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Effect Factors Evaluation of Internet of Things (IoT) Adoption in Agriculture: A Research on Small Island Development

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ABSTRACT

The rapid development of technology is bringing about fundamental changes in all areas of life, transforming traditional methods into digital solutions. In recent years, technological advancements have offered new opportunities across various sectors—from production and logistics to healthcare and agriculture—delivering significant gains in terms of efficiency and sustainability. In this context, Internet of Things (IoT) technologies are being used in the agricultural sector to increase productivity, optimize resource utilization, and promote sustainable production processes. Thanks to this technology, farmers can monitor environmental factors such as soil moisture, temperature, light, and pH levels in real time, and increase yield by applying appropriate agricultural techniques. Despite all these advantages, some farmers may be reluctant to adopt IoT due to concerns over its complexity compared to traditional methods or the perceived risk of job loss. This study aims to evaluate farmers' attitudes toward IoT technology by taking their concerns into account. The study analyzes whether three different factors have a positive (plus sign) or negative (minus sign) effect on IoT adoption in the agricultural sector. The analysis reveals not only significant differences but also similarities among different farmer groups. These findings provide important insights into which factors are more influential in the adoption of IoT. It is expected that such analyses will help guide the development of strategies tailored to different groups and support the wider adoption of IoT technologies in agriculture.

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Tarımda Nesnelerin İnterneti (IoT) Benimsenmesinin Etki Faktörleri Değerlendirilmesi: Küçük Ada Gelişimi Üzerine Bir Araştırma

ÖZET

Teknolojinin hızla gelişmesi, hayatın her alanında köklü değişimlere yol açmakta ve geleneksel yöntemleri dijital çözümlere dönüştürmektedir. Son yıllarda yaşanan teknolojik gelişmeler, üretimden lojistiğe, sağlıktan tarıma kadar pek çok sektörde yeni fırsatlar sunmuş, verimlilik ve sürdürülebilirlik açısından önemli kazanımlar sağlamıştır. IoT (Internet of Things) teknolojileri, tarım sektöründe verimliliği artırmak, kaynak kullanımını optimize etmek ve sürdürülebilir üretim süreçlerini teşvik etmek için kullanılmaktadır. Bu teknoloji sayesinde, çiftçiler topraktaki nem, sıcaklık, ışık, pH seviyesi gibi çevresel faktörleri gerçek zamanlı olarak izleyebilmekte ve uygun tarım teknikleri uygulayarak verimliliği artırabilmektedir. IoT teknolojisinin sunduğu tüm bu faydalara rağmen, geleneksel yöntemlere kıyasla daha karmaşık olan bu teknolojiye adaptasyon endişesi veya iş kaybı riski gibi nedenlerle çiftçiler bu teknolojiyi kullanma konusunda isteksiz görülebilirler. Bu çalışma ile amaçlanan, çiftçilerin endişeleri de göz önünde bulundurularak, IoT teknolojisine karşı yaklaşımlarının değerlendirilmesidir. Çalışmada 3 farklı faktörün tarım sektöründe IoT'nin benimsenmesi üzerinde pozitif (artı işareti) veya negatif (eksi işareti) bir etkiye sahip olduğu analiz edilmiştir. Analizler sonucunda anlamlı farkların yanı sıra gruplar arasında benzerliklerin de olduğu gözlemlenmiştir. Bu bulgular, özellikle

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IoT'nin benimsenmesi için hangi faktörlerin daha etkili olduğunu belirlemeye yönelik ipuçları vermektedir. Bu analizlerin farklı gruplara özgü stratejiler geliştirme ve IoT teknolojisinin benimsenmesini artırma açısından yol gösterici olması beklenmektedir.

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INTRODUCTION

Technological developments provide an environment for radical changes in all areas of life with innovative areas such as artificial intelligence, big data, Internet of Things (IoT), and blockchain. Artificial intelligence increases productivity in many sectors from agriculture to health, while big data analysis facilitates strategic decisions (Paramesha et. al., 2024). IoT provides energy savings and ease of use in a wide range of areas from smart cities to homes by enabling devices to work in connection with each other (Al-Obaidi et. al., 2022). Blockchain technology not only increases security in the financial sector but also ensures traceability in supply chain management (Javaid et. al., 2022). While digitalization creates great opportunities for businesses, it also necessitates workforce transformation and creates new skill requirements (Baethge-Kinsky, 2020; Baytorun et. al. 2018). Additionally, 5G technology allows more effective use of applications such as IoT and augmented reality (Lv, et. al., 2020). Technological advances support environmental sustainability, which then leads to emerging efficiencies in areas such as smart cities and precision agriculture (Khan et. al., 2021; Bayramoğlu et. al., 2025). In education, digitalization increases access to education through online platforms and individualized learning opportunities (Rakha, 2023). On the other hand, healthcare, telehealth, and AI-enabled diagnostic systems are improving patient care and diagnostic processes (Amjad et. al., 2023). Finally, investments in technology increase the global competitiveness among countries and contribute to economic growth (Çağlar, 2024a).

The Internet of Things (IoT) refers to the process of collecting, sharing, and analyzing data from devices that can connect to each other over the internet. With this technology, many objects, from household appliances to industrial machines and healthcare devices, can be interconnected via the internet to provide information to the user or perform automated processes (Laghari et. al., 2021; Hassan et. al., 2020). Additionally, IoT allows remote monitoring and control of devices, resulting in energy savings, security, and efficiency. For instance, IoT sensors on a farm can measure soil moisture and activate an automatic irrigation system, or in a smart home system, the thermostat temperature can be adjusted according to the user. This technology has become one of the key components of digitalization, offering great convenience in many areas from daily life to business processes (Ahmad et. al., 2024; Ahmad and Zhang, 2021).

IoT technology is revolutionizing agriculture (Özbilge et. al., 2020) through allowing farmers to monitor soil and weather conditions in real time, improving plant health (Javaid et. al., 2022). Sensors automate irrigation systems, which saves water and increases efficiency (Champness et. al., 2023). Other than such benefits, plant diseases and pests can be detected early, reducing intervention time (John et. al., 2023). IoT devices support farmers in saving time and costs while optimizing agricultural production processes (Dhanaraju et. al., 2022). Communication between agricultural machinery improves productivity and labor management (Prakash et. al., 2023). Using data analytics, farmers can make more informed decisions and optimize harvest time. As well as optimizing harvest time, the post-harvest process can also be tracked efficiently (Çağlar, 2024b). It also improves food safety by providing traceability of products to consumers (Balamurugan et. al., 2022). Hence, IoT technology stands out as an innovation that will shape the future of agriculture.

