Faculty of Economics and Business

Factor Influencing the Adoption of Smart Farming Technology: The Role of Technology Awareness as Moderator

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ABSTRACT

The adoption of Smart Farming Technologies (SFT) is essential for improving food security, especially for farmers. Challenges such as population growth, geopolitical tensions, low productivity and lack of knowledge hinder the widespread use of SFT, particularly in regions like Sarawak. This study identifies the factors influencing farmers' acceptance to adopt SFT, using the Unified Theory of Acceptance and Use of Technology (UTAUT) framework with technology awareness as a moderator. Through a quantitative survey of 330 farmers in various regions of Sarawak, key determinants like performance expectancy, effort expectancy, social influence, facilitating conditions, and technology awareness were identified. Data analysis using PLS-SEM revealed that while farmers are inclined to adopt SFT, significant barriers remain, particularly related to performance expectancy and social influence. The findings suggest that addressing these barriers can help the Sarawak government and stakeholders develop suitable technologies and policies to enhance food security. Ultimately, this could lead Sarawak to achieve sustainable food security and become a net food exporter by 2030, contributing to economic development.

Keywords: Smart Farming Technologies, Technology Acceptance, Food Security, Technology Awareness, UTAUT

Faktor yang Mempengaruhi Penggunaan Teknologi Pertanian Pintar: Peranan Kesedaran Teknologi sebagai Moderator

ABSTRAK

Penggunaan Teknologi Pertanian Pintar (TPP) adalah penting untuk meningkatkan keterjaminan makanan, terutamanya bagi petani. Cabaran seperti pertumbuhan penduduk, ketegangan geopolitik, pengeluaran yang rendah dan kekurangan pengetahuan menghalang penggunaan meluas TPP, terutamanya di kawasan seperti Sarawak. Kajian ini mengenal pasti faktor-faktor yang mempengaruhi penerimaan petani untuk penggunaan TPP, menggunakan kerangka Teori Penerimaan Penggunaan Teknologi Bersatu (TPPTB) dengan kesedaran teknologi sebagai moderator. Melalui tinjauan kuantitatif ke atas 330 petani di pelbagai kawasan di Sarawak, penentu utama seperti jangkaan prestasi, jangkaan usaha, pengaruh sosial, keadaan memudahkan, dan kesedaran teknologi telah dikenalpasti. Analisis data menggunakan PLS-SEM mendedahkan bahawa walaupun petani cenderung untuk penggunaan TPP, halangan yang ketara masih ada, terutamanya berkaitan dengan jangkaan prestasi dan pengaruh sosial. Penemuan ini mencadangkan bahawa menangani halangan ini boleh membantu kerajaan Sarawak dan pihak berkepentingan membangunkan teknologi dan polisi yang sesuai untuk meningkatkan keterjaminan makanan. Akhirnya, ini dapat membawa Sarawak mencapai keterjaminan makanan yang lestari dan menjadi pengeksport makanan bersih menjelang tahun 2030, menyumbang kepada pembangunan ekonomi.

Kata kunci: *Teknologi Pertanian Pintar, Keterjaminan Makanan,Penerimaan Teknologi, Kesedaran Teknologi,TPPTB*

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LIST OF ABBREVIATIONS

AC	The Acceptance of Farmers to Adopt SFT
AI	Artificial Intelligent
AM	Additive Manufacturing
AR	Augmented Reality
ARS	Simulation, Autonomous Robotic Systems
AVE	Average Variance Extracted
AW	Technology Awareness
BDA	Big Data Analysis
BRT	Behavioural Reasoning Theory
CB-SEM	Covariance Based Structural Equation Modelling
CC	Cloud Computing
CMV	Common Method Variance
CPS	Cyber-Physical Systems
CR	Composite Reliability
CSA	Climate Smart Agriculture
DOI	Diffusion of Innovation Theory
DT	Digital Twin
DTPB	Decomposed Theory of Planned Behaviour
EE	Effort Expectancy
EFA	Exploratory Factor Analysis
FAO	Food and Agriculture Organization
FC	Facilitating Conditions

FS	Food Security
GDP	Gross Domestic Product
GFSI	Global Food Security Index
HTMT	Heterotrait-Monotrait Ratio
IoT	Internet of Things
IDR	Import Dependence Ratio
IDT	Innovation Diffusion Theory
M-Ficord	Ministry of Food, Commodity and Regional Development Sarawak
MM	Motivational Model
NFI	Normed Fit Index
PE	Performance Expectancy
PFT	Precision Farming Technologies
PLS-SEM	Partial Least Square Approach to Structural Equation Modelling
SCT	Social Cognitive Theory
SDGs	Sustainable Development Goals
SEM	Structural Equation Modelling
SF	Smart Farming
SFT	Smart Farming Technologies
SI	Social Influence
SP	Smart Product
SMS	Short Message Service
SPSS	Statistical Package for Social Science

SRMR	Standardised Root Mean Square Residual
TAM2	Technology Acceptance Model 2
TOE	Theory of Expanded
TRA	Theory of Reasoned Action
TPB	Theory of Planned Behaviour
UTAUT	Unified Theory of Acceptance and Use of Technology
UTAUT2	Unified Theory of Acceptance and Use of Technology 2
WSN	Wireless Sensor Networks

CHAPTER 1

INTRODUCTION

1.1 Introduction

Food is a vital component for human survival. Every nation must have enough quantity and quality food sources for the growing population. In an extended period, prompt population growth coupled with a lack of food may result in famine and starvation, contributing to a rise in mortality. In concordance with global famines and food crises, food security was initiated at the 1974 World Food Conference. The academic community and politics have evolved, developed, and diversified this concept. Subsequently, several definitions of food security have been devised in light of the original perspective on food security issues. Scholars and international organisations may have defined it differently, but the core concept remained unchanged.

