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Awareness and Acceptance of the Internet of Things (IOT) among Agropreneurs

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Abstract
The increasing demand to adopt technological innovations in agriculture to improve productivity to make the sector sustainable calls for the importance of adopting the Internet of Things among agropreneurs. This study explores the awareness and acceptance of IoT technology among agropreneurs within Melaka, Malaysia. The structured questionnaire was administered to a total of 201 agropreneurs registered under FAMA and Yoshii Agro Care Enterprise. In this study, descriptive statistics and regression analyses were used to investigate the relationships among awareness, perceived usefulness, perceived ease of use, and actual IoT adoptions. Results showed a high level of awareness of the IoT but a very low adoption rate, with merely 26.4% of the respondents using IoT in farming. Perceived usefulness was proved to be a significant predictor of the adoption of IoT. Awareness itself may not drive adoption according to the results; efforts should focus on perceived usefulness and ease of use for better adoption. Future studies will, therefore, be directed to see how government support and infrastructure may facilitate IoT adoption among agropreneurs.
Keywords: Agropreneurs, Awareness, Technology Acceptance Model (TAM), Internet of Things (IOT)

Introduction

In October 2018, Malaysia introduced its Industry 4.0 strategy, "Industry4WRD: National Policy on Industry 4.0," focusing on the digital transformation of the nation's manufacturing and service sectors. Following this, the National Fourth Industrial Revolution Policy (National 4IR Policy) was launched in July 2021 to take Malaysia towards high-income status by 2025 through the use of state-of-the-art 4IR technologies and digitalization. The fact that Malaysia has accorded only a secondary position to these areas compared to Indonesia in the "Making

Indonesia 4.0" and Thailand in its "Thailand 4.0" initiatives, where all the emphasis has been given to the agriculture sector as well as food production.

Although its contribution to the Gross Domestic Product (GDP) is around 8.93 per cent in 2022 and declined to around 7.8 per cent in 2023 (DOSM, 2024), the agricultural sector remains crucial to Malaysia's socioeconomic development agenda, particularly in areas such as poverty alleviation, economic equality, food safety and security, and sustainability, as specified in the Sustainable Development Goals (SDGs)(Hassan et al., 2024). On the other hand, the population in Malaysia is forecasted to be 40.5 million in 2050, and the population growth will lead to a growth in food demand (Alfred et al., 2022). So, the rise in demand for food in terms of quality and quantity has increased the requisite for new and existing applications of science, technology, and innovation across the food system addressing all dimensions of the agricultural sector (Mo et al., 2023).

The situation has been worsened further by the scarcity of natural resources such as fresh water and arable land, as well as the declining production patterns of several staple crops. Another challenge to the agropreneurs is the changing demographics of agricultural labour. Additionally, agricultural labour has been reduced in the majority of countries. As a result of the shrinking agrarian workforce, the use of Internet of Things (IoT) solutions and trends in farming techniques has been accelerated to lessen the need for human labour (Morchid et al., 2024). The IoT is a promising technology that is providing several innovative ideas to improve agriculture. When it comes to farming, IoT refers to the use of sensors and cameras to turn all of the things that happen in farming into data. People who work with big data can use software algorithms to get information about a farm at different levels of granularity from a lot of different types of data. This includes things like weather, moisture, plant health, mineral status, chemical applications, pest presence, and so on (Alahmad et al., 2023; Dhruva et al., 2023; Pathmudi et al., 2023).

Agriculture is an excellent option for IoT adoption since it requires continual monitoring and management. The IoT and big data applications will be critical in increasing global food production in the future decades. For example, experts predict that IoT-based technologies like sensors on agricultural equipment, self-driving tractors, drones and GPS imagery, as well as weather tracking, would be the trend in future in helping agropreneurs feed the globe while simultaneously coping with limited supplies of fossil fuel, water and fertile land. This technology not only ensures the competitiveness and sustainability of the food industry but also increases the income level of agropreneurs (Ra et al., 2019a).

Despite IoT or smart farming having a lot of potential and trends in farming, the adoption rate in Malaysia is still low. According to Conway et al (2022), farmers are unwilling to shift or adapt to new methods of farming. This is because the majority of farmers, most of whom are elderly, are unwilling to change their farming practices due to a lack of knowledge and interest in the subject. The Industrial Revolution 4.0 (IR4.0) trend is revolutionizing production capabilities across the board, including in the agricultural sector. Up to now, most farmers have yet to grasp the importance and contributions of IR4.0 technology. For that reason, understanding IR4.0 among the farming community as well as other important stakeholders is very important so that this technology can be disseminated.

Despite the widespread recognition of IoT in enhancing agricultural productivity, there is limited research on the adoption and acceptance of IoT technology among agropreneurs in Malaysia, particularly those operating within the Federal Agricultural Marketing Authority (FAMA) and Yoshii Agro Care Enterprise, Melaka. Thus, this study intended to understand how technology awareness and user adoption could influence the use of IoT among agropreneurs in Malaysia.

The main contributions of this paper are to ascertain the level of awareness of IoT among agropreneurs as well as the perceived benefits it holds for enhancing the quality and quantity of agricultural production. The following sections comprise the remainder of the paper: In Section 2, a literature review and framework. Section 3 covers the research method and data collection techniques, with Section 4 presenting the results. In section 5, we provide some concluding remarks and make some recommendations. Finally, we make suggestions about the research's limitations and future research.

