adopsi teknologi belum merata, terutama pada anggota yang lebih tua dan memiliki keterbatasan dalam menggunakan telepon pintar dan media sosial. Selain itu, konten yang kurang relevan dalam grup WhatsApp terkadang mengganggu efektivitas komunikasi. Karena itu, komunikasi tatap muka tetap digunakan sebagai pendamping komunikasi digital. Ditinjau melalui teori Difusi Inovasi, PPL berperan penting sebagai fasilitator adopsi teknologi. Penelitian ini menunjukkan bahwa WhatsApp dapat memperkuat komunikasi pertanian perdesaan apabila didukung pendampingan literasi digital dan pengelolaan grup yang sistematis.

Kata kunci: WhatsApp; Komunikasi Pertanian; Kelompok Tani; Difusi Inovasi; Inklusi Digital

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Abstract

Digital communication technologies are reshaping how agricultural communities exchange information, coordinate activities, and access extension services, although their adoption remains uneven across rural populations. This study examines the use of WhatsApp within a 68-member farmer group in Wonosari Village, Tanjung Morawa, North Sumatra, Indonesia, focusing on its communicative benefits, adoption barriers, and implications for agricultural extension. Employing a descriptive qualitative design, the research draws on in-depth interviews with farmer-group leaders, direct observation, documentation, and relevant literature. The findings indicate that WhatsApp has supplemented traditional communication practices, including door-to-door information sharing and word-of-mouth exchanges, by enabling faster information dissemination, more accessible coordination, and more frequent interaction among farmers and agricultural extension workers (*Penyuluh Pertanian Lapangan*, or PPL). However, adoption remains uneven, particularly among older members who experience difficulties using smartphones and social media. Irrelevant group messages can also distract from agricultural discussions, while face-to-face communication continues to serve an important complementary function. Interpreted through Diffusion of Innovations theory, the findings highlight the role of agricultural extension workers in facilitating technology adoption and addressing differences in digital literacy. The study argues that WhatsApp can strengthen rural agricultural communication when accompanied by practical digital literacy support, purposeful group management, and communication strategies that accommodate members with varying levels of technological proficiency.

Keywords: Whatsapp; Agricultural Communication; Farmer Groups; Digital Adoption; Agricultural Extension; Rural Indonesia

INTRODUCTION

Wonosari Village, Tanjung Morawa District is known as a village for farmers because the majority of the community's income comes from the agricultural sector. This makes this village attract attention, especially in seeing how farmers there are developing in utilizing new communication technology or new media (Aker, 2011; Purnomo & Kusnandar, 2019). In the context of the current digital era, changes in people's behavior, especially in the way of communication, determine whether or not a village develops in realizing a better quality of life. Therefore, this study focuses on farmer groups in Wonosari Village to explore changes in their communication

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behavior in the agricultural sector due to the use of new media (Mahasiswa & Kpi, 2024). Moreover, in the current condition, WhatsApp has become the most frequently used communication media by the community, especially farmers in Wonosari village. WhatsApp is used as an internal communication tool by farmers because it is easy to use and can also expand communication through WhatsApp groups to disseminate important information related to agriculture.

Social change, including changes in communication behavior, is a process that includes "changes in social norms, social values, social interactions, patterns of behavior, social organizations, societal institutions, power structures, responsibilities, and authority." In a community, such as a farmer group, social change can have an impact on how individuals and groups interact, share information, and utilize new technologies to support their activities (Tey & Brindal, 2012; Zhang & Mishra, 2024). Public communication in da'wah that utilizes social media in its delivery can provide opportunities for communicators and communicators to interact with each other directly, reach a wider audience, and the process of delivering da'wah messages is fast and efficient (Steinke et al., 2019; Van Campenhout et al., 2021) .

In this case, the success of societies to adapt to social change is highly dependent on their ability to create harmonious, mutually supportive, and innovative environments (Purnomo & Kusnandar, 2019; Shang et al., 2021) . Islamic Broadcasting Communication (KPI) is a discipline that studies how the delivery of da'wah messages and Islamic information is carried out through various media. In the context of farmer groups, KPI has a role in supporting the dissemination of Islamic-based agricultural information, using social media such as WhatsApp to strengthen communication and coordination (Porciello et al., 2022; Rose et al., 2021) .