In addition, food security is a matter of utmost importance since it plays a pivotal role in safeguarding the overall welfare of its people. Ensuring that every individual has equitable and uninterrupted access to an adequate supply of safe and nutritious food to fulfil their dietary requirements is essential. The agriculture industry plays a crucial part in its food supply. For instance, climatic diversity and good soil facilitate the development of a wide range of crops, including rice, fruits, and vegetables. This is aligned with the Sustainable Development Goals (SDGs) that aim to reduce hunger, attain food security, promote nutritious food, and establish sustainable agricultural practices, as outlined in SDG 2.

Meanwhile, farmers, technology providers, legislators, and experts in agricultural innovations are currently elevating agricultural automation to a higher level. Various hi-tech apparatuses and methodologies introduced in the agricultural sector are commonly identified

as Smart Farming Technologies (SFT); they offer beneficial outcomes regarding cost-saving and growth in productivity and earnings (Basso et al., 2016; Virk et al., 2020).

1.2 Background of the Study

Food security is commonly defined as the equitable and consistent provision of nutritious, safe, and adequate food that satisfies the dietary requirements and preferences of all individuals, ensuring their ability to lead an active and healthy life (FAO, 2006). This definition is rooted in the World Food Summit of 1996. Furthermore, one of the United Nations' Sustainable Development Goals (SDGs) emphasised ending hunger, achieving food security, and improving nutrition by 2030. According to the Ministry of Agriculture and Food Security (2023), Malaysia's performance in Global Food Security Index (GFSI) is ranked 41^{st,} which is a decrease of seven places and moderately performed compared to the previous year, is ranked 39th, up nine places performed well with a score of 70.1. There is a decrease of 1.6 for the overall score faced by Malaysia, which consists of affordability, availability, quality and safety, and sustainability and adaptation, compared to the previous year's score of 5.1, which is the highest increase in score among the 113 countries involved.

A high self-sufficiency ratio (SSR) indicates an adequate food supply inside a country, representing one of the dimensions of food security. Availability encompasses several factors, such as domestic production, imports, exports, and the quantity of existing stockpiles inside the country. When the Self-Sufficiency Ratio (SSR) exceeds 100.0 percent, it signifies that the supply or production of a particular agricultural commodity is adequate to meet the nation's demands. Conversely, if the SSR falls below 100.0 percent, it shows an insufficiency in meeting the country's requirements. According to the Department of Statistics Malaysia (2023), several vegetables and fruits fall below 100 percent SSR, such

as round cabbage (45.6 percent), mango (32 percent), chilli (29.7 percent), and ginger (15.9 percent).

Although Malaysia has its agricultural output, it remains reliant on imports from other nations for some commodities. The Department of Statistics Malaysia (2023) reported that the value of imported food products has increased to RM75.6 billion in 2023 from RM44.6 billion in 2022. As a result of a more significant surge in imports relative to exports, the trade deficit for food products has grown to RM31.0 billion, representing a 24.3 per cent increase over the preceding year. For instance, the Import Dependence Ratio (IDR) for the following items surpassed 50.0 percent in 2022: ginger (2022: 85.6 percent; 86.5 percent in 2021); mango (2022: 79.7 percent; 92.6 percent in 2021); chilli (2022: 74.0 percent; 75.1 percent in 2021); and round cabbage (2022: 55.5 percent; 61.3 percent in 2021). Concurrently, the nation is compelled to continue importing agricultural products such as apples, shallots, onions, and garlic due to climate inconsistencies.

Due to its continued reliance on imports to maintain its food supply, Sarawak will continue to be susceptible to food insecurity for the foreseeable future. In 2022, food imports through Sarawak amounted to RM5.6 billion. The current surge in food prices can be attributed to any disruption in the import supply chain from exporting nations. The underdevelopment of the agro-food sector's capacity is an ongoing concern regarding Sarawak's food security. In recent years, commodity crops, particularly oil palm, have dominated agricultural development over sustenance crops.

Based on Figure 1.1, the increasing number of populations in Sarawak also impacts the higher food demand. According to the Department of Statistics Malaysia (2023a), the estimated population of Malaysia in the fourth quarter of 2022 is 33 million, up 1.30 percent from the fourth quarter of 2021 (32.6 million). In addition, Sarawak is estimated to see a

population growth from 2.45 million in 2020 to 2.47 million in 2021(Economic Planning Unit Sarawak, 2022). The projection shows that the population in Malaysia is increasing, which can influence the country's food demand. By 2050, it is estimated that the demand for food security will increase by 70 to 100 percent due to projected population growth (Silva, 2018). In order to sustain Malaysia's economic growth and meet the requirements of millions of starving people, food security is becoming increasingly important (Husni, 2017). Figure 1.1 illustrates the population trend from 2017 to 2021 in Sarawak.