Literature Review

Agricultural in Malaysia

In October 2018, Malaysia announced its Industry 4.0, or IR4.0, policy "Industry4WRD: National Policy on Industry 4.0," which focused on the digitalization of manufacturing and services. In July 2021, it announced the National Fourth Industrial Revolution Policy (National 4IR Policy), for it to leapfrog into a high-income nation by 2025 based on Fourth Industrial Revolution technologies and digitalization. Unlike in comparable-country initiatives like Making Indonesia 4.0 and Thailand 4.0, the major emphasis in Malaysia is placed on food production and agriculture, with sectors like those mentioned held as being secondary. Despite its contribution to the GDP declining 8.93 per cent in 2022 to around 7.8 per cent in 2023(DOSM, 2024), the agricultural sector remains critical to Malaysia's socioeconomic development agenda, particularly in terms of poverty alleviation, economic equality, food safety and security, and sustainability, as specified in the SDGs (Hassan et al., 2024). On the other hand, by 2050 the population of Malaysia is projected to reach 40.5 million and the increase in population will result from an increase in demand for food (Alfred et al., 2022). Thus, the increasing demand for food in terms of both quality and quantity has increased the need for new and existing applications of science, technology and innovation across the food system, addressing all dimensions of the agricultural sector (Kassim, 2020; Kaur, 2019).

The situation has been worsened further by the scarcity of natural resources such as fresh water and arable land, as well as the declining production patterns of several staple crops. Another challenge to the agropreneurs is the changing demographics of agricultural labour. Additionally, agricultural labour has been reduced in the majority of countries. As a result of the shrinking agrarian workforce, the use of Internet of Things (IoT) solutions and trends in farming techniques has been accelerated to lessen the need for human labour (I. H. Khan & Javaid, 2022). The IoT is a promising technology that provides several innovative ideas to improve agriculture. When it comes to farming, IoT refers to the use of sensors and cameras to turn all of the things that happen in farming into data. People who work with big data can use software algorithms to get information about a farm at different levels of granularity from a lot of different types of data. This includes things like weather, moisture, plant health, mineral status, chemical applications, pest presence, and so on. Agriculture is an excellent option for IoT adoption since it requires continual monitoring and management. The IoT and big data applications will be critical in increasing global food production in the future decades (Akhter & Sofi, 2022). For example, experts predict that IoT-based technologies like sensors on agricultural equipment, self-driving tractors, drones and GPS imagery, as well as weather tracking, would be the trend in future in helping agropreneurs feed the globe while simultaneously coping with limited supplies of fossil fuel, water and fertile land. This technology not only ensures the competitiveness and sustainability of the food industry but also increases the income level of agropreneurs (Xu et al., 2022).

Despite IoT or smart farming having a lot of potential and trends in farming, the adoption rate in Malaysia is still low. According to Lindsjö et al (2021), farmers are unwilling to shift or adapt to new methods of farming. This is because the majority of farmers, most of whom are elderly, are unwilling to change their farming practices due to a lack of knowledge and interest in the subject. Revolution in production capabilities is already taking place in all industries, including agriculture. Ironically, many farmers are still unaware of the significance of IR4.0 and its benefits (Lazim et al., 2020). It is, therefore, important that awareness be created among the farmers and other key stakeholders so that the technology can be effectively promoted. Accordingly, this paper will study the impact of awareness and technology user adoption on IoT use among agropreneurs in Malaysia. The main contributions of this paper are to ascertain the level of awareness of IoT among agropreneurs as well as the perceived benefits it holds for enhancing the quality and quantity of agricultural production. The following sections comprise the remainder of the paper: In Section 2, a literature review and framework. Section 3 covers the experimental design and data collection techniques, with Section 4 presenting the outcomes. In section 5, we provide some concluding remarks and make some recommendations. Finally, we make suggestions about the research's limitations.

Agropreneur and IoT

Jarkko et al (2006), invented the term agropreneurs, which comes from the words 'agro', 'agriculture', and 'preneur', 'entrepreneur'. It is a term used to describe self-starting farmers who desire to flourish in their farming businesses. As is, agropreneurs should diversify their activities by establishing businesses that will help them increase their income and enable them to survive on the farm. Thus, an agropreneur is someone who builds his or her firm on the back of agriculture. On the other hand, Widiyanti et al (2023), posited that agropreneurs as millennial farmers, stand out by demonstrating modern farming practices and positioning themselves not just as a farmer but also as an entrepreneurs. Agropreneurs are also referred to as agropreneurs, a phrase that combines the terms agro (agricultural) and entrepreneur (entrepreneurship).

According to Ra et al (2019), argued that an agropreneurs is an entrepreneur who wishes to succeed in the farm business. This shows that communities also believe that agropreneurs indeed play a significant role in contributing towards economic growth. Agropreneurs are gaining traction in both agriculture and entrepreneurship, particularly in terms of redefining new and modern agriculture. This is because agropreneurs are also linked to efforts to innovate and explore new ways such adoption of technology like agricultural IoT and means of venturing into a profitable agricultural enterprise (Zainol et al., 2021). The IoT is at the heart of smart agriculture technology and enables a transition from traditional, input-driven agriculture (labourers) to more innovative, knowledge-intensive agriculture. The suitability of enabling technologies such as IoT, autonomous robots, big data analytics, and artificial intelligence (AI), are also critical components of IR4.0.