Under pressure from factors such as a rapidly growing global population and climate change, the agriculture sector benefits from digital transformation processes to achieve sustainable production targets (Hrustek, 2020). In this context, IoT technology increases productivity in agriculture by providing farmers with solutions such as data-driven decision-making, automatic irrigation, crop health monitoring, and pest detection systems (Mishra & Mishra, 2024). In addition to saving water and energy, IoT's agricultural applications support sustainable agriculture by reducing environmental impacts. The literature emphasizes that smart agriculture applications with IoT have significant potential to improve product quality and reduce costs (Wolfert & Isakhanyan, 2022). This section discusses the development process of IoT in agriculture, and current applications and technical challenges encountered will be discussed.

Within the context of the study, the researchers provide a comprehensive review of emerging technologies for IoT-based smart agriculture. It also includes a taxonomy of IoT applications and blockchain-based supply chain management methods. The study highlights how IoT technologies are used in areas such as crop monitoring, irrigation management, and crop productivity. It also emphasizes that the data collection and analysis capabilities offered by IoT play a critical role in supporting environmental sustainability. These technologies are said to provide much higher yields compared to traditional farming methods. The study also addresses the future development areas of IoT-based agricultural applications and potential challenges, demonstrating the importance of digital transformation in agriculture (Friha et. al., 2021).

Another study provides a comprehensive overview of the developments and challenges in the use of IoT technology in agriculture. The study highlights the benefits of IoT in smart agriculture, such as water savings, crop monitoring, and environmentally friendly practices. It also highlights the importance of sensors, data analytics tools, and drone technologies used in precision agriculture and presents findings on how these tools increase productivity. The authors also address the main barriers to IoT applications, such as low data security, high cost, and energy consumption. Furthermore, the paper highlights the potential role of next-generation connectivity solutions such as 5G technology to make agricultural systems more integrated and efficient. Considering the significance of IoT-based agricultural applications in the context of environmental sustainability, this study sheds light on future research areas by proposing forward-looking solutions (Sinha and Dhanalakshmi, 2022).

In another similar study, researchers examine the use of IoT technologies in sustainable agriculture from a broad perspective. The study highlights that smart agriculture applications contribute to sustainability by saving water and energy in areas such as crop management, soil analysis, and yield monitoring. It also points out that the integration of technologies such as sensors, data analytics, and cloud-based solutions enables greater efficiency and environmentally friendly production in agricultural processes. However, the study notes that these technologies face significant barriers, such as high cost, infrastructure shortcomings, and security issues. The proposed future research for IoT applications in agriculture aims to develop better strategies to overcome these barriers, so that digital technologies can be used more widely and effectively in the agricultural sector (Gupta and Bindal 2022).

Another study conducted by Norwegian researchers examines the adoption process of Internet of Things (IoT) technologies by farmers in agriculture. The research highlights the potential of IoT to improve agricultural productivity, optimize resource use, and support environmental sustainability. In the fieldwork, which was carried out using qualitative methods, farmers' attitudes toward IoT, their level of knowledge, and their access to technological infrastructure emerged as key influencing factors. It was especially noted that IoT applications provided efficiency in areas such as livestock farming, irrigation, and greenhouse management. However, high investment costs, lack of technical knowledge, and concerns about data security were identified as major barriers to widespread adoption. The study emphasizes that government support, training programs, and technical consultancy services are important facilitators in this process. It also shows that economic and environmental sustainability goals play a significant role in farmers' decision-making processes and suggests that the findings from Norway could also apply to other countries with similar conditions. Overall, the study concludes that the effective implementation of IoT technologies in agriculture requires multidimensional support mechanisms (Lillestrøm et al., 2024).

In another review study, researchers analyzed the adoption of IoT technologies in agriculture and smart farming practices and evaluated their potential to contribute to the development of urban green areas. It is noted that IoT-based systems increase efficiency by monitoring various agricultural parameters—such as soil moisture, weather conditions, plant health, and resource use—in real time. The study emphasizes that IoT offers significant benefits in urban agriculture, particularly in terms of sustainability, environmental monitoring, and food security. Based on a literature review, the research draws attention to the compatibility of technologies such as smart sensors, automation systems, and data analytics with green city policies. Nevertheless, high costs, data security issues, and lack of technical knowledge remain the main factors limiting the widespread use of IoT. The authors argue that public policies, educational initiatives, and private sector investments play a critical role in achieving successful integration. They also recommend that future research should focus on user-friendly interfaces and energy-efficient solutions. Overall, the study reveals that IoT is a powerful tool that supports agricultural sustainability and promotes the expansion of urban green spaces (Madushanki et al., 2019).

Another review study aims to explore how IoT technologies have been applied in various ways in the agricultural sector of the United States and what kinds of tangible benefits they offer. Based on case studies from different agricultural production areas, the research underlines that IoT provides important opportunities in terms of sustainability and resilience. According to the findings, the use of IoT in precision agriculture increases efficiency in irrigation, fertilization, and pest control, while reducing environmental impact. However, the study also identifies major obstacles such as high infrastructure costs, data security concerns, system compatibility problems, and limited digital access in rural areas. To overcome these challenges, it is emphasized that stakeholders must collaborate on financial support, regulatory frameworks, technical guidance, and training (Ifty et al., 2023).

Finally, the researchers comprehensively analyze the current state of IoT-based technologies for sustainable agricultural practices. The research describes how IoT components such as smart sensors, data collection systems, cloud computing, and artificial intelligence are being used in agriculture. Additionally, the study emphasizes that these technologies improve efficiency in areas such as crop management, soil health monitoring, and water use. However, challenges such as cost, security concerns, data privacy, and infrastructure gaps are discussed as the main barriers limiting the widespread use of these technologies. The study also highlights the importance of IoT-based solutions in supporting environmental sustainability, enabling more efficient resource management in agriculture. IoT-enabled agricultural practices have great potential to both protect the environment and increase economic efficiency. In the future, advanced connectivity technologies and data security solutions are expected to contribute to overcoming these barriers (Santosh and Raghavendra, 2023).

MATERIALS and METHODS

As mentioned in the literature, many researchers have conducted studies on the factors affecting the adoption of IoT technology.

This study examined the factors that influence the adoption of IoT technology as well as the attitudes of farmers towards IoT in a small island developing country based on the previous study data.