In the case of the people of Wonosari Village, the use of new media by farmer groups still needs further research. The use of WhatsApp is not rare among farmers in Wonosari village, but the challenge is that many elderly residents do not understand how to use smartphones, let alone the WhatsApp application. Does this technology bring significant benefits in improving communication and farming effectiveness, or does it not have a significant impact? This study aims to analyze how new

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media affects changes in communication behavior of farmer groups in Wonosari Village, as well as identify benefits and challenges that arise in the context of agriculture. Thus, this research is expected to provide new insights into the role of communication technology in supporting the agricultural sector in the digital era (Ortiz-Crespo et al., 2021; Pesci et al., 2023) .

LITERATURE REVIEW

The Diffusion of Innovation Theory was first popularized by Everett Rogers in 1964 through his book entitled "*Diffusion of Innovations*". In this theory, Rogers explained that diffusion is the process by which an innovation is communicated through a specific channel within a certain period of time within a social system (Nakasone et al., 2014; Paustian & Theuvsen, 2017) . This process involves disseminating information about new ideas that were initially considered subjective, but through social construction, the meaning of the innovation evolves to be more objective (Magesa et al., 2023; Michels et al., 2020) .

In general, innovation diffusion can be interpreted as a social process in which new ideas are disseminated and adopted by society. This innovation was initially seen as subjective, but with the passage of time and through social interaction, the innovation becomes part of the norm or habit in society, therefore this research is very suitable to strengthen the theory of Everett Rogers in which this research can help farmers out there who still do not want any changes or technological innovations, especially communication through social media whatsapp which tends to be used a lot or various such as activities, organizations, and also among the community (Kudama et al., 2021; Mehrabi et al., 2020) .

The main components in the diffusion of innovation include several aspects. Innovation refers to new ideas, practices, or objects that are considered useful, such as the use of WhatsApp as a social communication medium. Communication channels are ways of communicating innovations to community members, such as through social media, training, or group discussions (Ingram & Maye, 2020; Klerkx & Rose, 2020) . Time is also an important factor in the innovation decision process which includes the stages of awareness, interest, evaluation, experimentation, and

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adoption. Adoption rates vary between groups, with early adopters tending to be quick to embrace innovation, while laggards are typically the slowest to embrace change. The social system includes a group of individuals or communities with a common goal, such as a group of farmers in Wonosari Village who utilize social communication technology (Granado-Díaz et al., 2024; Klerkx et al., 2019) .

RESEARCH METHODS

This research when viewed in its type includes qualitative descriptive research, which is research that only describes the phenomenon that occurs in detail which aims to explain aspects that are related to the observed phenomenon and explain the existing problems, both natural and man-made phenomena (Fabregas et al., 2019; Fielke et al., 2020) . These phenomena can be in the form of forms, activities, characteristics, changes, similarities, and differences between each other. This method focuses on the natural state of the research object, focusing on in-depth interviews, observations, documentation and also literature review to strengthen this research where data is collected without engineering, with the aim of obtaining thorough and in-depth information. In this study, the researcher applied a mentality of non-statistical data analysis techniques by using qualitative descriptive analysis, especially describing the symptoms and events of an event (Eastwood et al., 2019; Fernando, 2021). This research aims to explain and describe problems in a systematic, factual, and accurate manner. This approach is used to understand the nature, facts, and dynamics that occur in Wonosari Village, Tanjung Morawa District.

RESULTS AND DISCUSSION

Results

The farmer group in Wonosari Village was initially formed to make it easier for farmers to get subsidized fertilizers and as an extension of the government. Currently, farmer groups have collaborated with the Ministry of Agriculture and are under the auspices of the government. Farmer group activities include daily activities such as farming and scheduled weekly inspections. The media has only begun to be actively used in the last three years under the direction of PPL (Field Agricultural Extension Officer). This study aims to understand changes in the communication behavior of farmer

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groups in Wonosari Village, Tanjung Morawa District, in the new media era. Data was collected through in-depth interviews with the heads of farmer groups and direct observation in hamlet 4. This farmer group consists of 68 members who have taken advantage of new media for communication, although they still face some obstacles.



