

THE DETERMINANTS OF SUSTAINABLE AGRICULTURAL TECHNOLOGY ADOPTION

Faktor-Faktor Penentu Adopsi Teknologi Pertanian dan Keberlanjutannya

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Naskah diterima: 14 Juni 2020

Direvisi: 17 Agustus 2020

Disetujui terbit: 30 Oktober 2020

ABSTRAK

Pertanian memiliki peran penting karena lebih dari 60% populasi dunia bergantung pada pertanian sebagai mata pencaharian. Salah satu faktor penyumbang besar terhadap pertumbuhan produktivitas pertanian adalah penerapan teknologi baru. Teknologi baru pertanian diharapkan berperan sebagai jalan penting untuk keluar dari kemiskinan di sebagian besar negara berkembang. Namun, realita menunjukkan tingkat adopsi teknologi pertanian dianggap masih relatif rendah. Makalah ini merupakan *scientific review* yang merangkum dan menganalisis hasil-hasil penelitian tentang adopsi teknologi pertanian. Tujuan makalah adalah untuk mengamati pengalaman di sejumlah negara terkait adopsi teknologi pertanian dan menentukan faktor-faktor yang memengaruhi adopsi serta keberlanjutan suatu adopsi teknologi. Hasil studi mengungkapkan bahwa keputusan petani untuk mengadopsi teknologi baru bergantung pada interaksi dinamis antara karakteristik teknologi dan kondisi lingkungannya. Beberapa aspek yang memengaruhi adopsi teknologi pertanian antara lain aspek teknologi, ekonomi dan keuangan, sosial dan kelembagaan, serta usaha pertanian dan karakteristik rumah tangga petani. Namun, penentu adopsi teknologi pertanian tidak selalu tunggal, melainkan kombinasi dari beberapa faktor sehingga untuk memacu adopsi teknologi harus memperhitungkan semua faktor penentunya. Pendekatan yang komprehensif menjadi pilihan terbaik untuk menyebarluaskan teknologi baru pertanian. Pemerintah dapat menjadi fasilitator untuk adopsi teknologi dan memastikan teknologi yang disebarkan bermanfaat bagi petani.

Kata kunci: *adopsi, adopsi teknologi, faktor penentu, keputusan petani, teknologi pertanian*

ABSTRACT

Agriculture plays an essential role because more than 60% of the world's population depend on this sector. One of the factors contributing to the growth of agricultural productivity is new technology application. Agricultural technologies are crucial to alleviate poverty in most developing countries. However, adoption rate of the mentioned technologies keeps low in many countries. This paper aims to review some studies related to new technology adoption and to determine the influencing factors. The study revealed that farmers' decisions to adopt new technology depended on dynamic interaction between the technology's characteristics, conditions and circumstances. At least four aspects affect agricultural technology adoption, i.e., (i) technology, (ii) economy and finance, (iii) society and institution, and (iv) farm business and farmer household aspects. However, there is no single determinant of agricultural technology adoption instead of combining some elements. Improving adoption rate should take into account the entire factors. Thus, a comprehensive approach is the best choice to disseminate new technology. The government could play as a facilitator for technology adoption and ensure that such technology creates farmers' benefits.

Keywords: *adoption, agricultural technology, determinant factors, farmers' decision, technology adoption*

INTRODUCTION

Agriculture plays a vital role in economic growth, enhancing food security, poverty reduction, and rural development. Cited FAO data, Zavatta (2014) mentioned that more than 60% of the world's population depends on

agriculture for survival. This sector has counted for a 2.9% increase in the global GDP growth with differences at the continental level. The agricultural industry's growth was 14% in Africa, 5.9% in Latin America, 5% in Asia, 10% in China, and just 1.6% in Europe, 1.2% in the US, and 3.3% in Oceania. Smallholder agriculture is

also identified as a vital instrument for achieving Millennium Development Goals, one of which is to release the people suffering from extreme poverty and hunger by 2015 (World Bank 2008). Cervantes-Godoy and Dewbre (2010) argued that agricultural income growth is more effective in reducing poverty than other sectors. The reason for such an argument is (1) incidence of poverty tends to be higher in agricultural and rural populations than elsewhere, and (2) most of the poor live in rural areas, and a large share of them depends on agriculture for a living.

