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Mobile App Technology Adoption in Indonesia's Agricultural Sector: An Analysis of Empirical View from Public R&D Agency

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ABSTRACT

The adoption of digital technologies is expected to transform current agricultural system towards sustainability. Mobile application (mobile app) designed to assist farmers decision making has started to revolutionize the agricultural sector. The app can offer solutions to farmers by providing information of season prediction, cropping pattern, recommended fertilizers and varieties and so on. This paper aims to review a framework that adequately summarizes some of the determining factors for diffusion and adoption of digital farming technologies then discussed with local data based on the empirical view of public R&D agency engaged in agricultural sector. The result showed the framework could be used as the reference by providing important factors of the diffusion and adoption process of digital technologies. The findings of this study provided what matters more and less to strengthen the framework. However, limitations remain and future research is needed to improve the unit of analysis and the understanding.

I. INTRODUCTION

Agricultural sector faces many challenges to meet the demand while it needs to improve overall productivity (Cole, 2018; Finger et al., 2019; Girard & Payrat, 2017). It occurs as well in Indonesia. Efficiency and better management are the main issues. Digital technologies or smart farming or Agriculture 4.0 is expected to address these challenges by using information and communication technologies for data collection such as mobile apps, drones and robots to support the automation and sustainable processes (Bacco et al., 2019; OECD, 2019). These digital technologies have potential and disruptive impact for sustainable process in the future (Walter et al., 2017) that make it very important to understand the adoption of these technologies (Shang et al., 2021).

Since Indonesia government launched *Making Indonesia 4.0* program in 2018, innovation capabilities based on digital technology development from public R&D agencies are urgently

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needed to support the development of local industry and local commodity sectors[1]. Thereafter, digital technologies development has become a very prevalent theme particularly in public research and development (R&D) agencies.

Technology development is the main mission for public R&D agencies. However, another role which is very important that must be fulfilled is diffusion to benefit the society (Laliene & Liepe, 2015). Diffusion is an interactive process to deliver new product by changing the mindset and actions of potential users (Jamal et al., 2008; Rogers, 2003). While adoption is the outcome of diffusion.

The mechanism of digital technologies adoption must be understood on both the field and system level (Shang et al., 2021). The system depends on both user characteristics and environment conditions of the system (Alexander et al., 2013), for adoption to occur. The studies of digital technologies adoption in agricultural sector have emerged in recent years (Caffaro & Cavallo, 2019; Chuang et al., 2020; Drewry et al., 2019; Michels et al., 2020; Pivoto et al., 2019; Salimi et al., 2020; Thar et al., 2021; Zheng et al., 2019). Most of the cases came from USA and other developed countries. From these previous cases, Shang et al., (2021) has constructed a framework of diffusion and adoption of digital farming technologies integrating farm level evidence and system interaction. They have summarized some of the determining factors for diffusion and adoption so that it can be applied in studies investigating farmers' adoption decisions. However, they have pointed out that the implementation of this framework will require a more detailed specification in the context of the specific technology and region. This paper showed and discussed the different contexts related to specific technology and region in indonesia compared to the general result of the framework.

The public R&D Agency under Ministry of Agriculture of the Republic of Indonesia, as one of the largest agricultural R&D Agencies in Indonesia, was identified to have developed many products based on digital technologies from mobile apps, smart greenhouse, drones, to autonomous tractors. The reason why the viewpoint from this public R&D has increased because it is a large agency with the experience in developing and diffusing various types of agricultural technology from mechanical to digital.

This paper examined the integrated framework proposed by Shang et al., (2021) supported by a case of mobile app technology in which the data is based on the experience of the public agricultural R&D Agency under Ministry of Agriculture of the Republic of Indonesia in the diffusion of digital technology to local society. This knowledge will be useful as an input to increase the potency of the framework in its implementation for the diffusion of digital technologies that can be used by related stakeholders (i.e other ministries, agricultural firms and startups, university) in the context of mobile app technology in Indonesia. This study only analyzes insight from an R&D agency perspective; a limitation of the study. Nonetheless this agency, supported by its dissemination affairs division, has been building engagement with local authorities, extension services, and farmers.

II. METHODOLOGY

Agricutural sector should be one of Indonesia's comparative advantage by contributing 29.8% of manpower and giving 12,7% of contribution to Gross Domestic Product [GDP] (Statistics Indonesia, 2019). This paper takes the definition of agricultural sector or agriculture from Statistics Indonesia (2019) or locally known as BPS. BPS is a government institute of Indonesia that is responsible for conducting statistical surveys including surveys in agricultural sector. According to BPS, agriculture is a business activity which includes the cultivation of crops, horticulture, plantation, fishery, forestry and livestock.