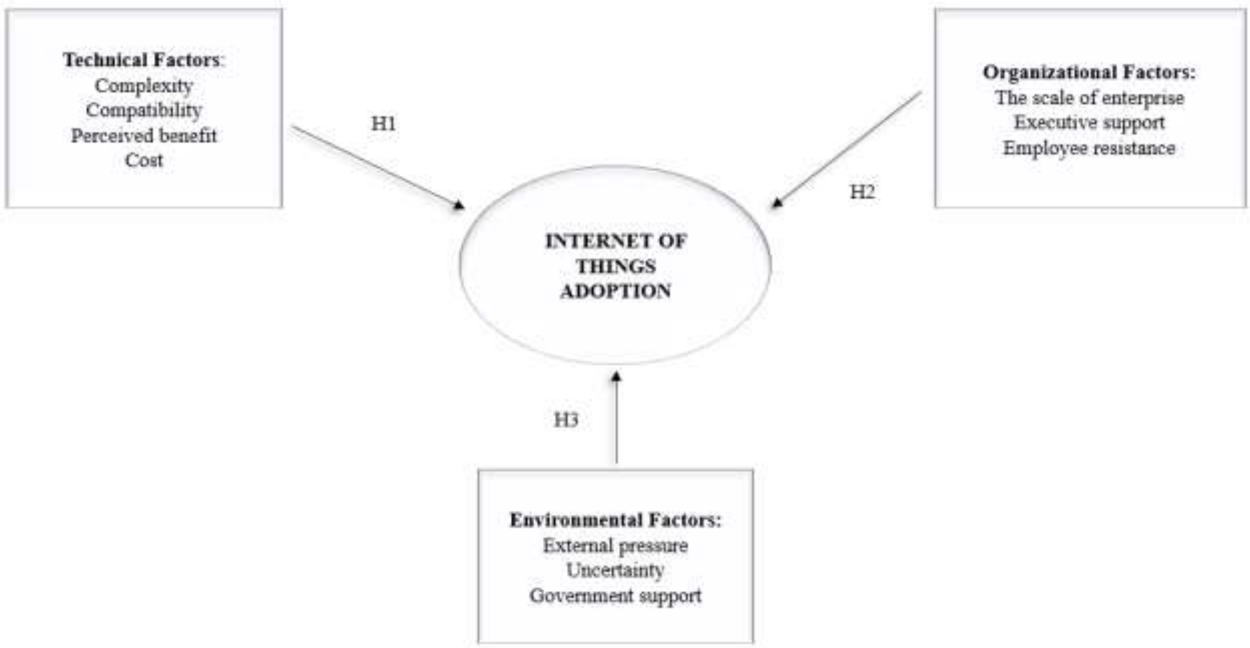

Figure 1. Model of the impact factors of IoT adaptation
Şekil 1. IoT adaptasyonunun etki faktörlerinin modeli

With regard to the literature review, Figure 1 shows the conceptual model in which 3 different factors are hypothesized to have a positive (plus sign) or negative (minus sign) impact on IoT adoption in the agricultural sector. These tested factors are categorized according to the Technology Organization Environment (TOE) structure: technical factors (complexity, compatibility, perceived benefit and cost), organizational factors (scale of business, managerial support and employee resistance) and environmental factors (external pressure, uncertainty and government support) (Baker, 2012).

As illustrated in Figure 1, this study investigates the factors influencing the adoption of Internet of Things (IoT) technologies in agriculture by using the Technology–Organization–Environment (TOE) theoretical framework. The TOE model provides a structured way to understand technology adoption by considering technological, organizational, and environmental dimensions.

The technological dimension includes farmers' perceptions of IoT in terms of complexity, compatibility, perceived benefits, and cost. The organizational dimension addresses variables such as farm size, managerial support, and employee resistance. The environmental dimension reflects external factors such as competitive pressure, uncertainty in technological development, and availability of government support.

Additionally, the study incorporates the variable of willingness to adopt—drawn from the Unified Theory of Acceptance and Use of Technology (UTAUT)—to account for individual intent in the adoption process. By combining both external conditions and individual-level motivations, the research offers a comprehensive view of IoT adoption.

Focusing on small-scale farming enterprises in island settings, the study aims to evaluate how farmers with limited resources approach new technologies from multiple perspectives. The survey was carefully designed to include items corresponding to each element of the theoretical framework, thereby ensuring consistency between the conceptual model and the data collection process.

Table 1. Cronbach's alpha test
Tablo 1. Cronbach'ın alfa testi

		N	%
Cases	**Valid**	200	100.0
	Excluded[a]	0	.0
	Total	200	100.0

a. Listwise deletion based on all variables in the procedure.

Cronbach's Alpha	**N of Items**
.879	51

In terms of this study, the related data were collected from a questionnaire designed and adapted from a study used in the literature (Lin et. al., 2016) and measured on a seven-point Likert scale where 1 means 'strongly disagree' and 7 means 'strongly agree'. The survey questions used in the study were revised for a small island developing country (Appendix A). These questionnaires were distributed to farmers via email in Google Forms format. This study was conducted in November 2024 with 200 valid questionnaires completed. As part of the research, a sample of 200 farmers engaged in agricultural production was selected. Participants were chosen from individuals who are actively involved in the agricultural sector and whose primary source of income is farming. This selection aimed to enhance the reliability of the study and ensure the collection of data relevant to the target group. The sample was formed to represent a homogeneous group in line with the purpose of the research.

As shown in Table 1, Cronbach's Alpha coefficient was calculated to assess the internal consistency of the scale used in the study. The resulting Cronbach's Alpha value was 0.879, which is well above the commonly accepted threshold of 0.70, indicating a high level of reliability. This result supports the conclusion that the questionnaire used in the study provides consistent and reliable measurements. Therefore, the findings obtained from the research can be considered statistically valid (Cortina, 1993).

In addition, to ensure the validity and reliability of the regression analysis, the basic assumptions of the multiple linear regression model were tested. The normality of residuals was evaluated using histograms and Normal Q-Q plots. Multicollinearity was assessed by examining the Variance Inflation Factor (VIF) and tolerance values. Homoscedasticity (homogeneity of variance) was checked by analyzing the distribution of standardized residuals.

RESULTS and DISCUSSION

Three different factors were analyzed to have a positive (plus sign) or negative (minus sign) impact on IoT adoption in the agricultural sector. The results show the impacts on IoT adoption.

The data analysis was performed with the statistical package program for social science (SPSS for Windows) and R software. The results reflect the impacts on IoT adoption.

Table 2 reflects the statistical analysis of the relationships between various factors and the tendency to adopt IoT. The basic statistical distribution of these factors is represented by means and standard deviations. Considering the data in Table 2, technical, organizational, and environmental factors play an important role in the IoT adoption process. Perceived Benefit (5.5150) and Compatibility (5.1133) have positive effects on IoT adoption. The perception of Costs (4.9717) still seems to be a barrier, so low-cost solutions and appropriate financial support should be provided. Also, training programs or awareness campaigns can be organized to reduce employee resistance (3.6667) and better explain the benefits of the technology. State Support (2.6225) is perceived to be quite low, so the government should provide more incentives and infrastructure support to the IoT adoption process. Uncertainty (4.8300) and External Pressure (4.1788) are important external factors affecting the viability of IoT technologies. Examples of successful implementation of IoT in the sector should be shared, and roadmaps should be created to reduce uncertainty. This information can provide guidance on which areas to focus on in developing IoT adoption strategies. Additionally, the mean values and standard deviations of the factors are presented in Figure 2. Each bar represents the average score of a specific factor, while the line on top of the bar indicates its standard deviation. Figure 2 clearly illustrates which factors were perceived more strongly (or weakly) by the participants.