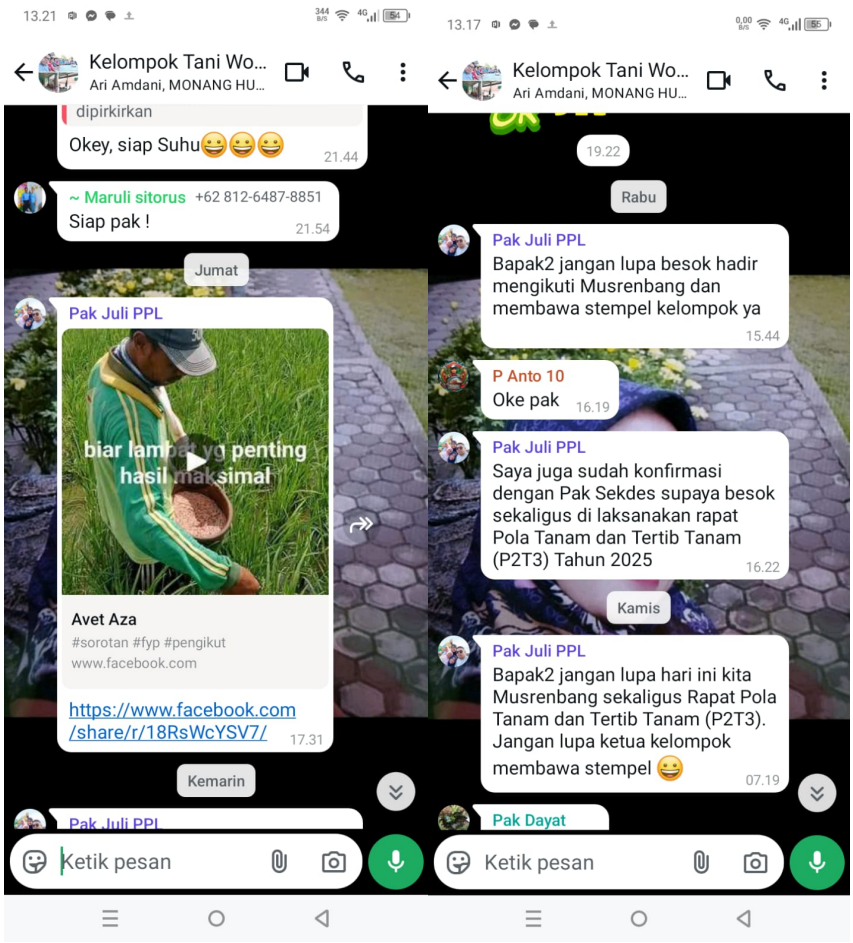
Gambar 1.1 Koordinasi Lapangan Antara PPL (Penyuluh Pertanian Lapangan) dengan Kelompok Tani Desa Wonosari
(Sumber: Ketua Kelompok Tani Dusun 4)

Before using new media, communication was traditionally carried out door-to-door, word of mouth, or at village events such as wirid. After using new media, information is now faster and more efficient conveyed through WhatsApp groups, although direct communication is still carried out for older members. The media used include WhatsApp, Facebook, and YouTube to share information and tutorials. There are several major obstacles in the use of new media. Many older members find it difficult to use social media such as WhatsApp, and irrelevant content is often sent to the group, causing inconvenience. To overcome this, the head of the farmer group continues to visit members who have not been able to use new media to convey information directly.

New media has created a platform to increase familiarity between members through digital communication. Minor conflicts, such as inconvenience due to irrelevant content, indicate the need for better group management. The use of WhatsApp and YouTube reflects the concept of

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"mediated social interaction" in new media theory, where technology becomes a bridge for faster and more efficient social interaction. New media make it easier to disseminate information and supervision carried out by PPL. Evidence such as screenshots of chats on WhatsApp shows this effectiveness. New media also increases familiarity between members by providing a space to share stories. But sometimes there are misunderstandings or inconveniences due to irrelevant content in the group.