This paper focus intentionally on the implementation of mobile application technology, specifically crops commodity (i.e rice, corn, soybean) that has been built by the public R&D Agency under Indonesia Ministry of Agriculture to provide a guideline of crop planting. This mobile technology has been implemented particularly in

[1] Opening remarks from Head of Research and Development Agency – Ministry of Industry at the launching event of Making Indonesia 4.0 as a part of Indonesia Industrial Summit Series in Jakarta - April 4, 2018

Java Island. From the report, in 2020, there were 9 public R&D agencies in Indonesia that have been identified as developing digital technology-based products (Febrianda et al., 2020) including The R&D Agency under Ministry of Agriculture of the Republic of Indonesia. However, most of the products from this agency were still prototype. Katam Terpadu is appointed because it was being diffused to farmers and claimed to be quite well accepted by its current users. The pro-innovation bias is the implication of most diffusion research that an innovation should be diffused and adopted by all members of a social system. This bias leads to underemphasize the rejection or discontinuance of innovations even though rejection or discontinuance can provide an important knowledge about how to prevent rejection. Therefore, data gathering can be conducted while the diffusion is still underway (Rogers, 2003).

This paper uses a qualitative approach based on deductive research logic. The conceptual framework serves as a tentative theory then tested with local data. Deductive research logic begins with theory and is aimed at testing arguments (Rashid et al., 2019).

Data were gathered through online interview and discussion by using Zoom meetings from August to December in 2020. The informants consisted of 3 related people: the head of dissemination affairs, 1 research and engineering staff, and 1 supporting staff from the public R&D Agency under Ministry of Agriculture of the Republic of Indonesia involved in the diffusion activities. Triangulation among informants and reengaging them with the result (member checking) were the aspects for validity and reliability of the study.

III. ANALYTICAL FRAMEWORK

This paper used the framework from Shang et al., (2021) and reviewed 32 empirical level studies on the adoption of precision and digital technologies and the diffusion of agricultural innovations. This study synthesized literature from the cases of USA, European countries, Canada, Australia, Brazil, China, and Iran to develop an empirically grounded conceptual framework. Apart from reviewing 32 empirical farm-level studies on the adoption of precision and digital farming technologies, 27 agent-based models were studied on the diffusion of agricultural innovations because these two approaches are weakly integrated (Shang et al., 2021). This is the latest integrated study that may serve as a reference for studying the adoption and diffusion of digital technologies. The results are synthesized then categorized into 6 influencing factors:

- Farm characteristic. It related to the farm size, biophysical condition.
- Operator characteristic. It related to education, age, income, knowledge and capacity.
- Interaction. It related to the interaction of users with consultant, extension service, farmer community, technology provider, other farmers, events.
- Institution. It related to subsidy/credit and regulations.

Table 1.
Product profiles

Name of product	Source	Type & Function	Status
Katam terpadu	R&D Agency – Ministry of Agriculture	It is commonly referred to as an app, is a type of application software designed to run on a mobile device, such as a smartphone. It provides guidelines and information about integrated cropping calendar including season prediction, cropping pattern, potential planting area, recommended fertilizer and varieties, tools and machinery, information for extension center, and supporting information. It runs on android device and computer as well	implemented

Source: Author's data

- Attributes of technology. It related to relative advantage, complexity, compatibility.
- Phsycological. It related to attitude, subjective norms and perceived behavioral control.