Table 2. Descriptive statistics
Tablo 2. Tanımlayıcı istatistikler

	Mean	Std. Deviation
Technical Factors - Complexity (TFC)	3.5883	1.00138
Technical Factors - Compatibility (TFCo)	5.1133	1.49574
Technical Factors - Perceived benefit (TFB)	5.5150	1.65445
Technical Factors - Costs (TFCost)	4.9717	1.63394
Organizational Factors - Enterprise Scale (OFES)	4.3967	1.57606
Organizational Factors - Executive Support (OFS)	4.0638	1.25163
Organizational Factors - Resistance from Employees (OFR)	3.6667	1.14985
Environmental Factors - External Pressure (EFEP)	4.1788	1.56404
Environmental Factors - Uncertainty (EFU)	4.8300	1.43423
Environmental Factors - State Support (EFSS)	2.6225	1.42263
Willingness to Adopt the Internet of Things (IoT) - Willingness to Adopt (IoTAdopt)	4.1800	1.66326

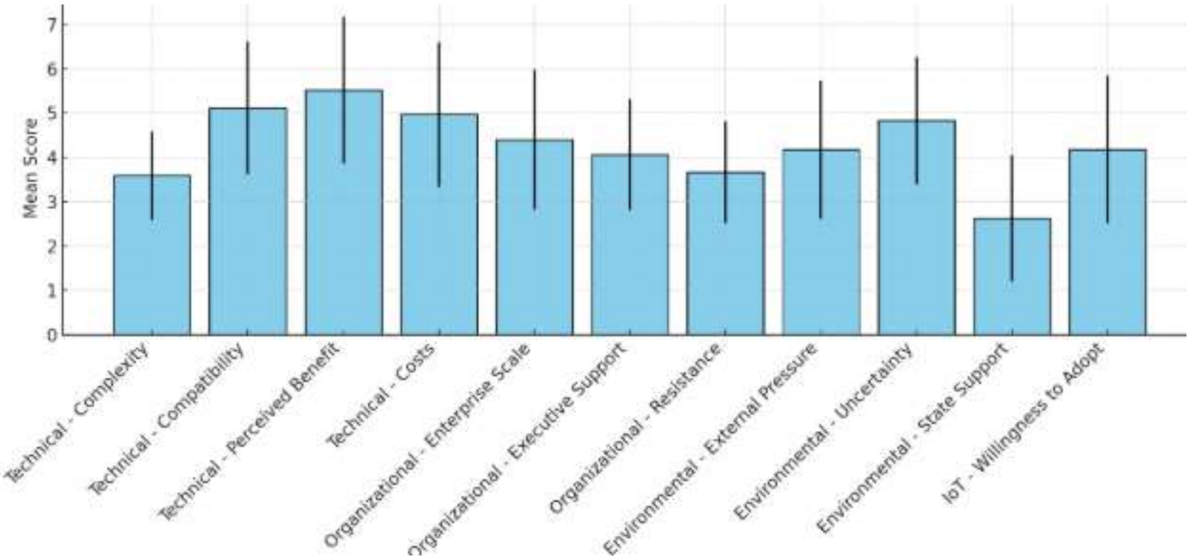

Figure 2. Mean and standard deviation of factors influencing IoT adaption
Şekil 2. IoT adaptasyonunu etkileyen faktörlerin ortalama ve standart sapması

Table 3 shows the characteristics of a sample according to demographic data and farming-related categories. Men have a clear majority in the sample indicating that men are more dominant among those engaged in farming. In terms of age range, farmers in the 46-60 age range are the largest share in the sample with 35.5%. Additionally, 45% of the sample has a bachelor's degree, indicating that a significant proportion of individuals engaged in farming are educated. 26% of high school graduates are also noteworthy. However, the proportion of no education or primary school graduates is quite low (6%). This suggests that education level may be associated with farming activities. Among those in the sample with farming experience, those with 16-20 years of experience (24.5%) and those with more than 20 years of experience (25.5%) predominate. This concludes that most of the individuals engaged in farming have been practicing the profession for many years and are experienced in their field. However, the proportion of beginner farmers (10.5%) is also remarkable. Farmers that perform a variety of farming practices constitute the largest group with 37.5%. The proportion of vegetable and fruit farmers is equal (26.5%). The proportion of farmers engaged in field crops is quite low (9.5%). This shows that there is diversity in types of farms, yet variation in farming is more common accordingly.

The results in Figure 3 show the percentages of farmers who have knowledge about various digital technologies. Overall, awareness levels vary significantly. High knowledge levels are observed for common technologies like smartphones and basic farm management software. Moreover, moderate awareness exists for precision agriculture tools, such as GPS-enabled devices and sensors. And finally, low knowledge levels are evident for advanced technologies like IoT and artificial intelligence.

Table 3. Frequency table
Tablo 3. Frekans tablosu

Variables		Frequency	Valid Percent
Gender	Famale	26	13
	Male	174	87
Age	18-30	46	23
	31-45	50	25
	46-60	71	35.5
	60+	33	16.5
Education	No Formal Education	2	1
	Primary School	10	5
	Middle School	14	7
	High School	52	26
	Undergraduate	90	45
	Graduate	32	16
Farming Year	1-5	21	10.5
	6-10	42	21
	11-15	37	18.5
	16-20	49	24.5
	20+	51	25.5
Farm Type	Vegetable Farming	53	26.5
	Fruit Production	53	26.5
	Field Crops	19	9.5
	Mixed Production	75	37.5

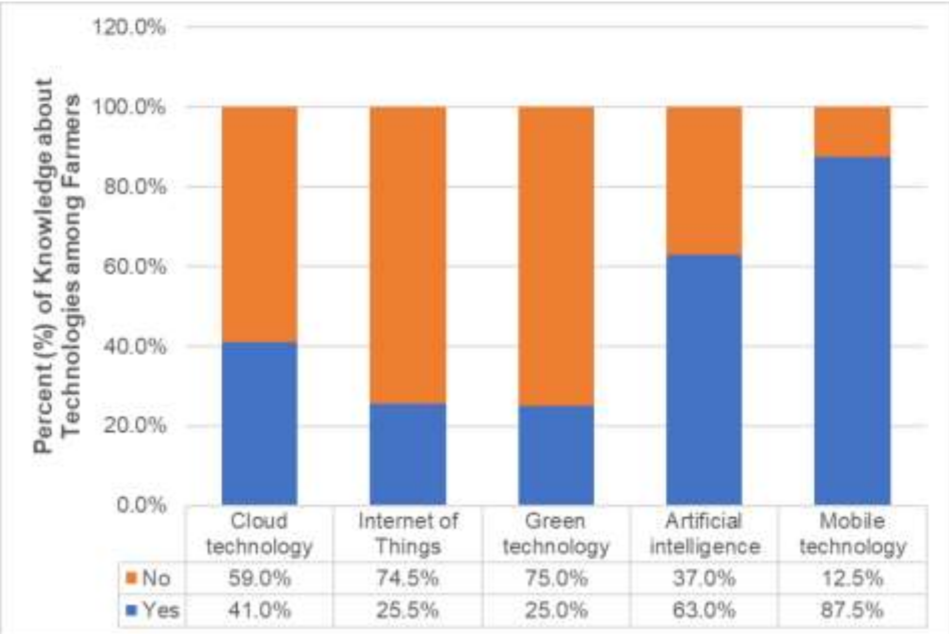

Figure 3. Knowledge about technologies among farmers by percentage.
Şekil 3. Çiftçiler arasında teknolojiler hakkındaki bilgi düzeyinin yüzdesel dağılımı.