Gambar 1.2 Screenshoot Room Chat Grup Kelompok Tani Desa Wonosari
(Sumber: Ketua Kelompok Tani Dusun 4 Desa Wonosari)

To overcome barriers in the adoption of new media, the government and PPL can play an important role in providing technology use training for older members. Better group management, such as relevant content guides, can improve communication effectiveness. This research provides

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an overview of the communication dynamics of farmer groups in the new media era. With the right support, new media have great potential to improve coordination and efficiency in farmer groups.

Discussion

In Islam, communication plays a very important role in conveying correct and useful information (Anggraini, 2024). This study highlights the use of WhatsApp by farmer groups, which is in line with the principles of Islamic Broadcasting Communication (KPI). This illustrates how the media can be used to convey positive messages and support the benefit of the people. In the Qur'an Surah Al-Hujurat verse 6, Allah SWT says:

يٰٓاَيُّهَا الَّذِيْنَ اٰمَنُوْٓا اِنْ جَاۤءَكُمْ فَاسِقٌۢ بِنَبَاٍ فَتَبَيَّنُوْٓا اَنْ تُصِيْبُوْا قَوْمًاۢ بِجَهَالَةٍ فَتُصْبِحُوْا عَلٰى مَا فَعَلْتُمْ نٰدِمِيْنَ (٦)

"O you who believe! If a wicked person comes to you with news, then examine (the truth), so that you do not bring a calamity upon a people without knowing the true circumstances, which will make you regret your deeds. "

This verse teaches that in disseminating information, it is important to clarify and verify. In the context of this research, farmer groups must ensure that the agricultural information they receive through WhatsApp is accurate and trustworthy. In addition, in Surah An-Nahl verse 125, Allah SWT says:

اُدْعُ اِلٰى سَبِيْلِ رَبِّكَ بِالْحِكْمَةِ وَالْمَوْعِظَةِ الْحَسَنَةِ وَجَادِلْهُمْ بِالَّتِيْ هِيَ اَحْسَنُۗ اِنَّ رَبَّكَ هُوَ اَعْلَمُ بِمَنْ ضَلَّ عَنْ سَبِيْلِهٖ وَهُوَ اَعْلَمُ بِالْمُهْتَدِيْنَ (١٢٥)

"Call (people) to the way of your Lord with wisdom and good instruction, and refute them in a better way."

This verse shows that the delivery of information, including among farmer groups, must be done with wisdom and wise methods. In this study, WhatsApp is used as a means to share useful agricultural information, facilitate productive discussions, and strengthen communication networks

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between farmers and agricultural extension workers (Deichmann et al., 2016; Dibbern et al., 2024) . From a KPI perspective, the use of WhatsApp by farmer groups reflects the theory of innovation diffusion, where new technologies are gradually adopted by the community. The role of agricultural extension workers in guiding farmers in the use of social media can be likened to the concept of tabligh (conveying the truth) in Islam (Choruma et al., 2024; Coggins et al., 2022) .

Thus, this study not only views WhatsApp as an ordinary communication tool, but also as a da'wah medium in the agricultural realm. The dissemination of correct, educative, and useful information in accordance with the principles of Islamic communication is the main focus of this study (Baumüller, 2018; Bronson & Knezevic, 2016). The internet is one of the results of advances in man-made science and technology, various functions of the internet such as a place for cyber social media communities, social media is a service that has an internet software system that allows users to interact and share data with other users on a large scale.

Social media has become a very popular platform among Indonesians, providing various ways to communicate, express themselves, and access information quickly. The word behavior in the English dictionary is called "*behave*" and "*conduct*". *Behave* means behavior, while *conduct* means behavior, behavior, attitude, character, leading, and demanding (Aker & Ksoll, 2016; Barnes et al., 2019) . So according to the review above, behavior change is the scope that relates actions to the behavior of a person in behaving, whether it is in the social environment of society or a certain group that causes someone to assess ourselves personally to get value in the community environment. Communication technology has developed with the times, making communication innovation easier and more practical (Abdullahi et al., 2021; Aker et al., 2016) .