The application of IoT is in line with the advent of IR4.0. IoT is a term that refers to smart farming and cloud computing technology that collects real-time data and connects sensors to smart machinery to enable data-driven and data-enabled farm management. In 1999, Kevin Ashton, head of the Massachusetts Institute of Technology's (MIT) Auto-ID Center, coined the term IoT (Hoang & Qu, 2024). He anticipated that the IoT would be formed in the future, mounted on ordinary goods with radio frequency identification (RFID) and sensors. The Internet of Things is a technology and environment that allows real-time data exchange through the Internet, using sensors installed on various items.

The IoT has paved a new era in agriculture and has been used in different agricultural methodologies, including farm management (Aggarwal et al., 2022), farm monitoring (Rahaman et al., 2024), livestock monitoring (Kler et al., 2022), irrigation control (Saini et al., 2022), greenhouse environmental control (Wang et al., 2020), autonomous agricultural automation (Kim et al., 2020), supply chain and logistics management (Tu, 2018), and even in services related to IoT in online food retailing that enable agropreneurs to identify the purchase frequency of ready-to-eat food products (Khan et al., 2021). Furthermore, IoT allows for the integration of wireless sensors and mobile networks for real-time monitoring and management of farms by farmers (Majumdar & Mitra, 2021; Simitzis et al., 2021). This real-time intelligent aiding system is critical for farm operations, which are always vulnerable to abrupt environmental change as a result of inclement weather or disease (Khattab et al., 2019). Additionally, agropreneurs may collect useful data using IoT technology, which is then used to create yield maps, which enable agropreneurs to produce low-cost, high-quality crops through precision agriculture (Ra et al., 2019).

Even though there are various benefits to implementing IoT in the agriculture sector and there are several Malaysia government incentives and plans to transform the agricultural sector to be a dynamic, sustainable and competitive sector including also application of IoT, the adoption of technology for "Sustainable Agricultural Practice" (SAP) among Malaysian agropreneurs is still at low adoption rate (Adnan et al., 2017, 2019; Dilipkumar et al., 2021) and many of them are still not fully aware of the importance of IoT in IR4.0 (Mat Lazim et al., 2020; Putri et al., 2021). The use of IoT technologies in agriculture is increasing all the time. IoT landscape has been significantly changed due to the COVID-19 pandemic (Yousif & Hewage, 2021). There have been numerous studies to determine what can truly improve the utilisation of IoT. The majority of studies have explained how consumers in the target audience perceive a particular IoT. To put it another way, it relies on how and what the specific IoT in agriculture is perceived. According to Pillai (2020), when people are aware of a particular technology, their inclination to use the IoT in agriculture increases. For instance, studied conducted by Chuang et al (2020), on Taiwan's farmers, the utilisation of IoT was high when the respondents were aware of the technology and had favourable to adoption or utilise it.

In line with this, the utilisation of IoT in agriculture is also contingent on how an institution, business and agencies promote those technologies to agropreneurs. Numerous studies indicate a substantial correlation between technology trend awareness and the adoption of IoT (Koohang et al., 2022). Despite the substantial correlation, the research has established that. Additionally, the target audience must have the intention to use the technology. As a result of these explanations, it is clear that there is considerable potential for increasing technology trend awareness to increase the intention to use the IoT in agriculture. Similarly, there is the possibility of establishing a strong relationship between the intention to use and adoption of IoT in agriculture among agropreneurs.

Technology Awareness

The idea of technology awareness first appeared in Rogers (1995), as the first step in the innovation diffusion theory on how to diffuse an innovation, according to this theory, the diffusion of innovation is composed of two major actors: the business or organisation that adopts the innovation or new technology, and the users or people who will apply it. The decision process for adopting an innovation is a five-stage process comprising the following: awareness, attitude formation, decision, implementation, and confirmation. In this context, awareness speaks to how much the target population becomes aware of and forms an opinion on the innovation. The awareness stage introduces an organisation or individual to the innovation's existence and provides knowledge about how the innovation works and its benefits. As a result, awareness serves as a precursor to the stage of innovation spread known as attitude development (Dinev & Hu, 2007; Rogers, 1995). Indeed, because much diffusion research is concerned with technological innovations, Rogers (1995), frequently used the terms “technology” and “innovation” interchangeably.

In the context of technology, awareness refers to knowledge and understanding about a specific technological product or service. According to the definition, technological awareness is the understanding of how to utilise and the characteristics of a specific technology or technological element (Ahmed et al., 2016). Technology trend awareness refers to an individual's ability to be aware of and conscious of new and popular technology that has gained universal adoption throughout concerned industries or marketplaces. This may also involve an individual's capacity to perceive and comprehend the utility and benefits of these technologies for a successful organisation (Pandey et al., 2021) and other areas like IoT in agriculture, which is our concern in this paper.

