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Exploring the Challenges of Adopting Smart Farming in The Agriculture Sector Among Smallholders in Malaysia

[1]Zubaidah Omar, [2]Abdul Rahman Saili, [1]Fazleen Abdul Fatah, [2]Ahmad Shahir Abd Aziz, [2]Zubaidah Yusop, [3]Fay Rola-rubzen and [4]Ahmad Safuan Bujang

[1]Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA (UiTM), Cawangan Melaka, Kampus Jasin, 77300 Merlimau, Jasin, Melaka, Malaysia, [2]Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA (UiTM), Cawangan Sarawak, Jalan Meranek, 94300 Kota Samarahan, Sarawak, Malaysia, [3]School of Agriculture and Environment, University of Western Australia, [4]Technology Commercialization Program, Malaysian Agricultural Research and Development Institute (MARDI)

Corresponding Author Email: arsaili@uitm.edu.my

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Abstract

Agriculture 4.0 or commonly known as smart farming technology is highly potential to be adopted to significantly increase farm productivity. However, it has not been widely used by many smallholder farmers in Peninsular Malaysia. A study was conducted to identify the challenges in implementing smart farming technologies involving twelve participants. From this study, it is revealed that high initial investment cost was a major concern among the smallholders to adopt the technologies as they find it financially burdening to do so. Secondly, poor connectivity and infrastructure causing difficulties to have access on vital information and services lead to inaccurate allocation which affects crop yields. Third, many participants stated that additional operational cost and limited technical skill hampered their intention to operate and maintain smart farming tools. Last but not least, the agricultural community's poor collaboration and knowledge sharing inhibit the spread of important knowledge regarding smart farming technologies among the farmers. To maximize profits and reduce expenses for smallholder farmers in Peninsular Malaysia, these issues must be resolved.

Keywords: Agriculture 4.0, Peninsular Malaysia, Smart Farming, Challenges

Introduction

Agriculture holds a significant position as a primary global food source, but the adverse effects of climate change and variability have intensified in recent times, posing a threat to this crucial

sector. By 2050, the world is projected to witness a population growth of over two billion people. However, the uncertainty surrounding climate conditions in certain regions negatively impacts agriculture and food production. To ensure sustainable food production, it is imperative for the agricultural sector to employ precise and timely utilization of all available resources, maximizing their efficiency and effectiveness (Wheeler et al., 2013).

Despite the declining contribution of the agricultural sector to the overall GDP, it continues to play a crucial role, particularly in poverty reduction. Compared to growth in other sectors, agricultural sector growth has a proportionally greater impact on reducing poverty (Diao et al., 2010). For instance, in Malaysia, a significant proportion of the impoverished population (34% of the total poor) remains concentrated in the agricultural sector. Consequently, it becomes evident that this sector holds the key to poverty reduction in the economy. However, the agricultural sector's potential to alleviate poverty can only be fully realized when it establishes strong and well-developed inter-industrial linkages with other production sectors (Honkavaara et al., 2013).

In developing economies, it has been a common practice to concentrate on enhancing the agricultural sector itself, with the belief that it will naturally lead to spillover effects on other sectors of the economy. Unfortunately, this assumption has frequently fallen short, creating doubts regarding the agricultural sector's contribution to overall economicdevelopment. Recent research by Valdés et al (2010) has shed light on this issue by demonstrating that the primary contribution of the agricultural sector to economic growth comes through forward linkages rather than backward linkages. This means that agricultural sector plays a vital role economically where the demand for its output is higher compared to its demand from other sectors. Hence, it is more beneficial to the agricultural sector itself by stimulating growth on its own output and still provides a minimal spillover effects on other sectors.

One potential factor for stimulating growth in agricultural sector is by adopting agricultural technology. It is undeniable that agriculture sector has increasingly relied on technological advancements in recent years to transform the way activities are performed, aiming to boost productivity. As mentioned by Adnan et al (2019), the progress in technology has brought about a significant shift in the dynamics of human engagement across all sectors, particularly in agriculture.