Various factors contribute to the growth of agricultural productivity; one of the most significant roles is technology application. Increasing agricultural productivity is crucial to fulfilling expected rising demand, and, as such, it is useful to examine recent performance in modern agricultural technologies (Challa 2013). Agricultural technologies include all kinds of improved techniques and practices that influence the growth of agricultural output (Jain et al. 2009).

Sunding and Zilberman (2002) noted that the change of technology was a primary element that shaped the agricultural sector in the last 100 years. In the range of period, the remarkable transformation in production patterns has occurred worldwide. Cassman (1999) revealed that the rapid growth in agricultural productivity beginning in the mid-1960s was primarily a result of four types of technological advancements, i.e., improved germ-plasma, increased fertilizer use, double cropping, and irrigation. According to Mwangi and Kariuki (2015), agricultural technologies are seen as an important route out of poverty in most developing countries. However, the adoption rate of the mentioned technologies has remained low in most of the countries.

The majority of smallholder farmers depend on traditional production methods, which has lowered the level of productivity. For instance, the study of Muzari et al. (2012) mentioned that over 70% of the maize production in the majority of developing countries is from smallholders who use traditional production methods. These farmers generally obtain low crop yields because the local varieties used by farmers have a low potential return. Most of the maize is grown under rain-fed conditions, and irrigation is used only in limited areas, little or no fertilizers are used, and pest control is not adequate. This phenomenon has triggered much discussion on the needs to increase productivity and sustainability in agriculture globally, but much less information is available on specific means to achieve this goal.

The importance of technology and the adoption of new agricultural technologies, mainly in developing countries, have attracted many researchers to explore this phenomenon. They consider that agriculture still occupies a notable role in those countries. Hence, the existence of innovation could generate an opportunity to lift farmer's income, which, in turn, enables alleviating poverty (Sharifi et al. 2010).

Many studies on innovation have been conducted and uptake of new technologies in developing countries over the decades. The process of adoption and the impact of adopting new technology on smallholder farmers have also been elaborated. However, modern agricultural adoption is often adopted slowly, and several aspects of adoption remain poorly understood (Bandiera and Rasul 2002; Simtowe 2011).

The paper aims to review various studies related to the adoption of new technology and define the determinant factors responsible for technology adoption. Besides, it also to know the factors responsible for the sustainability of adoption. The study results are expected to help the government and other stakeholders withdraw a policy recommendation or program to increase the technology adoption rate and maintain its sustainability.

CONCEPT OF TECHNOLOGY AND ADOPTION

Concept of Technology

Studies on technology adoption have been undertaken for more than four decades. One of the most prominent adoption models applied is Roger's proposal in his remarkable book called "Diffusion of Innovation." Rogers (2003) defined technology as "a design for instrumental action reducing uncertainty in the cause-effect relationship involved in achieving the desired outcome." Meanwhile, Loevinsohn et al. (2012) defined technology as the means and methods of producing goods and services, including organizational and physical processes.

According to Bonabana-Wabbi (2002), technology itself was intended to improve a given situation or change the status quo to a more beneficial level. It helped the applicant do work easier than he would have in the absence of the technology; hence it helped save time and labor. Technology permits some tasks to be easily accomplished or some service to be rendered. In general, technology consisted of two parts, namely hardware and software.

Hardware meant “the tool that embodies the technology in the form of a material or physical object,” while software was related to “the information base for the tool” (Rogers 2003).

In the case of technology as software, it usually has a low level of observability. Consequently, it tends to be slow in the adoption rate. In practical term, Feder et al. (1985) mentioned the hardware consist of indivisible technologies (i.e., machinery and other tools), and also divisible technologies (e.g., high-yield seeds and fertilizers). Meanwhile, the software part arises as to the information package, such as communication approaches and marketing strategies. Conclusively, technology refers to science, knowledge, or methods put into practical use to solve problems or invent useful tools to achieve a better condition.

Concept of Technology Adoption

Mardikanto (1993) defined adoption as the process of changing behavior in the form of knowledge (cognitive), attitude (affective), and skills (psycho-motoric aspect) in a person after receiving a message conveyed by another person such as an instructor to the target. To adopt an innovation requires a certain period from the start, someone knows the message, understand, think about, and consider until the adoption. Meanwhile, Loevinsohn et al. (2012) described adoption as an integration of new technology into an existing practice. It is usually preceded by a period of ‘trying’ and some degree of adaptation. Bonabana-Wabbi (2002) considered adoption as a mental process of an individual passes from first hearing about an innovation to ending.