There are several studies have been conducted to evaluate the relationship between technology awareness and the decision to adopt certain technologies. For example, Ahmed et al. conducted a study in 2016 to determine the impact of intention and technology awareness on the use of e-services by employees of a major private transport company through its three main subsidiaries in Pakistan. The results revealed that employees were more likely to adopt e-service technology if they were more aware or familiar with the technology. The authors concluded that increasing technology awareness can significantly increase the intention to use or adoption of technology.

Nevertheless, the primary obstacles to IoT adoption in agriculture include a lack of information, high adoption costs, and security concerns. The majority of agropreneurs are also unaware that IoT is being implemented in agriculture and some of them are resistant to novel ideas and will not adopt the technology even though it offers several benefits (Pillai, 2020). In this case, it can be assumed that before an agropreneurs may create positive or negative beliefs about using IoT technology, he must be aware of the benefits and threats or consequences use or not that technology. Therefore, awareness of IoT or smart farming in the context of this definition can be of great value for enhancing the adoption of agropreneurs to use it. In addition, Das et al., (2019), posited that the importance of technology awareness among agropreneurs was the primary area to improve.

Pillai (2020), also that a basic understanding of technology can considerably improve the behavioural intention to use or adoption of IoT in agriculture by agropreneurs or farmers. Additionally, Sinha & Dhanalakshmi (2022), suggested that a main challenge to IoT adoption in agriculture is a lack of sufficient awareness of IoT and its uses, particularly among rural farmers or agropreneurs. This is a common occurrence in developed countries, as the majority of farmers live in rural areas and are often illiterate. If human intervention is not possible, the agropreneur's failure to apply knowledge effectively can be a major obstacle to adopting the IoT. Simtowe et al., (2016) have also underlined the importance of awareness and highlighted that it can be considered as a precondition for the adoption of technology among farmers. On the other hand, Ebrahimi Sarcheshmeh et al. (2018) posited that lack of research in this regard.

Therefore, the Technology Acceptance Model (TAM) has been applied in this study (Figure 1). TAM was introduced by Davis in 1989 and explains users' perception of the usability of a technology. A relationship is proposed in this model between a user's perception of a given technology and his/her acceptance of that technology and also from acceptance to use. Two main factors are included in the model: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU refers to an individual's perception of the effect that applying a technology could be beneficial to him or her, for example, in improving his or her performance. PEOU, on the other hand, reflects the level of effort the user perceives is required to use the technology. While the attitude towards use (ATU) is the dependent variable. This model has been applied in numerous studies testing user awareness and acceptance of technology, for example, mobile banking (Mutahar et al., 2018), financial technology (Folkinshteyn & Lennon, 2016), gerontechnology (Jumbri et al., 2022; Zhou et al., 2020), social media (Singh & Srivastava, 2019), e-learning (Han & Sa, 2021), and many more including also in agricultural technology (Balakrishna & Nageshwara Rao, 2019). The TAM has been widely used to predict technology adoption behaviour. For agropreneurs, perceived ease of use and usefulness are particularly critical in influencing their decision to adopt IoT technology in managing farms.

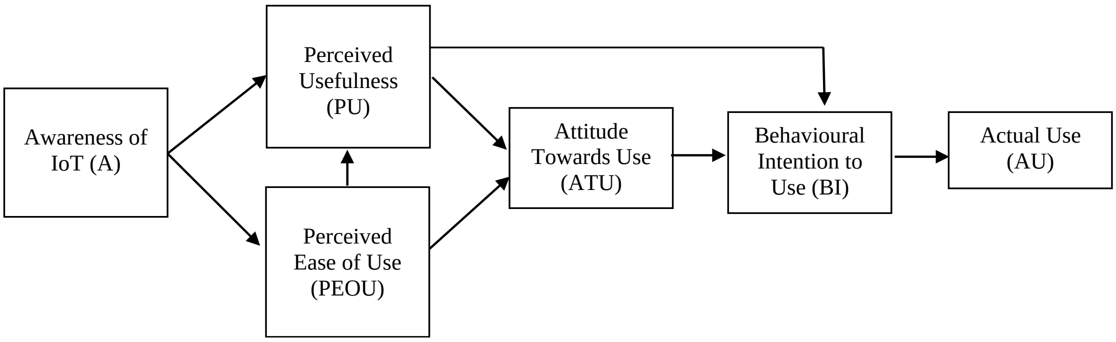

Figure 1. Technology Acceptance Model (TAM)

There are two objectives of this study. First, to determine the level of awareness and use of IoT in agriculture among agropreneurs at Melaka. Second, to examine the relationship between perceived usefulness, perceived ease of use, attitude and behavioural intention to use IoT among agropreneurs. There are three significant of this study. First, it offers important information to policymakers' maker especially the government to promote and encourage agropreneurs to use IoT in response to the Industry4WRD. Second, this study will encourage agropreneurs to adopt IoT in farming activities. Moreover, this study can be a useful reference for other researchers in the future. The research hypothesis for this study is shown in Table 1.