Figure 4 presents farmers' willingness to adopt various technologies. According to the results, the technologies with high perceived utility, such as farm management software and GPS devices, have the highest willingness scores. On the other hand, willingness is lower for advanced and complex technologies, like IoT and artificial intelligence, reflecting concerns about usability, cost, and compatibility. Moreover, a notable gap exists between knowledge and willingness for certain technologies, suggesting that improved understanding could positively influence adoption intentions.

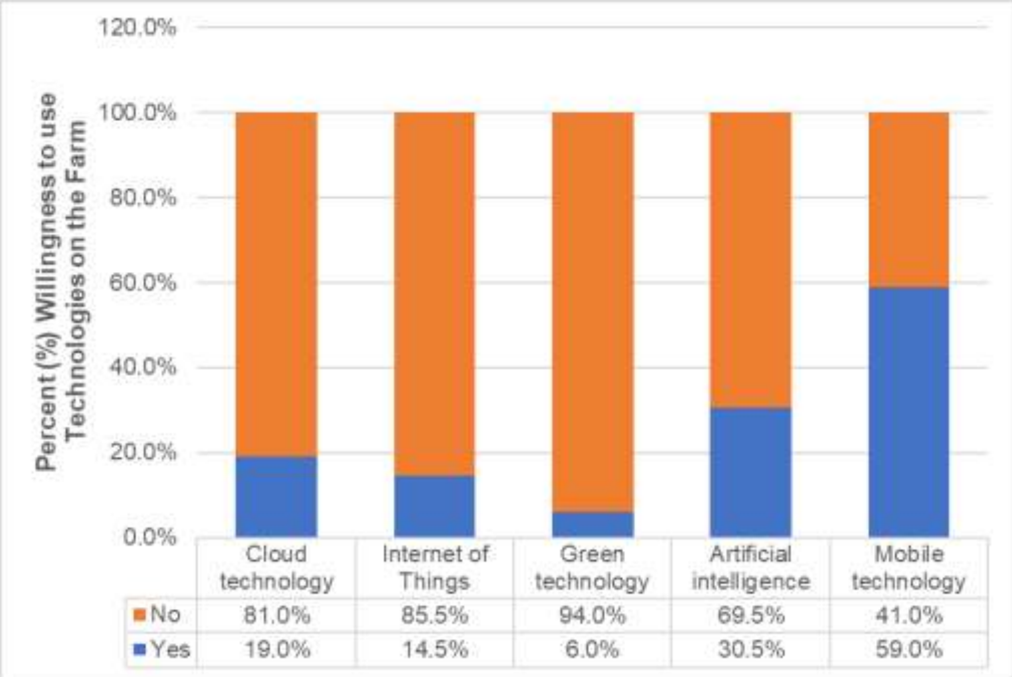

Figure 4. Willingness to use technologies on the farm by percentage.
Şekil 4. Çiftlikte teknoloji kullanma istekliliği yüzde olarak.

Table 4. Frequency table according to digital usage
Tablo 4. Dijital kullanımına göre sıklık tablosu

Variables		Frequency	Valid Percent
Digital Usage	Yes	57	28.5
	No	69	34.5
	Want to use it but haven't used it yet	74	37

Table 4 shows the preferences for the use of digital technologies on the farm. 28.5% of the sample is actively using digital technologies. This shows that there is a group that is currently embracing digitalization, but 71.5% of the total either do not use or have not yet made the transition to digital technologies. This rate indicates that digitalization still needs to become widespread. In addition to the 28.5% who have adopted digitalization, 34.5% do not use digital technologies at all. This shows that a large segment is lagging in the digitalization process and that awareness-raising activities are needed in this group. This group may be experiencing reluctance or a lack of access to digital technology.

Additionally, 37% who want to use digital technologies but have not yet done so represent individuals who are ready to digitize but face various barriers. These barriers may include cost, lack of education, infrastructure issues, or lack of knowledge. This is a critical segment that digital transformation strategies should target.

Table 5. Willingness to Adopt the Internet of Things (IoT) – According to Education
Tablo 5. Nesnelerin İnterneti'ni (IoT) Benimseme İsteği – Eğitime Göre

A3 education	N	Subset for alpha = 0.05
		1
No formal education	2	3.0000
Primary school	10	3.3000
Middle school	14	3.7500
High school	52	3.7500
Undergraduate	90	4.4222
Graduate	32	4.7344
Sig.		.262

Table 5 presents the willingness to use IoT technologies based on participants' education levels. To examine whether there are statistically significant differences in the tendency to adopt IoT technologies according to education level, a Tukey HSD test was conducted. The results indicate that, on average, willingness to adopt IoT increases with higher levels of education. For example, individuals with postgraduate education had an average score of 4.73, while those with no formal education had an average score of 3.00. However, the significance level (Sig. = .262), which indicates whether the differences between groups are statistically meaningful, is above the 0.05 threshold. Therefore, although the differences appear descriptive, they are not considered statistically significant. As a result, it cannot be concluded that education level has a meaningful effect on willingness to adopt IoT technologies.

Table 6. Willingness to Adopt the Internet of Things (IoT) – According to Age
Tablo 6. Nesnelerin İnterneti'ni (IoT) Benimseme İsteği – Yaşa Göre

A2 age	N	Subset for alpha = 0.05
		1
46 to 60	71	4.0634
31 to 45	50	4.1200
18 to 30	46	4.1304
over 60	33	4.5909
Sig.		.424

Table 6 examines the relationship between age distribution and the adoption of IoT technologies. The average willingness to adopt IoT among individuals aged 60 and above (4.59) is higher compared to other age groups. In contrast, the averages for the other age groups are quite similar: 4.13 for the 18–30 age group, 4.12 for the 31–45 group, and 4.06 for the 46–60 group. However, the significance level obtained (Sig. = .424) is greater than the 0.05 threshold, indicating that the differences between age groups are not statistically significant. Therefore, although some variation is observed across age groups, it cannot be concluded that age has a statistically significant effect on the adoption of IoT technologies.