Indeed, once the technology is developed, it entails being delivered to the users. According to Oye et al. (2012), technology is worthless, except it is disseminated and adopted. Adoption or acceptance of technology can be regarded as a function of the user’s engagement in technology use. Louho et al. (2006) mentioned that technology acceptance is concern about how people accept or adopt a particular technology for practice. Also, acceptance can be portrayed as a critical factor in determining the achievement of any technology (Dillon and Morris 1996).

In technology adoption, the transfer processes are considered a bridge between the innovator’s motivation (a technology provider) and the user’s interest. This manner can be referred to as the technology diffusion or adoption process. According to Rogers (2003), the adoption process is “a mental process

through which an individual passes from hearing about an innovation to final adoption.” In practice, the adoption process does not occur instantaneously. It means that the decision to accept or reject a new technology will consider several phases and involves a sequence of thoughts and decisions.

Feder et al. (1985) proposed that an appropriate quantitative definition is required to obtain an accurate adoption analysis. The description should be distinguished between individual or farm level adoption and aggregate adoption. Rogers (2003) has accommodated the Feder’s proposal by distinguishing the term of adoption and diffusion. He stipulated the diffusion as “*the process in which innovation is communicated through certain channels over time among the members of a social system.*” It is stated that diffusion is a social process, while adoption is an individual manner. Meanwhile, Stoneman (2002) provided another definition of diffusion: “*the process by which new technologies spread across their potential markets over time.*” Both authors have a similarity to include “the process” and “the overtime” as keywords in diffusion term to represent the importance of two aspects.

Indeed, defining technology adoption is a complicated task since it varies with the technology adopted (Mwangi and Kariuki 2015). Therefore, researchers should clearly assert how they define technology adoption to develop an appropriate tool to gauge it. The process of adoption mainly relies on how adopters perceive innovation/technology attributes. According to Rogers (2003), the innovation-diffusion process is essentially related to the reduction of uncertainty toward an innovation. He suggests that innovation’s attributes will affect the decision to adopt or reject a certain innovation/technology. The attributes consist of five characteristics, namely: (i) relative advantage (ii) compatibility; (iii) complexity, (iv) trialability, and (v) observability.

Consequently, according to Rogers (2003), the technology adoption process should consider five criteria to ensure the adopters hold a positive perception toward technology. A better judgment will lead the potential user (for example, farmer) to adopt technology more quickly. Further, he also claims that five characteristics of innovation significantly contribute to adoption, since 49–87% of the variance in adoption rate was satisfied by these attributes.

However, the diffusion innovation concept is employed massively to seek the factors affecting

adoption when the innovations/technologies are already adopted. In terms of the prospect of technology adoption or the opportunity of technology will be accepted by the user, Ajzen (1991) proposed the Theory of Planned Behavior (TPB). Such theory asserts that behavior could be predicted by the strength of an individual's intention to engage a particular action. Attitudes, subjective norms, and perceived behavioral control are assumed able to predict an individual's beliefs about the behavior. The intention is appropriate to predict behavior. It implies that the more influential the individual's intention to undertake a practice, the more likely they will execute such action.

Another famous theory which also concerns with user acceptance is the Technology Acceptance Model (TAM) proposed by Davis (1989). Similar to the Diffusion of Innovation, TAM also considers technology characteristics as the determinant for the intention to adopt. However, TAM formulates the more straightforward technology attributes, namely perceived usefulness (PU) and perceived ease of use (PEU). Empirically, TAM is proven powerful to determine factors affecting the attitude and behavior intention of particular technology adoption.

Further, one model for change in individuals, the Concerns-Based Adoption Model (CBAM), applies to anyone experiencing change: policymakers, teachers, parents, and students (Hall and Hord 1987). Such a model and other developmental models of its type hold that people considering and experiencing change evolve in the kinds of questions they ask and in their use of whatever the change is. Khoboli and O'toole (2012) identify seven levels of change in CBAM are awareness, information, personal concerns, management, consequences, collaboration, and refocusing.