In the classification of adopters, PPL plays a role in assisting farmers in understanding and utilizing the use of new media. Young members who are more open to technology become early adopters, while new members who adopt after seeing the success of other users fall into the late majority category (Abbasi et al., 2022; Aker, 2011; Aker & Ksoll, 2016). Older members who still rely on traditional communication fall into the category

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of laggards. Age factors and traditional habits are significant barriers to technology adoption, according to this theory. It was adopted by changes in communication in the farmer group of Wonosari Village following the stage of innovation diffusion, which started from awareness after directions from PPL about the use of new media. Young members are starting to show interest in new media and compare the benefits to traditional means. WhatsApp groups are used as a test in conveying information before most of the members end up (Baumüller, 2018; Coggins et al., 2022; Eastwood et al., 2019).

CONCLUSION

This study shows that the use of WhatsApp social media in communication of farmer groups in Wonosari Village has a positive impact on increasing the effectiveness of communication and coordination. Prior to the use of social media, communication within farmer groups was traditionally done through face-to-face meetings and verbal methods, which were often time-consuming and inefficient. However, after the adoption of WhatsApp and other social media, the dissemination of information became faster, accessibility increased, and coordination between members was more effective.

However, this study also found several obstacles in the implementation of social media. Key challenges include the digital divide between young and old, a lack of technological understanding among senior members, and potential communication disruptions due to less relevant content in WhatsApp groups. To overcome this obstacle, education and training efforts are needed from the government or related parties to increase the digital literacy of farmers so that the use of technology can be more optimal.

The results of this study confirm the relevance of the Innovation Diffusion theory in the context of farmer group communication. The social media adoption process follows a pattern of awareness, interest, evaluation, experimentation, and adoption stages, where farmers gradually begin to embrace new technologies after seeing the benefits firsthand. With better management and support from other parties, social media can become a more effective tool in supporting communication and development of the agricultural sector in the digital era.

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BIBLIOGRAPHY

1) Abbasi, R., Martinez, P., & Ahmad, R. (2022). The digitization of agricultural industry—A systematic literature review on Agriculture 4.0. *Smart Agricultural Technology, 2*, 100042. https://doi.org/10.1016/j.atech.2022.100042
2) Abdullahi, K. A., Oladele, O. I., & Akinyemi, M. (2021). Attitude, knowledge and constraints associated with the use of mobile phone applications by farmers in North West Nigeria. *Journal of Agriculture and Food Research, 6*, 100212. https://doi.org/10.1016/j.jafr.2021.100212
3) Aker, J. C. (2011). Dial "A" for agriculture: A review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics, 42*(6), 631–647. https://doi.org/10.1111/j.1574-0862.2011.00545.x
4) Aker, J. C., Ghosh, I., & Burrell, J. (2016). The promise (and pitfalls) of ICT for agriculture initiatives. *Agricultural Economics, 47*(S1), 35–48. https://doi.org/10.1111/agec.12301
5) Aker, J. C., & Ksoll, C. (2016). Can mobile phones improve agricultural outcomes? Evidence from a randomized experiment in Niger. *Food Policy, 60*, 44–51. https://doi.org/10.1016/j.foodpol.2015.03.006
6) Barnes, A. P., Soto, I., Eory, V., Beck, B., Balafoutis, A., Sánchez, B., Vangeyte, J., Fountas, S., van der Wal, T., & Gómez-Barbero, M. (2019). Exploring the adoption of precision agricultural technologies: A cross regional study of EU farmers. *Land Use Policy, 80*, 163–174. https://doi.org/10.1016/j.landusepol.2018.10.004
7) Baumüller, H. (2018). The little we know: An exploratory literature review on the utility of mobile phone-enabled services for smallholder farmers. *Journal of International Development, 30*(1), 134–154. https://doi.org/10.1002/jid.3314
8) Bronson, K., & Knezevic, I. (2016). Big Data in food and agriculture. *Big Data & Society, 3*(1), 1–5. https://doi.org/10.1177/2053951716648174
9) Choruma, D. J., Dirwai, T. L., Mutenje, M., Mustafa, M., Chimonyo, V. G. P., Jacobs-Mata, I., & Mabhaudhi, T. (2024). Digitalisation in agriculture: A scoping review of technologies in practice, challenges, and opportunities for smallholder farmers in Sub-Saharan Africa. *Journal of Agriculture and Food Research, 18*, 101286. https://doi.org/10.1016/j.jafr.2024.101286