Table 7. Comparison between farming types and factors
Tablo 7. Tarım türleri ve faktörleri arasındaki karşılaştırma

	FARMING TYPE			
	Mixed Production	Fruit Production	Field Crops	Vegetable Farming
TFC	a(3.42)	a(3.42)	a(3.80)	a(3.90)
TFCo	a(5.99)	b(4.61)	a(5.49)	b(4.23)
TFPB	a(5.72)	a(5.16)	a(6.07)	a(5.37)
TFCost	a(5.07)	a(4.86)	a(5.17)	a(4.85)
OFES	b(3.96)	ab(4.38)	a(5.08)	ab(4.76)
OFS	ab(3.90)	ab(3.95)	b(3.72)	a(4.52)
OFR	bc(3.37)	ab(3.81)	c(3.07)	a(4.13)
EFEP	b(3.50)	a(4.46)	b(3.52)	a(5.08)
EFU	a(4.74)	a(5.22)	a(5.15)	a(4.44)
EFSS	b(2.20)	b(2.69)	a(3.78)	b(2.72)
IoTAdopt	b(3.25)	a(4.35)	a(4.52)	a(5.18)

Table 7 shows that different farm types respond differently to technical, organizational, and environmental factors and their impact on IoT adoption. Vegetable Farming in particular has high values for IoT adoption and external pressures, while Mixed Production generally has lower values. This suggests that IoT adoption and other factors need to be optimized across farming types

Table 8 shows the different approaches of age groups to various technical, organizational, and environmental factors. There are significant differences between age groups, especially in technical factors such as perceptions of complexity, compatibility, and cost. IoT technology adoption also varies across age groups, with the 60+ age group having a more positive attitude. This kind of information provides important clues for developing age-specific strategies.

Table 8. Comparison between age and factors.
Tablo 8. Yaş ve faktörler arasındaki karşılaştırma.

	AGE			
	18-30	31-45	46-60	60+
TFC	a(3.92)	b(3.04)	ab(3.53)	a(4.04)
TFCo	b(4.93)	a(5.73)	ab(4.95)	b(4.76)
TFPB	a(5.50)	a(5.65)	a(5.34)	a(5.69)
TFCost	a(5.30)	b(4.21)	ab(5.05)	a(5.47)
OFES	a(4.39)	a(4.56)	a(4.25)	a(4.44)
OFS	ab(4.05)	a(4.58)	ab(3.67)	ab(4.13)
OFR	ab(3.69)	a(4.04)	b(3.41)	ab(3.60)
EFEP	a(4.34)	a(4.34)	a(3.88)	a(4.34)
EFU	a(4.60)	a(5.23)	a(4.79)	a(4.61)
EFSS	a(2.80)	a(2.64)	a(2.48)	a(2.63)
IoTAdopt	a(4.13)	a(4.12)	a(4.06)	a(4.59)

Table 9. Analysis of variance results for the multiple linear regression analysis
Tablo 9. Çoklu doğrusal regresyon analizi için varyans analizi sonuçları

Model	Sum of Squares	Degrees of freedom (df)	Mean Square	F	P value	R^2	Durbin-Watson
Regression	382.69	10	38.26	43.09	.000	.695	2.166
Residual	167.83	189	.88				
Total	550.52	199					

Dependent Variable: IoTAdopt; Predictors: (Constant), TFC, TFCo, TFPB, TFCost, OFES, OFS, OFR, EFEP, EFU and EFSS

In consideration of Table 9, the regression model is statistically significant ($P < 0.05$), suggesting that the predictors collectively explain an important amount of the variance in IoTAdopt (willingness to adopt IoT technologies). The coefficient of determination (R^2) value implies that 69.5% of the variability in IoTAdopt can be explained by the model. Additionally, the Durbin-Watson statistic is 2.166, which is close to the ideal value of 2, indicating no significant autocorrelation in the residuals. These results confirm the reliability of the model in explaining IoT adoption tendencies among farmers.

Table 10. Multiple linear regression results for the prediction of IoTAdopt with the other factors.
Tablo 10. IoTAdopt'un diğer faktörlerle tahmini için çoklu doğrusal regresyon sonuçları.

Model	Unstandardized Coefficients		Standardized Coefficients	Collinearity Statistics	
	B	Std. Error	Beta	Tolerance	VIF
(Constant)	3.561	.504			
TFC	.312	.112	.188	.353	2.832
TFCo	-.953	.078	-.857	.331	3.022
TFBP	.651	.098	.647	.170	5.891
TFCost	-.399	.077	-.392	.284	3.522
OFES	.409	.096	.387	.194	5.155
OFS	-.657	.133	-.494	.160	6.244
OFR	.468	.139	.324	.175	5.714
EFEP	.112	.068	.105	.400	2.501
EFU	.368	.084	.317	.307	3.261
EFSS	-.122	.067	-.104	.498	2.008

The results of the analysis of how and to what extent the various factors measured in this study affect IoTAdop are given in Table 10. The regression coefficients and their significance reveal the influence of various factors on IoT adoption. Key results suggest that the less complex systems are more likely to be adopted (TFC; $\beta = 0.188$, $P < 0.05$). On the other hand, the lack of compatibility with existing systems strongly deters adoption (TFCo; $\beta = -0.857$, $P < 0.05$). The results also made it possible to see that the farmers prioritize systems offering clear advantages (TFPB; ß = 0.647, $P < 0.05$). Moreover, as expected, high costs were noted to discourage adoption (TFCost; ß = -0.392, $P < 0.05$). In terms of the organizational factors, it was observed that the larger enterprises are more inclined to adopt IoT (OFES; ß = 0.387, $P < 0.05$). It was also noted from the results that the lack of support from decision-makers is a critical barrier for system adoption (OFS; ß = -0.494, $P < 0.05$). According to the environmental factors, pressure from stakeholders would encourage adoption (EFEP; ß = 0.105, $P < 0.1$). One of the most significant factors affecting technology adoption is that the management of uncertainty is a key challenge but can also drive adoption (EFU; (ß = 0.317, $P < 0.05$). Moreover, an examination of the standardized coefficients (Beta) in the model reveals that the variables TFBP and OFS have the greatest impact on the dependent variable. These findings indicate that the model has a high explanatory power and that the independent variables make significant contributions.

To assess whether the independent variables in the model cause multicollinearity, Tolerance and Variance Inflation Factor (VIF) values were analyzed. The VIF values for all variables remain below 10, with most values ranging between 2 and 6. The highest VIF was found for the OFS variable, at 6.244, which is still below the commonly accepted threshold of 10. Therefore, it is concluded that there is no serious multicollinearity issue. Additionally, all Tolerance values are above 0.1, indicating an acceptable level of variable distinction within the model. Consequently, it can be stated that multicollinearity is not present at a level that would negatively affect the regression analysis.

Additionally, the normality of residuals was assessed using histograms and Normal Q-Q plots. The standardized residuals appeared to be approximately normally distributed, and the Q-Q plot showed that the observed values closely aligned with the expected normal distribution. Although the Shapiro-Wilk test was statistically significant ($p < 0.05$), considering the large sample size ($N = 200$), the visual assessments suggest that the assumption of normality is adequately met for regression analyses. Furthermore, all skewness values were found to fall approximately within the range of –0.5 to +0.5, indicating that the distribution is fairly symmetrical. Most kurtosis values also fell within the range of –1 to +1, which suggests that the distribution is either close to normal or slightly flatter (platykurtic).