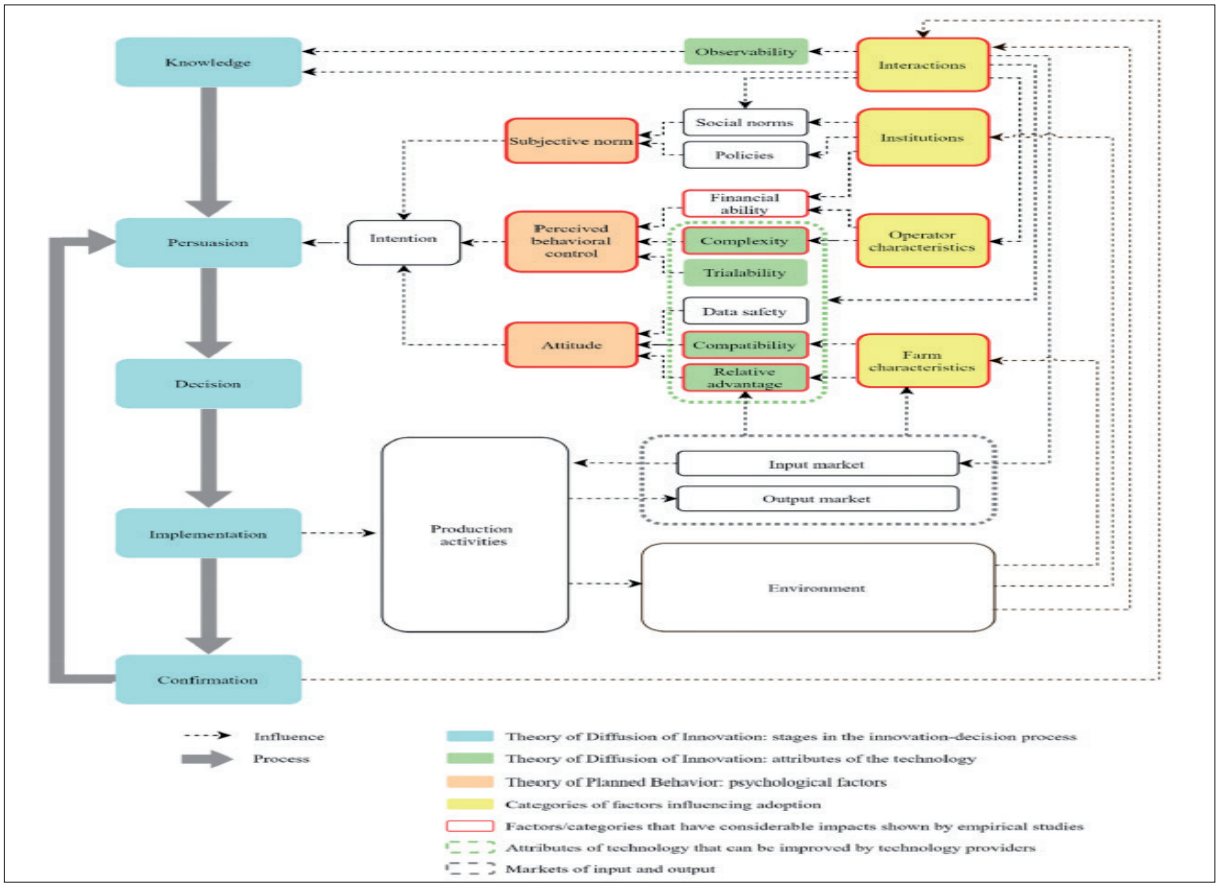
These factors are accepted as influencing factors on farmers' technology adoption decision-making at different stages of the adoption. These stages of adoption used inn this framework came from the theory of Diffusion of Innovation/DOI (Rogers, 2003).

IV. RESULT AND DISCUSSION

a) Knowledge stage

This is the first stage where users or farmers became aware of a technology's existence and eventually is interested. Knowledge about a new technology comes from interactions with agents (Rogers, 2003). In this stage, usually information spreads in a social network (Beretta et al., 2018).

The framework indicates that interaction with agents (i.e technology provider and extension service) who both introduce technology and serve as advisory service, had considerable impact during knowledge stage. Events (i.e agricultural trade, shows and workshops) in general also play a role in farmers' adoption. Networking events like attending workshops and exhibitions significantly influence farmers' adoption (Tamirat et al., 2018). However, the framework concludes that there is no significant impact from a farmer community and other similar farmers. The finding indicated that these factors (agents and events) had an impact only on new farmers. In diffusion of innovation theory, they (earlier adopters) are usually younger, had more years of education, and had larger sized farms. They only cover 13.5% of adopter categorization (Rogers, 2003). The finding showed that most of the farmers received the information about this mobile app technology from their community or organization and their



Source: Shang et al. (2021)

Figure 1. Conceptual framework of adoption and diffusion of digital farming technologies.

peers. They started to get interested when that information is accompanied by a success story from their fellow farmers. Therefore, this finding signifies that it becomes very important to create role models from the knowledge stage to reach more adopters by exchanging positive information and experience in using new technology. (Kutter et al., 2011; and Roger, 2003), had stated the same argument.