Table 1
Research Hypothesis

Variable	**Related Hypothesis**
Awareness	$H_{1:}$ Awareness is positively related to related to perceived usefulness. $H_{2:}$ Awareness is positively related to perceived ease of use.
Perceived Usefulness	$H_{3:}$ Perceived usefulness is positively related to attitude towards use. H_4: Perceived usefulness is positively related to behavioural intention to use.
Perceived Ease of Use	$H_{5:}$ Perceived ease of use is positively related to perceived usefulness. $H_{6:}$ Perceived ease of use is positively related to attitude towards use.
Attitude Towards Use	$H_{7:}$ Attitude towards use is positively related to behavioural intention to use IoT.
Behavioural Intention to Use	H_8: Behavioural Intention to Use is positively related to actual use.

Research Methods

The respondents of this study are agropreneurs registered under the Federal Agricultural Marketing Authority (FAMA), Melaka and Yoshii Agro Care Enterprise which is a company involved in agricultural activities in Melaka and has a vision to develop quality crops for developing nations. A structured questionnaire was developed to reflect the research objectives and conceptual framework of the study. There were three sections: the first comprised demographic information, including gender, age, education, income level, and experience in the relevant field. These variables were selected to gain a better insight into the sample and give a pool of variables for further analysis. The second part included questions to measure whether the respondents are aware of IoT in the agricultural sector. The third part discusses the farmers' intentions to adopt IoT in the future.

A total of 300 questionnaires were administered and 208 returned, constituting a response rate of 66.7%. Seven incomplete responses were removed and finally, 201 completed questionnaires were used in the statistical analysis. The sample of 201 agropreneurs was selected based on their registration with FAMA and Yoshii Agro Care Enterprise, ensuring a representative sample of IoT users in Melaka's agricultural sector. A 5-point Likert scale (see Table 2) questionnaires (1= Strongly Disagree; 2= Disagree; 3=Uncertain; 4=Agree; 5=Strongly Agree) was validated by a panel of experts in the field and also in a pilot test. Technology awareness and intention to use IoT were measured in this empirical research. A pilot study was conducted with 30 agropreneurs who were excluded from the final study population. Descriptive statistics was used to identify the level of respondents' awareness and acceptance towards IoT in agriculture. The items of all factors were ranked based on the highest until the lowest mean score (Table 2).

Table 2
Mean Range of Likert Scales

No	Description	Mean Range	Scale	Interpretation
1	Strongly Disagree	1.00 – 1.79	1	Very Low
2	Disagree	1.80 – 2.59	2	Low
3	Uncertain	2.60 – 3.39	3	Moderate
4	Agree	3.40 – 4.19	4	High
5	Strongly Agree	4.20 – 5.00	5	Very High

Pilot testing was done with a sample of 30 agropreneurs to determine the reliability and validity of the questionnaires. The Cronbach Alpha Coefficient (α) was used in determining internal reliability or consistency. Reliability is obtained when the Cronbach α value is greater than 0.5, according to Allison (2012). The results of the study found that all these factors have internal consistency with their respective measurement indicators as a value above 0.75 (Table 3)—far greater than the threshold of 0.5—of Cronbach α, indicating strong internal consistency.

Table 3
Value of Cronbach's Alpha Coefficient by Each Factor of TAM

Factors	**Cronbach Alpha Coefficient (α)**	**Number of Items**
Awareness of IoT	0.845	7
Perceived Usefulness	0.852	7
Perceived Ease of Use	0.884	5
Attitude Towards Use	0.878	4
Behavioural Intention to Use	0.785	3
Actual Use	0.775	2
Total		**26**

Results

Demographic Profile

The demographic profile of the sample population is shown in Table 4. A total of 86.6% of the respondents were male and 13.4% were female. The majority of respondents are bachelor's degree holders (49.8%) with fewer than two years of experience in the area (38.3%). As shown in the table, a large number of respondents belong to the age group of 20-29 years (53.2%) and least respondents in the age group of 50 years and above (1.5%). Most of the respondents' income in terms of profit per harvest was below RM 5,000 with 77.6% and between RM 5,001 to RM 10,000 with 22.4%. Results also indicated that only 26.4% of respondents have answered 'yes' to the "Are you currently using IoT in your farming activities?". The table shows that the majority of respondents have selected 'no' means and are not currently using or applying IoT in their farming activities.

Table 4
Demographic variables

Variables	**Frequency (*f*)**	**Percentage (%)**
Gender		
Male	174	86.6
Female	27	13.4
Age		
Below 19	10	5.0
20 – 29 years old	107	53.2
30 – 39 years old	67	33.3
40 – 49 years old	14	7.0
50 years old	3	1.5
Estimated Income per harvest		
<RM 5,000	156	77.6
RM 5,001 – RM 10,000	45	22.4
>RM 10,001	0	0
Education Level		
SPM	22	10.9
Diploma	75	37.3
Bachelor degree	100	49.8
Master	2	2.0
Experienced in Agricultural		
Less than a year	55	27.4
2 - 3 years	77	38.3
4 years and above	69	34.3
Are you currently using IoT in your farming activities?	53	26.4
Yes	148	73.6
No		
Total	**201**	**100**

Descriptive Analysis (Variable)

The analysis from Table 5 shows that the respondents are generally highly positively aware (M = 4.49; SD = 0.73) of applications related to the Internet of Things in agriculture. They strongly agreed on the importance of the Internet of Things in Agropreneur (M = 4.92; SD = 0.75) and its capacity to increase the productivity level of agropreneurs with more efficiency in the use of resources (M = 4.01; SD = 0.72). They are pretty aware that IoT can provide data collection and make farm management easy for agropreneurs (M=4.98, SD=0.75) and what it can do towards their economic growth (M=4.08, SD=0.73). They also agreed that using IoT in agriculture can meet the growing demand for crops while providing the highest quality standards (M=4.65; SD=0.78). The majority of the respondents in the future also plan to use IoT in their farms (M=4.12; 0.66) and they were they need to enhance their knowledge about IoT in agriculture (M=4.68; SD=0.70). However, the result suggests that awareness alone is insufficient for technology adoption. Factors such as cost, lack of training, and infrastructure could be barriers likely to hinder IoT usage.