Homoscedasticity (equal variance of residuals) was evaluated by examining the distribution of standardized residuals. No clear patterns or funnel-shaped distributions were observed, which indicates that the assumption of constant variance is likely met. Overall, the findings suggest that there is no serious issue related to heteroscedasticity.

As per Figure 5, the Dim1 axis is strongly related to the factors representing the technical advantages and perceived benefits of IoT (TFCo - Fit, TFBP - Perceived Benefits). In particular, the group that uses IoT ("Yes") is positively clustered on Dim1. This suggests that one of the most important factors influencing the use of IoT is the alignment of the technology with user needs (TFCo) and the perceived benefit from this technology (TFPB). For example, the fact that IoT in agriculture offers tangible benefits to farmers, such as streamlining business processes, reducing costs or increasing productivity, supports that this group tends to adopt IoT.

On the other hand, Dim2 axis is more related to organizational (OFES - Organizational Support) and environmental (EFEP - External Pressures) factors. In particular, the fact that the "Plan" group is distributed on the Dim2 axis indicates that environmental and organizational factors may be more decisive in the decisions of these individuals or organizations to adopt IoT. This reveals that groups that have not yet used IoT but plan to use it in the future may be more affected by external pressures or government support (EFSS). Furthermore, the EFSS (Government Support) variable is represented by a shorter arrow in the graph compared to other factors, which may indicate that government support has less impact on IoT adoption in agriculture. However, this may indicate an area of opportunity to increase the impact of government policies or incentives on IoT adoption.

Accordingly, it is emphasized that government support plays a relatively weak role in farmers' adoption of IoT technologies. To improve this, it is recommended that national and local authorities provide financial incentives, invest in rural digital infrastructure, and offer targeted training and advisory programs (Lillestrøm et al., 2024; Ifty et al., 2023). In addition, regulatory frameworks should be developed specifically for data security and standardization in agricultural IoT applications (Gupta & Bindal, 2022). Sharing real-world success stories through awareness campaigns may also help build trust and motivation among hesitant farmers (Madushanki et al., 2019). These multidimensional strategies would not only strengthen public support mechanisms but also accelerate the digital transformation of agriculture (Santosh & Raghavendra, 2023). Policymakers can play a catalytic role in mainstreaming IoT adoption in the farming sector by addressing barriers related to cost, access, knowledge, and trust.

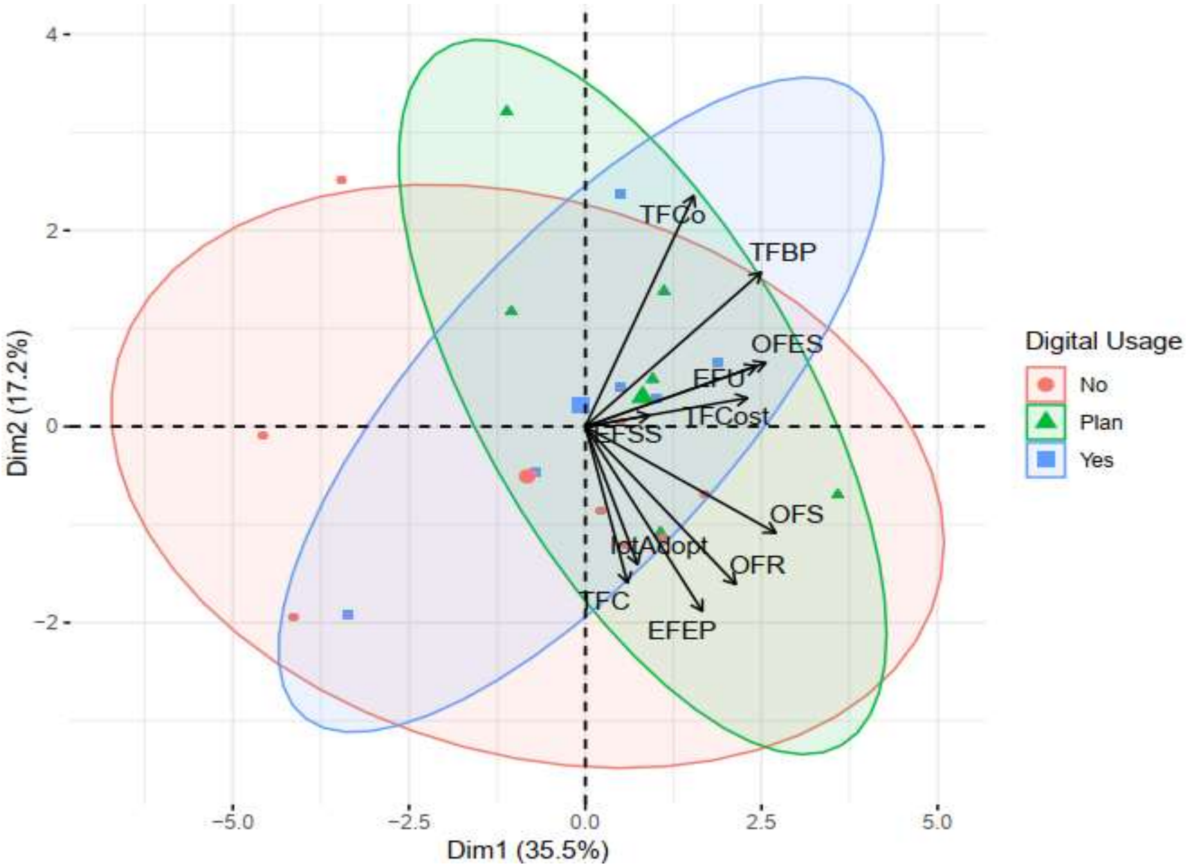

Figure 5. PCS biplot graphs according to factors.
Şekil 5. Faktörlere göre PCS biplot grafikleri

Overall, Figure 3 shows that IoT adoption is driven by multiple factors. While technical compatibility (TFCo) and perceived benefit (TFBP) are among the most influential factors in IoT adoption, environmental factors such as organizational support and external pressures may be more decisive for certain groups. Making factors such as external pressures and government support more effective, especially for groups that are considering using IoT but have not yet used it, can increase the adoption of this technology.

CONCLUSION

This study was conducted to assess the adoption and benefits of IoT (Internet of Things) technology in the agricultural sector, including the optimization of resource management, an increase in productivity while reduction in costs, and support to sustainable agricultural practices. Global challenges and the pressure on agricultural production, together with a growing population, highlight the important role of IoT in modern agricultural practices. This research presents compelling findings on the adoption of IoT technology in agriculture, particularly in the context of small island development.

The findings show that IoT has been largely adopted by some segments, while others are open to experimenting with the technology but are not yet actively using it. In addition to its benefits, some technical and organizational factors tend to influence the adoption of IoT in a negative way. Especially high costs, technological complexity, and resistance among employees are the main elements limiting the common use of IoT. On the other hand, external pressure – market demand and competition encourage the adoption of IoT. This study highlights that the adoption of IoT would be easier with lower costs, better technical infrastructure, and training for technological adaptation among employees.