This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

10) Coggins, S., McCampbell, M., Sharma, A., Sharma, R., Haefele, S. M., Karki, E., Hetherington, J., Smith, J., & Brown, B. (2022). How have smallholder farmers used digital extension tools? Developer and user voices from Sub-Saharan Africa, South Asia and Southeast Asia. *Global Food Security, 32*, 100577. https://doi.org/10.1016/j.gfs.2021.100577
11) Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). SAGE.
12) Deichmann, U., Goyal, A., & Mishra, D. (2016). Will digital technologies transform agriculture in developing countries? *Agricultural Economics, 47*(S1), 21–33. https://doi.org/10.1111/agec.12300
13) Dibbern, T., Romani, L. A. S., & Massruhá, S. M. F. S. (2024). Main drivers and barriers to the adoption of digital agriculture technologies. *Smart Agricultural Technology, 8*, 100459. https://doi.org/10.1016/j.atech.2024.100459
14) Eastwood, C., Klerkx, L., Ayre, M., & Dela Rue, B. (2019). Managing socio-ethical challenges in the development of smart farming: From a fragmented to a comprehensive approach for responsible research and innovation. *Journal of Agricultural and Environmental Ethics, 32*(5–6), 741–768. https://doi.org/10.1007/s10806-017-9704-5
15) Fabregas, R., Kremer, M., & Schilbach, F. (2019). Realizing the potential of digital development: The case of agricultural advice. *Science, 366*(6471), eaay3038. https://doi.org/10.1126/science.aay3038
16) Fernando, A. N. (2021). Seeking the treated: The impact of mobile extension on farmer information exchange in India. *Journal of Development Economics, 153*, 102713. https://doi.org/10.1016/j.jdeveco.2021.102713
17) Fielke, S., Taylor, B., & Jakku, E. (2020). Digitalisation of agricultural knowledge and advice networks: A state-of-the-art review. *Agricultural Systems, 180*, 102763. https://doi.org/10.1016/j.agsy.2019.102763
18) Granado-Díaz, R., Colombo, S., Romero-Varo, M., & Villanueva, A. J. (2024). Farmers' attitudes toward the use of digital technologies in the context of agri-environmental policies. *Agricultural Systems, 221*, 104129. https://doi.org/10.1016/j.agsy.2024.104129
19) Ingram, J., & Maye, D. (2020). What are the implications of digitalisation for agricultural knowledge? *Frontiers in Sustainable Food Systems, 4*, 66. https://doi.org/10.3389/fsufs.2020.00066
20) Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and Agriculture 4.0: New

This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

contributions and a future research agenda. *NJAS – Wageningen Journal of Life Sciences, 90–91*, 100315. https://doi.org/10.1016/j.njas.2019.100315