Smart Farming Technologies (SFT) encompass the utilization of advanced technologies such as the Internet of Things (IoT), cloud storage, big data, and mobile devices to collect external environmental data and monitor crop growth. The primary objective is to manage risks and effectively provide necessary intervention to enhance the quality and quantity of agricultural produce. There are several advantages from modernizing agriculture through the adoption of SFT. Firstly, it enables cost reduction by optimizing input applications such as fertilizers and plant protection products, based on the specific needs of the soil and crops. This approach minimizes the environmental impact of farming practices (Basso et al., 2016). Additionally, SFT also attracts and retains more youth in the agricultural sector Ena et al (2023), expanding and strengthening the agricultural value chain Klerkx (2019), building resilience against climate change Chandra et al (2018), and promoting sustainable urban agriculture for city development (Azunre et al., 2019).

According to Ena et al (2022), there is a growing recognition of how SFT can address climate, labour, and production-related challenges. Through SFT, it can reduce the need for extensive human labour using automation and thus it is a perfect solution to be adopted among smallholders especially in Malaysia. However, Malaysia is still lagging behind neighbouring countries in terms of SFT adoption in agricultural advancement despite the availability of SFT in Malaysia and its potential to positively impact farm profitability, structural development, and environmental sustainability.

Smart farming technology is an agricultural approach that involves managing individual fields and crops according to their specific needs through the use of technology such as precision farming. Precision farming has proven to be an effective management practice for sustaining crop production (Wicaksono et al., 2022). This can be further emphasized by the advent of the Fourth Industrial Revolution (IR 4.0) and its involvement in modernizing agricultural sector. Through the integration of smart farming technology, precision farming enables farmers to gather and analyse high-quality agricultural data, including information on crops and soil elements that are essential for farmers to make informed decisions and effectively manage their crops.

The reasons behind hesitancy among smallholders to adopt smart farming technology are not yet clearly understood leading to a low-level of adoption despite the numerous potential benefits that smart farming offers. Therefore, the primary focus of the study was to investigate the matter by identifying the factors behind it. It is important for the agriculture sector to comprehensively understand the challenges associated with the adoption of smart farming technology as it is essential based on the potential that SFT offers in order to significantly enhance productivity and efficiency in agriculture. By overcoming the challenges factor, the agriculture sector can then be able to fully leverage the transformative power of smart farming technology and as thus benefits the smallholder farmers.

Methodology

The research employed the snowball sampling method to continuously recruit participants where this technique involves current subjects referring to and recruiting future subjects who share similar interests. The study involved 12, 30 to 55 years old smallholder participants, who adopted technology in their farming practices. In-depth interviews were conducted to delve into their emotions, experiences, life histories, and other relevant details. The researchers employed thematic analysis as a method for analysing the qualitative data. Thematic analysis involves examining a dataset for recurring patterns, comprehending them, and reporting on them (Braun et al., 2006). Following the interviews, the data collected were transcribed and subjected to thematic analysis to identify patterns and themes. The coding process helped condense and organize the data, and each theme was carefully examined to gain insights into the participants' perceptions and motivations. Finally, main and sub-themes were identified and named based on the initial themes generated and reviewed. The insights and thoughts shared by the participants were transcribed verbatim. Transcription involves converting spoken words from audio-recorded interviews into written text. Although this process can be challenging, accurate transcription can be achieved with careful planning, as emphasized by (Lapadat et al., 2000).

Results

The analysis of qualitative data has revealed that all twelve participants expressed that they have more than one constraint factorsto adopt smart farming technology. The main theme includes high initial investment costs,bad network coverage in rural areas,lack of knowledge and awareness, insufficient government assistance, technical skills, and capacity.

Theme 1: High Initial Investment Cost

The majority of the participants highlight that they need more cost to add smart farming technology to their farm. Their current financial ability hinders their intention to adopt more technology in the field.

"In the future, I have a desire to enhance the technological aspects of my hydroponic plants. However, I currently face a financial constraint that prevents me from pursuing this upgrade. The incorporation of smart technology in hydroponics requires a substantial investment, making it necessary to secure significant funds in order to implement these advancements." (En Di).