A more sophisticated theory of adoption is called the Unified Theory of Acceptance and Usage of Technology (UTAUT) proposed by Venkatesh et al. (2003). This model is developed by combining various models of human behavior theories. In practice, this theory focuses more on examining the intention to adopt information technology. The UTAUT model is known to have 20 to 30% explanatory power higher than TAM. The average only shows an explanation power of 40 to 50% about the end-user behavior intentions to use information technology. UTAUT is the most dominant and comprehensive theory in the literature on the current interest in using technology (Schaupp et al. 2010). UTAUT can

explain up to 70% of the variants of behavioral intention.

According to some definitions mentioned above, technology adoption refers to accepting a new thing or technology innovation. There is quite a difference between adoption and diffusion concept. The concept of adoption is associated individually instead of diffusion that addresses collective action.

DETERMINANTS OF TECHNOLOGY ADOPTION

There is enormous literature addressing the determinants of technology adoption. Basically, in terms of agricultural technology, Loevinsohn et al. (2012) mentioned that farmers' decisions to adopt new technology depended on the dynamic interaction between characteristics of the technology itself and the conditions and circumstances. It is in line with the study of Sambodo (2007), who evaluated the determinants of agricultural technology adoption. He concluded that three aspects influenced the farmer's decision to adopt the technologies: technology characteristics, farm, and farmhouse characteristics, and government policy.

Meanwhile, Pannel et al. (2006) mentioned the determinant of agricultural technology adoption comprised five aspects: personal characteristics, economic, cultural, social, and attributes of innovation. Further, the meta-study of Prokopy et al. (2008) revealed a positive association between adoption rate with an education degree, capital, income, landholding, information access, environmental attitude, environmental awareness, and utilization of social network in the adoption of best management practices.

Due to many studies that propose factors influencing the adoption of technologies, this study will assess agricultural technology adoption determinants by classifying them into some aspects. The classification consists of (i) technological aspects, (ii) economic and financial aspects, (iii) social and institutional aspects, and (iv) farm and farmer household aspects. This systematical discussion enables us to gain a depth view of how each element influences adoption.

Technological Characteristics

Rogers (2003) mentioned that potential adopters would evaluate the technology based

on its attributes compared to existing practices. Thus, how the farmers perceive technology's characteristics against current practice would significantly affect their adoption behavior. Doss (2003) mentioned that the attributes of technology were pre-requisite of particular technology adoption. The trialability or a degree to which potential adopters can try something out on a small scale first. If the potential adopters were satisfied, they then adopted it ultimately. Therefore, trialability was a significant determinant of technology adoption.

Meanwhile, Mignouna et al. (2011) stated that technology's characteristics play a critical role in adopting the decision process. They argued that farmers, who perceive the technology as consistent with their needs and compatible with their environment, probably adopt it since they find it a positive investment. Ndah et al. (2011) reported that farmers' perceptions of fish farming facilitate them to adopt or reject it. According to Karugia et al. (2004), it was important for any new technology to be introduced to farmers. They should be involved in its evaluation to find its suitability to their conditions.

Economical and Financial Aspects

Economic and financial aspects are probably the primary motive for a farmer to adopt new technology. Conversely, uncertainty about economic or financial profit could be a major barrier to implementing a particular technology farming practice. For instance, in the case of organic farming technology, Serra et al. (2008) attested that organic price premiums and subsidies were found to be powerful instruments to motivate the adoption of organic technologies.

Foster and Rosenzweig (1995) claimed that a critical determinant of new technology adoption was the farmer's net gain from adoption, including all new technology costs. The cost of adopting agricultural technology could become the constraint of technology adoption. Makokha et al. (2001) reported the high cost of technology as an obstacle to adopting fertilizer. The cost of hired labor was also informed by Ouma et al. (2002) as one among other factors restraining the adoption of fertilizer and hybrid seed in Kenya.

Diuro (2013) reported a significantly higher adoption intensity and expenditure on purchased inputs among households with off-farm income than their counterparts without off-farm profit. However, not all technologies have shown a positive relationship between off-farm income and their adoption. Some studies on

technologies that are labor-intensive have shown a negative correlation between off-farm income and adoption.

The accessibility of credit was reported to stimulate technology adoption (Mohamed and Temu 2008). It is believed that access to credit promotes the adoption of risky technologies through relaxation of the liquidity constraint and the boosting of the household's risk-bearing ability (Simtowe and Zeller 2006). With the option of borrowing, a household can make away with risk-reducing but ineffective income diversification strategies and focus on riskier.