Table 5
Awareness of IoT in agricultural

	Items	**Mean (M)**	**Standard Deviation (SD)**	**Rank**
1	I believe IoT in agriculture is important.	4.92	0.75	2
2	IoT in agriculture could enhance productivity and enable efficient utilization of resources.	4.01	0.72	6
3	IoT will help me to collect data and make it easier to manage my farms.	4.98	0.75	1
4	IoT in agriculture will generate economic growth.	4.08	0.73	5
5	I need to enhance my knowledge of IoT in agriculture.	4.68	0.70	3
6	I plan to use IoT in agriculture in the future.	4.12	0.66	5
7	I believe IoT can meet the growing demand for crops while providing the highest quality standards.	4.65	0.78	4
Total average		**4.49**	**0.73**	

Table 6
Perceived Usefulness of IoT

	Items	Mean (M)	Standard Deviation (SD)	Rank
8	I could improve the quality and quantity of production by using IoT.	3.78	1.23	4
9	I could increase my productivity by using IoT.	3.79	1.35	3
10	I could enhance my effectiveness in utilizing resources by using IoT.	3.35	0.75	7
11	I could control my farm remotely by using IoT.	3.37	1.25	6
12	I could reduce wastage and control costs by using IoT.	3.87	1.30	2
13	I could make forecasting and real-time monitoring of the production by using IoT.	3.38	1.13	5
14	I find IoT is a useful tool to improve food security in Malaysia.	3.96	1.77	1
Total average		**3.64**	**1.25**	

The respondents acknowledged that they have a high level of awareness towards the usefulness of IoT in agriculture (see Table 6). In general, the respondents agreed (M=3.64; SD=1.25) with the benefits of using IoT in their farms. Specifically, the respondents strongly agree that the IoT is a useful tool to improve food security in Malaysia (M=3.96; SD=1.77) and reduce wastage and control the cost of managing their farms (M=3.87; SD=1.30). They also agreed that IoT could increase productivity (M=3.79; SD=1.35) and improve the quality and quantity of agricultural production (M=3.78; SD=1.23). However, the respondents were unsure whether IoT could enhance their effectiveness in utilizing resources (M=3.35; SD=0.75), could control their farm remotely using IoT (M=3.37; SD=1.25) and agropreneurs able to make forecasting and real-time monitoring the production by using IoT in agricultural (Table 6).

Table 7
Perceived Ease of Use

	Items	Mean (M)	Standard Deviation (SD)	Rank
15	Learning to use IoT is easy for me.	3.68	0.98	5
16	I think using IoT is easy.	3.88	0.96	2
17	I found the IoT to be easy to use.	3.75	0.95	4
18	Using IoT it is easy to get to do what I want it to do.	3.81	0.96	3
19	Using IoT is convenient.	3.89	1.07	1
Total average		**3.82**	**0.98**	

The analysis of Table 7 shows that the overall perceived ease of use of IoT technology is positive, with an average score of 3.82 and a standard deviation of 0.98, indicating general consistency in responses. Users found IoT most convenient (M = 3.89, SD = 1.07), followed by ease of use (M = 3.88, SD = 0.96), and its ability to perform tasks effectively (M = 3.81, SD =

0.96). However, learning to use IoT was rated slightly lower (M = 3.68, SD = 0.98), suggesting minor challenges in the learning process. Overall, IoT is perceived as user-friendly, but improving the learning experience could enhance user adoption.

Table 8
Attitude Towards Use

	Items	**Mean (M)**	**Standard Deviation (SD)**	**Rank**
20	IoT is useful for my farm.	3.79	1.00	3
21	Adopting the IOT for my farm is a good idea.	3.99	0.82	1
22	The advantages of using IoT in agriculture overweight the disadvantages of not using it.	3.35	1.10	4
23	I will voluntarily use the IoT shortly.	3.82	0.99	2
Total average		**3.74**	**0.98**	

While the findings of descriptive analysis for attitude factor reported that the highest mean score (M=3.99; SD=0.82) for item 21 (Adopting the IoT for my farm is a good idea), and the lowest mean score (M=3.35; SD=1.10) for item 22 (The advantages of using IoT in agricultural overweight the disadvantages of not using it), and support the findings for perceived ease of use factor where the acceptable of IoT among agropreneurs is convenient for them in general, however, they do not understand the advantages of using IoT in the agricultural sector. Thus, it is important to educate agropreneurs about the benefits using of IoT, especially in the era of IR 4.0. Therefore, instead of an affordable and easily accessible IoT system, it is important to educate the agropreneurs in terms of the advantages of IoT, so that they can utilize the IoT in their agricultural activities (Table 8).