The research concludes the potential of IoT to transform agricultural production processes on small islands. In this context, IoT is a critical tool to support sustainable agricultural practices and increase productivity in the agricultural sector. Furthermore, the results of this study provide recommendations for policymakers, agricultural experts, and technology providers to guide the wider adoption of IoT in the agriculture sector.

Consequently, the adoption of IoT technology in agriculture may have a broader impact by improving the technological infrastructure and increasing user adoption. While this study has highlighted the potential benefits of IoT in the agriculture sector, it has also discussed in detail the factors hindering its adoption. Future work could focus on developing more specific strategies to enable IoT adoption in the agricultural sector. This could include a comprehensive roadmap to support agricultural production on small islands and encourage IoT adoption by farmers in these regions.

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APPENDIX

Internet of Things (IoT) Adoption Survey - PART-A

A.1. Please select your gender.
☐ Woman
☐ Male

A.2. What is your age range?
☐ 18-30
☐ 31-45
☐ 46-60
☐ 60 +

A.3. What is your level of education?
☐ No formal training
☐ Primary School
☐ Middle School
☐ High School
☐ Bachelor Degree
☐ Postgraduate

A.4. How many years have you been farming?
☐ 1-5
☐ 6-10
☐ 11-15
☐ 15-20
☐ 20 +

A.5. Please indicate your farm type.
☐ Vegetable Production
☐ Fruit Production
☐ Dry farming
☐ Mixed (please specify) ....

A.6. Please indicate the total area of your farm (in dönüm).
☐ Vegetable Production: ....
☐ Fruit Production: ....
☐ Dry Agriculture: ....

A.7. Are you familiar with the following digital technologies? If yes, please select the items (you can choose more than one).
☐ Cloud technology
☐ Internet of Things
☐ Green technology
☐ Artificial intelligence
☐ Mobile technology
☐ Other ....

A.8. Do you use any digital technology?
☐ Cloud technology
☐ Internet of Things
☐ Green technology
☐ Artificial Intelligence
☐ Mobile technology
☐ Other ....

A.9. Do you use any digital technology on your farm?
☐ Yes
☐ No.
☐ I want to use it but I haven't used it yet

A.10. If you are using or considering using digital technology, which technology would you like to use on your farm?
☐ Cloud technology
☐ Internet of Things
☐ Green technology
☐ Artificial Intelligence
☐ Mobile technology
☐ Other ....

Internet of Things (IoT) Application Survey - PART- B
1: Strongly disagree 2: Disagree 3: Somewhat disagree 4: Neutral 5: Somewhat agree 6: Agree 7: Strongly agree

ITEMS	1	2	3	4	5	6	7
Technical Factors							
Complexity							
1- The actual operation of an Internet of Things system is relatively complex.	1	2	3	4	5	6	7
2- It is not convenient to use the Internet of Things system.	1	2	3	4	5	6	7
3- Using an IoT system requires a comprehensive experience.	1	2	3	4	5	6	7
Compatibility							
1- Internet of Things technology can be well integrated into farm business.	1	2	3	4	5	6	7
2- The Internet of Things system is compatible with marketing structures.	1	2	3	4	5	6	7
3- The Internet of Things system is aligned with the goals of sustainable agricultural systems.	1	2	3	4	5	6	7
Perceived benefit							
1- Internet of Things technology can reduce the cost of labor.	1	2	3	4	5	6	7
2- Internet of Things technology increases automation and improves the efficiency of applications (e.g. irrigation)	1	2	3	4	5	6	7
3- Internet of Things technology enables early detection and timely management of problems (pests, nutrient deficiencies, etc.).	1	2	3	4	5	6	7
4- Internet of Things technology helps to optimize energy consumption.	1	2	3	4	5	6	7
5- Internet of Things technology enables remote monitoring of farms.	1	2	3	4	5	6	7
Cost							
1- Adoption of IoT technology will increase the cost of hardware equipment.	1	2	3	4	5	6	7
2- Adoption of IoT technology will increase operating costs.	1	2	3	4	5	6	7
3- Adoption of IoT technology will increase the cost of maintenance.							
Organizational Factors							
Enterprise Scale							
1- Large-scale farms are more willing to implement IoT technology.	1	2	3	4	5	6	7
2- Large-scale farms have more resources to implement IoT technology.	1	2	3	4	5	6	7
3- Large-scale farms have a better chance of succeeding in implementing IoT technology.	1	2	3	4	5	6	7

Executive Support							
1- Top executives are paying attention and actively discussing the adoption of IoT technology.	1	2	3	4	5	6	7
2- Senior executives provide significant support to IoT technology in terms of manpower, money, etc.	1	2	3	4	5	6	7
3- Senior managers are willing to take the risk of implementing IoT technology.	1	2	3	4	5	6	7
4- Senior managers encourage employees to apply IoT technology in daily work.	1	2	3	4	5	6	7
Resistance from Employees							
1- Employees oppose IoT technology because they don't see themselves as capable enough.	1	2	3	4	5	6	7
2- Employees are afraid of losing their jobs because of IoT technology.	1	2	3	4	5	6	7
3- Employees are used to using barcode scanning.	1	2	3	4	5	6	7
Environmental Factors							
External Pressure							
1- Competitive pressures force businesses to adopt IoT technology.	1	2	3	4	5	6	7
2- Social factors such as culture, tradition, etc. positively influence the adoption of IoT technology.	1	2	3	4	5	6	7
3- Partners demand the implementation of Internet of Things technology.	1	2	3	4	5	6	7
Uncertainty							
1- Customer demands are diverse.	1	2	3	4	5	6	7
2- Customer demands are variable.	1	2	3	4	5	6	7
3- The pace of development of new technologies is rapid, which could threaten IoT technology.	1	2	3	4	5	6	7
4- Competitors are adopting more advanced technology.	1	2	3	4	5	6	7
State Support							
1- The state provides financial support for the development of IoT technology.	1	2	3	4	5	6	7
2- The state issues relevant policies that strongly support the development of IoT technology.	1	2	3	4	5	6	7
Willingness to Adopt the Internet of Things (IoT)							
Willingness to Adopt							
1- I plan to adopt the Internet of Things technology in the next year.	1	2	3	4	5	6	7
2- I plan to experiment with Internet of Things technology in the next year.	1	2	3	4	5	6	7

Abbreviations:
TFC: Technical Factors - Complexity
TFCo: Technical Factors - Compatibility
TFPB: Technical Factors - Perceived benefit
TFCost: Technical Factors - Costs
OFES: Organizational Factors - Enterprise Scale
OFS: Organizational Factors - Executive Support
OFR: Organizational Factors - Resistance from Employees
EFEP: Environmental Factors - External Pressure
EFU: Environmental Factors - Uncertainty
EFSS: Environmental Factors - State Support
IoTAdopt: Willingness to Adopt the Internet of