Unfortunately, access to credit seems to be gender-biased in some nations where female-headed households are discriminated by credit institutions (Muzari et al. 2012). Therefore, policymakers need to improve current smallholder credit systems to guarantee that a broader spectrum of smallholders can access credit, more specifically, female-headed households (Simtowe and Zeller 2006). In specific cases, they probably necessitate designing credit packages that are tailored to meet the needs of particular target groups (Muzari et al. 2012). It will help empower women and enable them to adopt agricultural technologies to enhance economic growth.

Social and Institutional Environments

Not all farmers are motivated to perform a new technology solely to obtain better income; instead, social factors such as peer pressure can affect farmers' decisions. For instance, Khaledi et al. (2011) mentioned friends and family's influence during this phase of considering organic farming as a future option for the farm. This phenomenon implies that to encourage farmers' engagement, the role of people whom farmers appreciate is also essential. Therefore, the involvement of public figures, both formal and informal, is an appropriate strategy. It is also common that there are persons regarded as a public figure or leader who strongly influences farmer decision-making among farmer societies. In terms of technology adoption, they could be appointed as a pioneer to be involved in the program to promote particular technology. Rogers (2003) considered these people as an agent of change.

Social group members' status could enhance social capital allowing trust, ideas, and information interchange among farmers (Mignouna et al. 2011). Farmers within a social group learn from each other the benefits and usage of new technology. Uaiene et al. (2009)

recommended that social network influence was important for individual decisions. By studying the effect of a community-based organization in adopting corm-paired banana technology, Katung and Akankwasa (2010) found that farmers who participated more in community-based organizations were encouraged to adopt the technologies.

Farm and Farmer Household Aspects

Farm size plays a critical role in the adoption process of new technology. Many authors have analyzed farm size as one of the essential determinants of technology adoption. For instance, Nowak (1987) mentioned that farmers with wider landholdings had more opportunities to involve in new activities. According to Lavisson (2013), farm size can affect and, in turn, be affected by the other factors influencing adoption. Some technologies are termed as scale-dependent because of the great importance of farm size in their adoption (Bonabana-Wabbi 2002).

The farmer's human capital is assumed to influence farmers' decisions to adopt new technologies significantly. Several adoption studies have attempted to measure human capital through the farmers' educational accomplishment, age, gender, and household size (Mignouna et al. 2011; Keelan et al. 2014). Farmer's educational achievement has been assumed to have a positive influence on farmers' decision to adopt new technology. The educational attainment level of a farmer increases his ability to obtain, process, and use relevant information in adopting new technology (Mignouna et al. 2011; Lavisson 2013).

For instance, a study by Okunlola et al. (2011) on the adoption of new technologies by fish farmers and Ajewole (2010) on adopting organic fertilizers found that the level of education gave a positive and significant influence on adoption. Higher educational attainment influenced respondents' attitudes and insights, making them open-minded, rational, and able to examine the benefits of the new technology (Waller et al. 1998). It facilitated the introduction of an innovation, which ultimately affected the adoption process (Adebiyi and Okunlola 2013). The literature studied by Uematsu and Mishra (2010) also reported a positive relationship between education and adoption.

On the other hand, some authors have reported an insignificant or adverse effect of education on technology adoption (Banerjee et al. 2008; Samiee et al. 2009). In terms of

studying the effect of education on technology adoption, Uematsu and Mishra (2010) reported a negative influence of formal education towards adopting genetically modified crops. Since the above empirical evidence has shown mixed results on education and the adoption of new technology, more study needs to be done to develop a more consistent result.

Age is also reported to be a determinant of the adoption of new technology, although the direction (positive/negative) is not particular. Older farmers are considered to have advanced knowledge and experience over time and can better evaluate technical information than younger farmers (Mignouna et al. 2011; Kariyasa and Dewi 2011). On the contrary, age was also found to have a negative relationship with the adoption of technology, as Alexander and Van Mellor (2005). This study discovered that the adoption of genetically modified maize increased with age for younger farmers as they gain experience and increase their human capital stock.

Further, the issue of gender in agricultural technology adoption has been scrutinized for a long time, and most studies have reported mixed evidence regarding the different roles of men and women in technology adoption (Bonabana-Wabbi 2002). Doss and Morris (2000) discovered no significant association between gender and probability to adopt improved maize in Ghana. They concluded that technology adoption decisions depend primarily on access to resources, rather than on gender. Also, the adoption of improved maize depends on access to land, labor, or other resources. On the other hand, gender may have a significant influence on some technologies. Gender affects technology adoption since the household head is the primary decision-maker. Men have more access to and control over vital production resources than women due to socio-cultural values and norms (Omonona et al. 2005; Mignouna et al. 2011). For instance, a study by Obisesan (2014) on the adoption of technology found that gender had a significant and positive impact on adopting improved cassava production in Nigeria.