Table 9
Behavioural Intention to Use

	Items	**Mean (M)**	**Standard Deviation (SD)**	**Rank**
24	I will increase the use of IoT on my farm.	3.75	0.95	2
25	I tend to use IoT to improve the production of my farm.	3.81	0.96	1
26	I will recommend to other agropreneurs to use IoT for farming activities.	3.35	1.00	3
Total average		**3.64**	**0.97**	

The respondents also acknowledged that they have a high level of behavioural intention to use IoT in agriculture (see Table 9). In general, the respondents agreed (M=3.64; SD=0.97) that the using of IoT will benefit their agricultural activities and production. The results indicated that the highest mean score (M=3.81; SD=0.96) for item 25 (I tend to use IoT to improve the production of my farms), where the lowest mean score (M=3.35; SD=1.00) was received for item 26 (I will recommend to other agropreneurs to use IoT for farming activities). This leads to the optimistic assumption that the respondents plan to use IoT in their farming activities, however, they are still not confident to recommend to others to use IoT for farming activities. To overcome these challenges all agencies such as governments, universities or researchers need to promote the uptake of IoT among society, especially agropreneurs. Transfer of knowledge on various types of IoT in agricultural sectors will increase the agropreneur's confidence in applying the technology (Pham et al., 2021).

Table 10
Actual Use

	Items	**Mean (M)**	**Standard Deviation (SD)**	**Rank**
27	I always use IoT on my farm.	3.89	1.06	2
28	I believe that using IoT can enhance my productivity.	3.99	0.82	1
Total average		**3.94**	**0.94**	

Lastly, the results (see Table 10) for the actual use dimension indicated that the top-ranked item 28 was the respondent's belief that using the IoT can enhance their productivity (M=3.99; SD=0.82), while the lowest mean score (M=3.89; SD=1.06) was received for item 27 (I always use IoT in my farm). This indicated that the respondents lack of usage of IoT in their agricultural activities, which leads to the assumption that developing awareness and knowledge acquisition can enhance behavioural change to use the technology.

Correlation and Regression Analysis

Regression (β) and correlation (r) analyses were carried out to determine the existing significant relationships between the TAM variables, which are Awareness (A), Perceived Usefulness (PU), Perceived Ease of Use (PEOU), Attitude Towards Use (ATU), Behavioural Intention to Use (BI), and Actual Use (AU). The correlation coefficient (r) value is range from -1 to +1. R=1 indicate the variable is positive, r=-1 shows that the variable is negative and no relationship between the variable when r=0. Table 11 demonstrates the scale of the correlation coefficient.

Table 11
The scale of Correlation Coefficient

Pearson's Correlation Coefficient	**Interpretation**
0.00 to 0.30 (0.00 to -0.30)	Negligible Relationship
0.30 to 0.50 (-0.30 to -0.50)	Weak Positive (Negative) Relationship
0.50 to 0.70 (-0.50 to -0.70)	Moderate Positive (Negative) Relationship
0.70 to 0.90 (-0.70 to -0.90)	Strong Positive (Negative) Relationship
0.90 to 1.00 (-0.90 to -1.00)	Very Strong Positive (Negative) Relationship

Source: Parvev Ahammad

Table 12
Correlation Between the Constructs

Hypothesis	**Hypothesized Path**	**P-Value (P)**	**Correlation Coefficient (r)**	**Regression (β)**	**Result of Hypothesis**
H_1	A and PU	0.008	0.758**	0.657	Supported
H_2	A and PEOU	0.007	0.645**	0.610	Supported
H_3	PU and AU	0.015	0.720**	0.561	Supported
H_4	PEOU and PU	0.020	0.550**	0.500	Supported
H_5	PEOU and ATU	0.018	0.646**	0.540	Supported
H_6	ATU and BI	0.009	0.621**	0.517	Supported
H_7	BI and AU	0.005	0.719**	0.346	Supported

** Correlation is significant at the 0.01 level (p<0.01)

The correlation coefficient and regression value for all variables are presented in Table 12. Findings show all variables were proven to have positive path correlations. Furthermore, agropreneurs awareness has a strong positive correlation to perceived usefulness and actual use of IoT with values (r=0.758) and (r=0.720) accordingly. The hypothesis result shows that the perceived usefulness has significantly influenced the awareness of agropreneurs to use IoT. Perceived usefulness also has been shown as the most important driver of IoT adoption among agropreneurs. It is indicated that the number of agropreneurs using the IoT is increasing as they know the advantages of using the IoT in their daily activities. H_1 is accepted and validated, thus failing to reject the hypothesis. It has shown that perceived usefulness influences more than 66% of agropreneurs intention to use IoT.

The Beta coefficient showed a moderate positive relationship between perceived ease of use and awareness of agropreneurs (β=0.610) and actual use (β=0.645). It means that the easier and simpler use of IoT will encourage more agropreneurs to be willing to use IoT. Thus, H_2 and H_3 are accepted and validated thus failing to reject the hypothesis. This study also found that perceived ease of use had a moderately significant impact on both perceived usefulness and actual use with values of 0.550 and 0.646 respectively. Therefore, H_4 and H_5 are accepted and validated. In terms of behavioural intention to use, this study found a moderate positive relationship between behavioural intention and actual use (β=0.621) and a strong relationship between behavioural intention with actual use (β=0.719).