While the observability (visible to others) of technology by peers is considered in the framework to have no impact to the adoption rate. The finding showed that such visibility stimulated peer discussion among fellow farmers that lead to an intention to adopt. The easier it is for individuals to see the results of the products, the more likely they are to adopt (Rogers, 2003).

b) Persuasion stage

The second stage is a persuasion stage. This is a very important stage where farmers ascertain the potential value of adoption. Intention to adopt, as the output of the persuasion stage, is determined by attitude, subjective norms, and perceived behavioral control.

First, subjective norms. It refers to the perceived pressure or expectation to adopt or not. It is influenced by policy or institution and social norms. Institutions in society can have a positive impact for the adoption. For example, subsidy/credit is believed to have a positive effect on adoption. The main constraint to adopt agricultural apps in Myanmar is lack of access to smartphone (Thar et al., 2021). From this case, the mobile app is free. Farmers need only a proper mobile device like regular smartphone. It did not interfere with the adoption process because farmers could use a cellular phone to obtain the guide information through short message service/SMS. Yet the complete manual requires access from mobile app and it needs a smartphone. Social norm is influenced by interaction (mainly with respected farmers or role models). Most of the farmers started to have interest and intention when that information is accompanied by a success story from respected farmers or their role models. External pressure from farmers' community positively contributes to adoption (Aubert et al., 2012).

Second, perceived behavioral control refers to farmers' believed ability to implement adoption. It is influenced by farmers' financial ability and complexity of the technology. Farmers' financial ability depends on both income (included in operator characteristic) and subsidy/credit accessibility (included in institution). Complexity depends on farmers' characteristic including education, age, knowledge and capacity. The finding justifies the framework where most of the adopters were with higher income and were young farmers. More importantly, these young farmers have better digital literacy. Lack of knowledge and capacity, especially in software and data transfer, is a barrier to digital technology adoption (Katalin et al., 2018). Nevertheless, it was also found that some of the older farmers showed moderate confidence when they had support from young family member or young co-workers with better digital literacy. The role of this member is to create a positive opinion of ability to implement adoption. Therefore, it is quite important to bring this member into the diffusion process because he/she can assist the main operator orthe main farmer in routine use of the technology.

Third, attitude refers to farmers' positive or negative evaluation of adoption. It is influenced by farmer's assumptions about the relative advantage and compatibility of technology to the existing condition (Shiau et al., 2018). Farmers' assumption about relative advantage and compatibility depends on farm characteristics. Relative advantage is a perceived usefulness like increasing productivity, profitability or offering better management (Reichardt & Jürgens, 2009). Relative advantage (especially profitability) depends on the cost and benefit of the technology. In this case, the app did not require high cost while it can provide various information towards better planting management. The app seems to produce a positive relative advantage. Farmers' attitude was influenced primarily by compatibility of the app which depends on biophysical conditions or infrastructure that refers to the technical adaptability of the technology (Robertson et al., 2012). Poor telecommunication infrastructure is still the barrier to have full access especially in marginal areas because the app needs internet connection.

It seems that because of this, its implementation is still being carried out in Java.

c) Decision stage

After intention is formed in the persuasion stage, farmers decided to adopt in the decision stage. Adoption is a decision to make a full use of the technology as the best course of action available (Rogers, 2003; Shang et al., 2021).

d) Implementation stage

Implementation occurs when farmers both installed the app and put the guideline from the app into use. The implementation stage depends on environment such as field infrastructure.

e) Confirmation stage

The confirmation stage refers to an evaluation based on whether the criteria initially set up for adoption/rejection has been met. The farmer confirms if the technology will be considered for the next simulation period according to the performance of the technology. Farmers' evaluation is the input for technology providers (included in interaction) so that they can improve some attributes of the technology (Xu et al., 2020).

The finding showed that while the role models adopted then implemented the app by trying it first with mentoring mechanism from technology provider or extension service, the rest implemented the app without trial. Trial is an important part of the decision to adopt (Rogers, 2003), yet the success trial from the earlier adopters can be a good sample to be followed. Nevertheless, the evaluation has not been carried out in long term.