In terms of Indonesia cases, several studies about determinants of adoption demonstrated similar results. Farid et al. (2018) have conducted research to determine factors influencing the *Jajar Legowo* planting system adoption by the farmers in Malang District. The effect of farmers' internal and external factors on the opportunity of *Jajar Legowo* system adoption was analyzed using multiple linear regression. The findings showed that the farmers' attitude

had a positive tendency amounting to 72.5% of the opportunity to adopt *Jajar Legowo* planting system based on the principle of *Jajar Legowo* planting system. Internal factors such as age and profitability showed a positive effect on the opportunity of *Jajar Legowo* system adoption. In contrast, the external factor, such as the price variable, had a negative impact. Other variables, i.e., education, experience, land, extension intensity, extension materials, extension methods, and extension media, did not affect the opportunity of *Jajar Legowo* planting system adoption.

Further, the study of factors affecting *Jajar Legowo Super* technology has been conducted by Sirnawati and Sumedi (2019). Their study demonstrated that the determining factors for adopting such a technology package are the attitude of openness of farmers, technological excellence, and farmers' access to credit. Environmental conditions demanding diverse social and characteristics of farmers applying different dissemination methods require flexibility in technology dissemination methods.

The study of Yahya (2016) aims to determine factors that influence farmers' adoption of integrated rice field management in Deli Serdang North Sumatra Province. The result showed that the significant factors determining the farmers' adoption were cosmopolitan and farmer's presence. The other variables, such as education, self-efficacy, and extension agents' role, were also significant. Meanwhile, the farmer's motivation and farmer leaders' role was not significant in integrated rice field management. This study proposed that the more cosmopolite, the faster the farmers adopted technology in integrated rice field management.

Meanwhile, Rastiyanto et al. (2014) carried out the study to determine factors influencing the adoption of organic agriculture in the yard's usage by farmers in the City of Serang, Banten. The study results indicated that the level of education, income, and innovation factors affected the adoption of organic agriculture in the yard's usage in Serang City. The size of the yard and source of information had no impact on the adoption of organic agriculture in the use of the yard.

THE SUSTAINABILITY OF TECHNOLOGY ADOPTION

The individual's decision concerning the adoption or rejection of the innovation is one of

the most studied innovation research areas. The most widely accepted model of the individual's choice is called the innovation-decision model (Rogers and Shoemaker 1977). The model uses concepts from Learning theory, post-purchase dissonance, and general decision-making processes to suggest four steps: (1) knowledge - the individual is exposed to the innovation by personal contact or social interaction; (2) persuasion - the only forms a favorable or unfavorable attitude toward the innovation; (3) decision the innovation is adopted or rejected; and (4) confirmation - the individual seeks support about the decision, with four possible outcomes. If taken, the innovation may be used further or discontinued at a later point in time. If rejected, further consideration may result in continued rejection or later adoption.

Most studies related to the confirmation stage usually focus on the activities or adopters, rejecters, or both. One of the components commons to any adopter is the discontinuance decision, which terminates the use of the innovation. In the past, there was still limited research on the continuance or discontinuance decision and the resulting discontinuance process (Black 1983). Some studies attempted to seek the factors affecting the continuance or discontinuance of technology adoption, mainly in agricultural technology.

Several studies proposed various reasons causing the farmers to continue or discontinue the adoption of a particular technology. For instance, the study of Olalekan and Simeon (2015) in Nigeria showed that 51.7% of households that initially adopted improved maize varieties (IMVs) then abandoned their adoption while only 48.3% continued adopting them. This study revealed the off-farm income, frequency of extensive service contact, membership in associations, and level education significantly influenced the discontinued use decision of IMVs by the farm households. Based on this result, the study suggested that improvement of farmer education and the accessibility of effective and efficient extension delivery services ensured the continued use of IMVs and increased maize production. The other study revealed that farmers' household continues to use improved maize seeds simply if the use of technology could generate a net gain (Carletto et al. 1999).