In summary, the results of this study confirmed all the hypotheses. All hypotheses in this study were proven to have positive path correlation and are accepted or supported as shown in Table 9. Only H_1 which is the relationship between awareness (A) and perceived usefulness (PU) and H_7 (the relationship between BI and AU) had the strongest impact. While, other hypotheses (H_2, H_3, H_4, H_5 and H_6) also had a positive impact although the magnitude of the effect was moderate.

Conclusions and Recommendations

This research uses TAM, which integrates awareness as an external variable. The result of this research shows that all hypotheses were confirmed. Results from the empirical findings in this study reveal that perceived usefulness plays a key role in affecting agropreneurs decision to use IoT in their farms. The awareness of the IoT has the strongest significant impact on the perceived usefulness of agropreneurs. Therefore, this finding would suggest that policymakers and knowledge transfer experts like researchers from universities or government agencies need to highlight the technology's benefit as a cost and labour-saving tool that can be used at their farm to foster a positive attitude among agropreneurs toward the adoption of IoT.

As affirmed by Caffaro et al (2020), and Chuang, Wang, & Liang (2020), the literature describes the key role of users in realizing the potential of IoT through increasing production efficiencies among agropreneurs in the use of more effective resources. For example, it is supposed to generate information that aids agropreneurs in the monitoring of farming operations and performance, making informed decisions toward an increase in both quality and quantity; providing greater control over livestock and crop management, transportation, and supply chain optimization; as well as full insight into performance and crop conditions. Additionally, IoT may further provide smart solutions for climate change challenges mitigation and enhancing food security within Malaysia. Training and information sessions on IoT in the agricultural sector need to focus primarily on how the IoT can help improve the efficiency and effectiveness of agropreneurs in managing their farms rather than the procedures of actual use of IoT. To enhance IoT adoption, government agencies and industry stakeholders must provide targeted training and financial incentives. Such initiatives could help agropreneurs overcome perceived barriers related to technology complexity and costs. These findings are consistent with the research by Wee & Lim (2022), which identified financial constraints and a lack of technical support as significant barriers to IoT adoption among agropreneurs in Malaysia.

The result of the study showed that although the level of awareness of IoT is high, however, the level of utilization is relatively low since only 26.4% of the respondents have used it before. This study agrees with the reports of existing literature that there is a low level of utilization of the IoT among farmers or agropreneurs in Malaysia (Nistah et al., 2021; Norazman et al., 2023; Zainol et al., 2021). Therefore, the finding of this study suggests a discrepancy between the level of awareness and the rate of usage, supporting the new perspective, contrary to what has previously been found in many studies that awareness may not always lead to the usage of technology. In this study, TAM has been used to analyse the respondent's attitudes towards the use of IoT. The result indicated the agropreneurs attitude towards the use of IoT is greatly influenced by their perceived usefulness of the IoT. This means that the positive or negative attitude of the agropreneurs towards IoT will depend on whether or not they think or perceive that the use of IoT is beneficial to them. Hence, clear information on the advantages of using IoT is essential for improving agropreneurs' perception of the usefulness of the IoT.

However, although the adoption of IoT in the agricultural sector offers great benefits to agropreneurs, the actual acceptance of IoT by agropreneurs would take a long time. Nistah et al (2021), posited that most farmers are reluctant towards technology adoption or acceptance due to finance, complexity, technical skills, industrial and government policy, knowledge, and also not fully aware of the advantages and benefits of IoT in the agricultural sector. In addition, although IoT in agriculture is growing, still there are some challenges in implementing IoT especially in developing countries and rural areas within the available infrastructure like internet, wireless cellular network, power consumption batteries lifetime and bandwidth. The high cost of IoT hardware, the complexity of deployment, and the lack of a technological ecosystem are the main challenges especially to the farmers or agropreneurs in remote and rural areas (Dupont et al., 2018). Thus, it is the role of the government to provide facilities, especially in rural areas and to ensure the agropreneurs gain a proper empowerment program. Without the involvement of policymakers and investing in the transformation of agriculture, the objectives of Industry4WRD which aims also to transform the agricultural sector in 2025 will not be achieved.

Limitations of the Study and Future Research

This study had also some limitations. First, the sample size of this study is only agropreneurs registered under the Federal Agricultural Marketing Authority (FAMA) and Yoshii Agro Care Enterprise in Melaka. Thus, it may not be representative of the entire region or Malaysia. Future studies need to focus on a more larger and diversified sample size to verify and generalize the findings. Second, this research used variables of TAM to analyse the awareness and acceptance of agropreneurs towards IoT in agriculture. Thus, future research should consider other variables and theories to analyse agropreneurs' awareness and acceptance of IoT. Third, it would be interesting to study the typical characteristics of IoT that agropreneurs prefer to adopt in their farms. Lastly, several factors that potentially influence agropreneurs' acceptance and adoption of the IoT should be explored and examined in the future. For instance, the authors are planning to conduct another study on the impact of privacy, security and trust towards the acceptance of IoT among agropreneurs.

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