Another participant said they wanted to use more technology but were having trouble since they lacked the required funds.

"Currently, I am utilizing solar technology in my hydroponic setup, which has proven to be highly advantageous as it helps me reduce electricity expenses. While researching additional advanced technologies, I discovered that their implementation is no longer feasible for me due to their exorbitant costs." (En Zam).

According to one respondent, the majority of farmers are hesitant to adopt smart farming technology due to the higher associated costs.

"Despite having spoken with numerous farmers, all of them have rejected the idea of adopting technology in their fields due to its high cost. They express concerns about having to make substantial investments for relatively small-sized operations." (En Ha).

Theme 2: Inadequate Infrastructure and Connectivity

All participants concur that reliable coverage is crucial for smart farming technology implementation. This ensures that all devices can communicate effectively and accurately to calculate precise amounts of fertilizers for each plant. Interestingly, there is a farmer who has encountered coverage issues in the past on his farming.

"I have a desire to utilize smart farming technology for my crops. However, the effectiveness of this technology is hindered by the low coverage in my area. As a result, I am unable to accurately monitor and control the temperature, as well as the precise amounts of fertilizer and water required for my plants. In order to leverage the capabilities of this technology device to measure temperature and manage nutrient levels effectively, a high coverage area is necessary." (En Su).

According to one of the respondents, each device must be designed with a backup strategy in case problems occur in regions with spotty service. This backup strategy makes sure that the devices can keep working efficiently even if they run into issues outside of the network's area.

“I have installed smart farming technology on my farm, which I personally created and set up. But I've noticed a problem with the system. The device needs manual program loading whenever there is a low coverage region. This is a problem for me because it makes it difficult for me to use my smartphone to track the temperature, the amount of fertilizer, and the water supply. Effective monitoring is being made more difficult by a lack of coverage or inconsistent connectivity because there are times when I am unable to acquire the required information because of bad network circumstances.”(En Dan).

Other participantsdiscussed a personal problem they had with adopting smart farming on their property.

“I am a farmer who has embraced smart agricultural technology and created my own device. One of the biggest difficulties I had to overcome was internet connectivity. To solve this problem, I've developed a number of backup programs that will ensure operation even when there is poor internet access. In such circumstances, the gadget runs based on the pre-programmed settings, supplying the plants with the required quantities of nutrients. The disadvantage is that when there is no internet connectivity, I am unable to monitor and manage the system using my computer or smartphone." (Izz).

Theme 3: Additional Cost and Limited Technical Skill

All participants agree that the difficulties they must overcome are influenced by higher expenses and a lack of technical expertise. One of the participants explained, that if there are problems with the technical instruments, they will need to invest more money to fix the technical issue.

"I need to spend more money if my tools break down, and I need to fix them as fast as I can to keep my farm running efficiently. I also have problems with the staff’s lack of technical expertise when it comes to successfully using the equipment”. (En Hash).

Moreover, one of the participants pointed out the necessity of investing a specific amount of funds to upgrade their tools from version 1.0 to the present version 4.0. Alongside this financial aspect, they also faced difficulty in recruiting workers who possessed the required technical expertise to proficiently operate these tools.

“I once went to a government seminar, but I had a hard time understanding what was being said there. I then started my own independent studies, which inspired me to develop my own technologies. I used my fundamental knowledge of electrical studies to advance from the first edition to the present 4.0 iteration. To assure the precision and effectiveness of my agricultural implements, the update procedure required considerable financial expenditure. Furthermore, I encountered challenges in locating workers with the necessary technical expertise. Even though I offered job opportunities that specifically demanded technical skills, it remained challenging to find individuals who were equipped with such skills”. (En Mu).

A participant highlighted the necessity for additional funding to acquire more equipment and ensure the optimal functioning of their farm. They emphasized the significance of attending technology seminars in order to upgrade their knowledge on adopting technology due to their limited technical proficiency.