V. LIMITATION

There are some limitations in this study that could be addressed in future research. First, data gathering was carried out during pandemic situation, therefore this study could not reach other important actors such as farmers and extension services by online. They must be reached by field study. Study using quantitative approach, for example a survey, involving farmers and extension services will improve the current discussion especially the context in Indonesia. Data from these actors will be very important to strengthen the validity of the study as well. Second, this study described the adoption of mobile app technology in crops production. This leads to the specification that might not be relevant for other specific technologies and other commodities. Third, there are several factors that are not related to this study, for example farm characteristics (i.e land ownership and farm succession) could be an important factor influencing farmers' adoption decision in that require high investment. In this study, the initial investment is not much. Fourth, the focus of analysis lies in the knowledge and persuasion stage where the intention of adoption is built. For example, in the confirmation stage where farmers confirm it after some period of real use (not trial) according to the performance of the app technology and will try to give some feedback. This insight will be very important to improve the complete understanding as well as the aspect of sustainability.

VI. CONCLUSION

In the knowledge stage, interaction with agents and events are important to obtain the information. However, it was found that most of the farmers received the information from their community. Interaction with farmers' community also play an important role in the first stage of adoption. In these interactions, the observability factor of technology stimulated discussion among fellow farmers on their community.

In the persuasion stage, farmers' mindset was built. This mindset depends on their psychological factors as subjective norm, perceived behavioral control, and attitude. These psychological factors are influenced by various factors such as interaction, institution, operator characteristic, farm characteristic, and attributes of technology. Furthermore, this study also indicates that support from a younger member can reduce the complexity perceived as relatively difficult to understand and to use by the older farmer. Trialability of the technology is still important especially for the role models who firstly adopted the technology by trial activity.

Table 2.
The influencing factors in the knowledge and the persuasion stage.

Stages	Framework	Finding
Knowledge	Interaction with agents (i.e technology provider, extension service).	Interaction with agents (i.e technology provider, and extension service).
		Observability of technology (included in attributes of technology).
		Interaction with farmers' community (included in interaction).
	Interaction with events (i.e agricultural trade, shows and workshops).	Interaction with events (i.e agricultural trade, shows and workshops).
Persuasion	Subjective norm (included in phsycological) is influenced by subsidy/credit (included in institution).	Subjective norm (included in psyhcological) is influenced by subsidy/credit (included in institution).
	Subjective norm is also influenced by social norm. Social norm is influenced by respected farmers or role models (included in interaction).	Subjective norm is also influenced by social norm. Social norm is influenced by respected farmers or role models (included in interaction).
	Perceived behavioral control (included in phsycological) is influenced by income (included in operator characteristics) and subsidy/credit access (included in institution).	Perceived behavioral control (included in phsycological) is influenced by income (included in operator characteristic).
	Perceived behavioral control is also influenced by complexity (included in attributes of technology). Complexity is influenced by education, age, knowledge and capacity (included in operator characteristic).	Perceived behavioral control is also influenced by complexity (included in attributes of technology). Complexity is influenced by education, age, knowledge and capacity (included in operator characteristic).
		Complexity is influenced by support from young family member or young co-worker.
		Perceived behavioral control (included in phsycological) influenced by trialability (included in attributes of technology) especially for earlier adopter.
	Attitude (included in phsycological) is influenced by relative advantage and compatibility (included in attributes of technology).	Attitude (included in phsycological) is influenced by relative advantage and compatibility (included in attributes of technology).
	Relative advantage is influenced by cost and benefit.	Relative advantage is influenced by cost and benefit.
	Compatibility is influenced by infrastructure.	Compatibility is influenced by infrastructure.

Factors that have impact on both the framework and the finding

Factors that are also considered to have impact from the finding

VII. IMPLICATION TO MANAGEMENT

These are the implications both from the framework and related literature as well as from the finding to foster the diffusion and adoption of mobile app technologies through interventions. They are as follows:

- New technology can be diffused through media or social media, and the events (i.e exhibition, workshop) involving stakeholders (i.e technology provider, extension services, local authorities, farmers' communities) (Indraningsih, 2018; Shang et al., 2021).
- Building a good cooperation and collaboration with extension services to diffuse new technology to farmers' community. The

adoption of new technology usually occurs as there is communication among peers that occurs within the group or organization of potential users (Dearing & Kreuter, 2010; Rice, 2017; Rogers, 2003).

- Creating role models as opinion leader. The role of this figure is important to motivate other potential users who are still hesitant to adopt new technology.
- Recruiting new technology ambassadors from younger members (i.e family or co-worker) that has better digital literacy to support the complexity that perceived as relatively difficult to understand and use by older users.
- Strive for an attractive user interface but easy-to-understand. The lower the complexity, the better the user's perception (Magsamen-Conrad & Dillon, 2020).

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