21) Klerkx, L., & Rose, D. C. (2020). Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways? *Global Food Security, 24*, 100347. https://doi.org/10.1016/j.gfs.2019.100347
22) Kudama, G., Dangia, M., Wana, H., & Tadese, B. (2021). Will digital solution transform Sub-Sahara African agriculture? *Artificial Intelligence in Agriculture, 5*, 292–300. https://doi.org/10.1016/j.aiia.2021.12.001
23) Magesa, M., Jonathan, J., & Urassa, J. (2023). Digital literacy of smallholder farmers in Tanzania. *Sustainability, 15*(17), 13149. https://doi.org/10.3390/su151713149
24) Mehrabi, Z., McDowell, M. J., Ricciardi, V., Levers, C., Martinez, J. D., Mehrabi, N., Wittman, H., Ramankutty, N., & Jarvis, A. (2021). The global divide in data-driven farming. *Nature Sustainability, 4*, 154–160. https://doi.org/10.1038/s41893-020-00631-0
25) Michels, M., Fecke, W., Feil, J.-H., Musshoff, O., Pigisch, J., & Krone, S. (2020). Smartphone adoption and use in agriculture: Empirical evidence from Germany. *Precision Agriculture, 21*(2), 403–425. https://doi.org/10.1007/s11119-019-09675-5
26) Nakasone, E., Torero, M., & Minten, B. (2014). The power of information: The ICT revolution in agricultural development. *Annual Review of Resource Economics, 6*, 533–550. https://doi.org/10.1146/annurev-resource-100913-012714
27) Ortiz-Crespo, B., Steinke, J., Quirós, C. F., van de Gevel, J., Daudi, H., Mgimiloko, M. G., & van Etten, J. (2021). User-centred design of a digital advisory service: Enhancing public agricultural extension for sustainable intensification in Tanzania. *International Journal of Agricultural Sustainability, 19*(5–6), 566–582. https://doi.org/10.1080/14735903.2020.1720474
28) Paustian, M., & Theuvsen, L. (2017). Adoption of precision agriculture technologies by German crop farmers. *Precision Agriculture, 18*(5), 701–716. https://doi.org/10.1007/s11119-016-9482-5
29) Pesci, S., Galt, R. E., Durant, J. L., Manser, G. M., Asprooth, L., & Pinzón, N. (2023). A digital divide in direct market farmers' online sales and marketing: Early pandemic evidence from California. *Journal of Rural Studies, 101*, 103038. https://doi.org/10.1016/j.jrurstud.2023.103038

This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

30) Porciello, J., Coggins, S., Mabaya, E., & Otunba-Payne, G. (2022). Digital agriculture services in low- and middle-income countries: A systematic scoping review. *Global Food Security, 34*, 100640. https://doi.org/10.1016/j.gfs.2022.100640

31) Purnomo, S. H., & Kusnandar. (2019). Barriers to acceptance of information and communication technology in agricultural extension in Indonesia. *Information Development, 35*(4), 512–523. https://doi.org/10.1177/0266666918767484

32) Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.

33) Rose, D. C., Wheeler, R., Winter, M., Lobley, M., & Chivers, C.-A. (2021). Agriculture 4.0: Making it work for people, production, and the planet. *Land Use Policy, 100*, 104933. https://doi.org/10.1016/j.landusepol.2020.104933

34) Shang, L., Heckelei, T., Gerullis, M. K., Börner, J., & Rasch, S. (2021). Adoption and diffusion of digital farming technologies—Integrating farm-level evidence and system interaction. *Agricultural Systems, 190*, 103074. https://doi.org/10.1016/j.agsy.2021.103074

35) Steinke, J., Achieng, J. O., Hammond, J., Kebede, S. S., Mengistu, D. K., Mgimiloko, M. G., Mohammed, J. N., Musyoka, J., Sieber, S., van de Gevel, J., van Wijk, M., & van Etten, J. (2019). Household-specific targeting of agricultural advice via mobile phones: Feasibility of a minimum data approach for smallholder context. *Computers and Electronics in Agriculture, 162*, 991–1000. https://doi.org/10.1016/j.compag.2019.05.026

36) Tey, Y. S., & Brindal, M. (2012). Factors influencing the adoption of precision agricultural technologies: A review for policy implications. *Precision Agriculture, 13*(6), 713–730. https://doi.org/10.1007/s11119-012-9273-6

37) Van Campenhout, B., Spielman, D. J., & Lecoutere, E. (2021). Information and communication technologies to provide agricultural advice to smallholder farmers: Experimental evidence from Uganda. *American Journal of Agricultural Economics, 103*(1), 317–337. https://doi.org/10.1002/ajae.12089

38) Zhang, J., & Mishra, A. K. (2024). ICT adoption, commercial orientation and productivity: Understanding the digital divide in rural China. *Smart Agricultural Technology, 9*, 100560. https://doi.org/10.1016/j.atech.2024.100560

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