"I require extra funds to upgrade my farm equipment and enhance its efficiency. Furthermore, my lack of technical expertise is a hurdle in pursuing further investments. I'm actively seeking opportunities to expand my knowledge and skills in the realm of smart agricultural technologies". (En Din).

Theme 4: Limited Collaboration and Knowledge Sharing

The participants agree that they have few possibilities for collaboration and few opportunities to exchange information with other professionals. This specific restriction is a major barrier to the small-scale agriculture operators' widespread adoption of smart farming techniques. Notably, one of the participants mentioned that the lack of information sharing and collaborative activities would make it more difficult for them to effectively manage their agricultural operations.

"I purchased a smart farming tool from a friend, and it significantly aided me in efficiently managing my farm. Recently, I was presented with an offer from a university to receive another tool in exchange for granting them permission to utilize the tool on my farm. This form of collaboration is rather restricted and not universally accepted. Additionally, the information sharing I receive is also limited, requiring me to conduct searches on Google and YouTube for support" (Encik Syed).

One of the respondents brought up the challenge of finding partnerships and ideas appropriate for their farm's equipment. They also saw a lack of the necessary comprehension, which led them to turn to Google for further details.

"Similar to this, I lack options to work in collaboration with professionals that would increase the production of my farm by better utilizing its equipment. Online searches and other people's insights are my main information sources. I also admit to performing independent research and development projects on my farm while utilizing the current technology to increase effectiveness and precision". (En Zam).

One person talked about his farm-related tool and his ongoing efforts to acquire relevant knowledge.

"I used to use a tool that was connected to the internet and was a result of smart farming technology. However, because I live in arural area, implementing it created a lot of difficulties. I learned this information via websites like Google and YouTube. Unfortunately, my efforts had unsuccessful outcomes because the tool's data readings did not match the characteristics specific to my area. Additionally, getting support from outside sources has proven to be challenging; poorly, I lack established relationships and the essential direction to decide which channels to use". (En Keri).

Discussion

The findings have shed some light on the challenges in adopting smart farming which include a high initial investment cost, inadequate infrastructure and connectivity, additional cost and limited technical skill, andlimited collaboration and knowledge sharing. All participants in this study managed their farms by themselves from the beginning and experiencedhardship in doing all farming activities. The main challenge of smart farming adoption isthe high initial investment cost to start using smart farming technology. According to Lazim et al.(2020), implementing the new technology integrating IR4.0 needed a significant amount of money. Although employing smart farming has long-term financial advantages for farmers, the expensive cost of equipment and technology makes it tough for them, so they prefer to stick with theconventional methods. Agussabti et al.'s (2022) research shows that respondents, including farmers and extension workers, believed that the high investment costs and restricted access to demonstrations were the main barriers to the adoption of smart farming technology in the cultivation of food crops.Smallholders desire more cost-effective, easy-to-use and integrated smart farming systems (Dobermann et al., 2004). Likewise, smart farming entails the use of modern technologies in day-to-day field activities. As a result, farmers' lack of understanding of various technologies and equipment would eventually prove devastating. The most essential thing is for farmers to fully comprehend the concept of smart farming and all of the instruments involved. Developed countries such as Japan, the USA, and Europe have succeeded in the development of intelligent agricultural systems based on IoT such as employing driverless tractors. However, this technology is expensive and small-scale farmers cannot afford to utilize the technology. Even though the technology can promote efficiency and practicality, the cost is also a critical parameter to consider for the adoption of this technology. In this sense, the ubiquitous availability of low-cost electronics will favour the introduction of such digital applications.

Additional costs and limited technical skillsare identified as the otherchallenges of adopting smart farming technology among smallholders. This included not only the original cost to design a module architecture but also transformative expenses to adopt the technology. IoT deployment, for example, is broken down into hardware and software costs, which include the costs of system creation, upkeep, and ongoing subscriptions for the use of IoT platforms or centralized services (Farooq et al., 2019). In poor countries, farmers frequently lack formal education and useful skills. They lack a compelling reason to learn about new technologies, and government officials minimize the significance of these developments (Ramdinthara et al., 2020). In light of the fact that traditional farming techniques demand less financial investment, which is the main reason why farmers favour them over smart farming strategies. (Khan et al., 2016).