Meanwhile, Anaeto et al. (2016) investigated the adoption and discontinuance utilization of Alley farming by farmers. Data were collected from 120 randomly selected Alley farming technology farmers who adopted the technology and discontinued its usage. The study results

showed that most of the farmers who took the technology then stopped, and significant factors that led to the discontinuance among others included financial implications, inadequate information sources, environmental factors, and insufficient extension contact. The study result recommended that extension service should improve the mechanism and channels used in introducing the technology, following up intensively, and providing adequate extension contact between the farmers and extension service.

Bello et al. (2012) identified the factors influencing the discontinuance of improved rice technologies in Nasarawa State of Central Nigeria. The result showed that education and extension contact had significant and negative relationships, while age had a positive and meaningful relationship with the discontinuance of improved rice technologies' adoption. Farmer should be supported to participate in the on-going government rural literacy campaign while extension contact is enhanced to minimize improved rice technologies' discontinuance.

In Indonesia cases, Suryani et al. (2017) have studied the Yard Management Technology continuance among female farmers. The results showed the variables such as individual characteristics, innovation characteristics, the performance of the instructor/ facilitator, and external environmental support have a real influence on the sustainability of adoption. The indicators of individual characteristics that significantly influence were age, motivation, number of family members, education level, time spent by female farmers, and family income. Meanwhile, the indicators of the characteristics of innovation were the relative advantages and suitability of innovation. The facilitator's performance indicators covered the visit rate and knowledge level. External indicators, i.e., marketing support, family support, and group support, have a significant effect on yard management technology sustainability.

Abdullah et al. (2015) conducted the study to analyze the sustainability of livestock waste-treatment technology adoption as an organic fertilizer in the integration of beef and rice. The analysis of continuity utilized the Multi-Dimensional Scaling (MDS) approach. The results showed that the adoption of the sustainability index value of livestock waste treatment technologies in the integration of beef and rice based on the dimensions of the ecological, economic, social, and cultural were in the category of less sustainable with each index value of 35.18, 36.92, and 37.86 or less sustainable. Based on the technological

dimension, it was quite sustainable, with an index value of 74.12. The study suggests that to sustain the adoption of technology for processing livestock waste into organic fertilizer in the integration of beef cattle and rice should pay attention to the ecological, economic, socio-cultural, and technological dimensions.

Meanwhile, Arsil et al. (2019) mentioned that three factors had been identified as the cause of discontinuance of System Rice Intensification (SRI) adoption, namely 'relative advantage,' 'complexity,' and 'compatibility.' The main barrier was identified, such as rice price, which is similar to the conventional system. Still, more considerable effort is required from farmers than in the previous farming practice. They also mentioned that to increase farmers' profits; rice can be promoted as a high-value product that contains organic pesticides or no chemical. The empowerment of farmer groups is also crucial in developing and expanding the market for SRI rice. It needs to optimize education, training, and fieldwork to increase farmers' knowledge to increase farmers' motivation. The other study by Suryani et al. (2017) claimed that farmers' characteristics and innovation's natures, extension worker's/facilitator's performance, and external environmental support significantly affected adoption sustainability.

CLOSING REMARK

The agriculture sector still has a significant role in economic development, especially for developing countries. Technology is the key to improve agriculture productivity and value-added. However, technology adoption even low among smallholder farmers. Therefore, identifying the determinants of adoption is necessary to formulate a strategy for accelerating the adoption.

Recognizing the factors that influence or hinder the adoption of agricultural technology is essential in planning and executing technology-related programs to meet food production challenges in developing countries. The perception of farmers towards technology characteristics is a crucial precondition for adoption to occur. Other determinants of agricultural technology adoption include economic, farmer and farm characteristics, and technological and institutional aspects. Based on this review study, it seems that the determinant of agricultural technology adoption is not always a single factor, instead of a mixture of some aspects. Thus, to improve the adoption

rate, it should be paid attention to entire factors. A comprehensive approach is the best choice to disseminate new technology.

Conclusively, to enhance technology adoption, policymakers should understand what farmers need and their ability to adopt the technology. The government and inventors also should provide an appropriate and useful technique for farmers.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the full support of the ACIAR Area-Wide Management (AWM) project Team, especially for Stefano De Faveri, Peter Jhonson, and Vijay Shanmugam, who encourage us to prepare this paper and also provide useful comments. We also express appreciation for the reviewer, who provides fruitful insight for improving this paper.

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