Recognizing the importance of ICT in this global era, communities in rural areas were also exposed to this borderless technology. Various initiatives have been implemented by the government and relevant agencies to increase the use of the internet in rural areas. However, the level of acceptance and access to internet services is very minimal. Meanwhile, internet access is only or mostly provided in urban areas (Derashid et al., 2013; Dawood et al., 2019; Yaacoub et al., 2020). In contrast, the majority of agriculture and plantations take place in rural areas which necessitates strong network performance and bandwidth speed to utilize cloud computing technology (Fakhruddin, 2017). Therefore, the application of numerous smart agricultural technologies canbecome difficult until this internet service challenge is

overcome. It is practically challenging to operate smart farming technology in the absence of fast and reliable internet services because the majority of sensors and cloud-based computing rely on cloud services. Therefore, the services and networks must be robust enough to be used in rural regions (Balafoutis, 2017).

Smallholders and producers continue to use traditional technologies and methods because of the principle of increased imperatives for change and a lack of traditional backing, the demand for spatial is higher in developed countries (Dobermann et al., 2004). In contrast to what is happening in Malaysia, they are concerned about the outcome of smart farming. Many services are unviable, and the benefits are ambiguous, resulting in weak imperatives for change (Daberkow & McBride, 2003). Furthermore, owing to structural issues, they are still employing the conventional way. Small farm sizes and isolated areas with restricted access to the most up-to-date equipment and information are some examples.

Rural areas are where most agricultural and plantation activities take place, and a strong and dependable signal is crucial for the efficient application of smart farming technologies. The connectivity is a crucial enabler in SFT. It ensures the precision instruments to come up with a precise data of the exact amount of resources required for plant growth and productivity. The lack of or absence of a strong connectivity could have detrimental effects on plant development which may be caused by an incorrect resource allocation. (Balafoutis, 2017).

Farmers in South Asia and Southeast Asia are most likely to face the difficulties of not having the resources to buy the most basic necessities such as fertilizer and pesticides, let alone cutting-edge farming equipment despite efforts to mechanize farming methods (Shahbaz et al., 2010). As stated by Yang et al (2020), the key factor in developing smart farming is human resource development. Therefore, training initiatives were offered by the government to educate participants with a positive attitude and practical skills and to increase their understanding of smart farming. Four types of training courses were offered, each of which included a lecture, a benchmarking visit, an international visit, and assistance from a smart farming service team. This sort of training that enriches the smallholders with technology adoption skills and understanding is essential as the government is now encouraging farmers and agribusinesses to adopt innovative digital technologies and intelligent mobile devices in their farming practices.

Conclusion

The result from data analysis of 12 interviews with smallholder farmers in Peninsular Malaysia has enabled researchers to identify the difficulties and challenges in adopting smart farming. Although it is recognized by the participants that the adoption of this technology has the potential to completely transform the agricultural industry by making it more effective, productive, and sustainable, there are obstacles that make it difficult for smallholders to embrace it for their farms. The notable obstacles identified include high investment costs, additional fees, lack of infrastructure, inadequate skills, knowledge, and teamwork.

In order to overcome these challenges, governments and industries work together to encourage the use of smart farming technologies by launching awareness campaigns, offering financial incentives, and facilitating access for farmers in both rural and urban areas.

Agricultural research institutions and extension agencies can also play crucial role in educating smallholder farmers on smart farming practices by providing them with the essential information and skills required. The future of agriculture in Peninsular Malaysia as well as globally is optimistic with the right support from every agency related. It is critical for smallholder farmers in Malaysia to fully adopt smart farming technology as it holds the potential to make a substantial contribution to food security and sustainability for future generations. In line with that, this research offers key information regarding the obstacles that lead to a low adoption level of smart farming technology among smallholders in Peninsular Malaysia. As such, this data can be utilized in order to promptly address the issues and come up with a proper solutions moving forward.

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