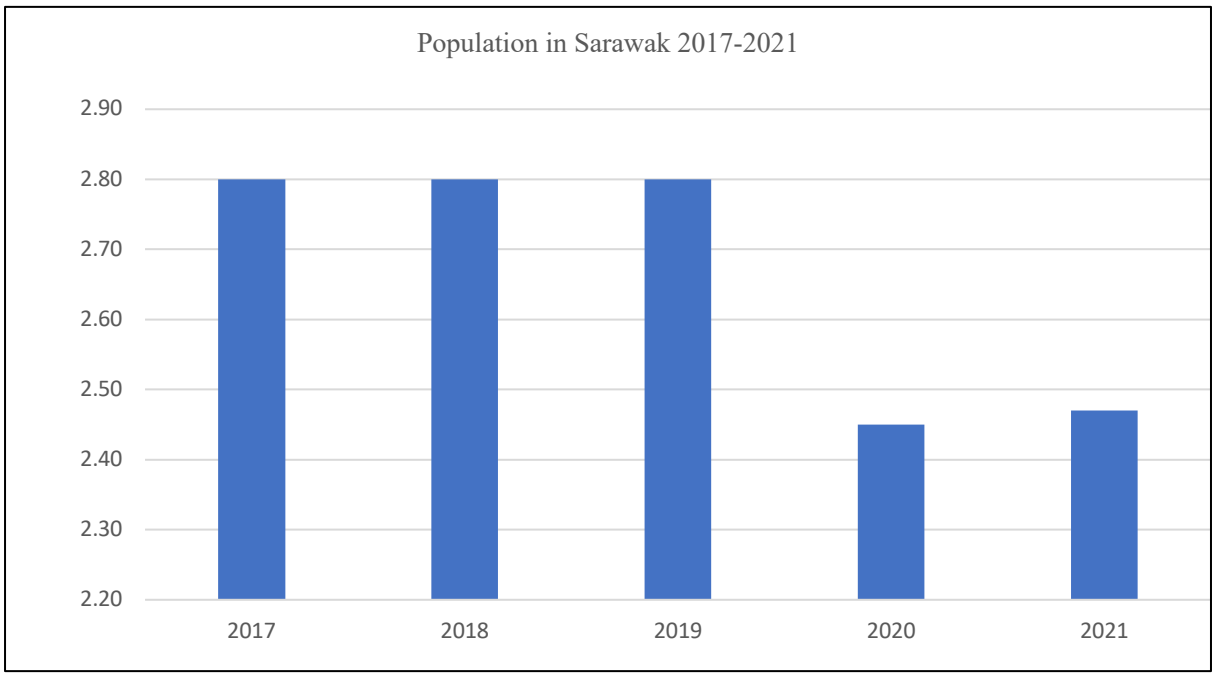

Figure 1. 1: Population in Sarawak 2017-2021
Source: Economic Planning Unit Sarawak (2022)

In order to maintain food security in the region, introducing SFT to farmers can offer plenty of benefits. Integrating advanced sensors, robotics, artificial intelligence, and other digital technologies into agriculture is called smart agricultural technologies. These technologies provide numerous advantages, such as optimising water and fertiliser use, decreasing labour costs, increasing crop production, and minimising environmental impact.

However, farmers need to implement intelligent farming technologies in their agricultural endeavours, as this can help to increase productivity and income. In addition, it can also reduce overall spending time and improve the quality of agricultural products, ultimately contributing to the maintenance of food security in terms of availability, accessibility, utilisation, and stability.

Moreover, the state government has enacted to urge the farmers to adopt and practice the digitalisation of agricultural technologies as they offer various benefits. Based on the Sarawak Digital Economy Strategy (SDES) 2018 – 2022, the government's goals are to increase the agriculture sector's productivity and efficacy and gain access to new markets for agricultural products (State Service Modernisation Unit, 2017). According to Sarawak Digital Economy Strategy 2018 – 2022, there are three prominent initiatives by the government to achieve goals, as mentioned before. Firstly, adopt digital technologies to transform the agricultural sector and drive innovation. For instance, the implementation of IoT and sensors for smart farming, the implementation of a geospatial system for agriculture planning and operation support in the development of agro parks, and the development of anchor farmers. Secondly, establish an efficient distribution system for agriculture inputs and products, such as the IoT for collection, processing, and packaging centres, collection centres, intelligent supply chains, and logistics. Lastly, develop new markets and expand existing ones for agricultural produce and products, collaborating with domestic and international investors and venture capitalists, branding, and e-commerce.

Therefore, a better understanding of the factors influencing the acceptance of SFT among farmers in Sarawak is a severe matter of endorsing SFT execution, thus ensuring a sustainable food production practice in the region. The report will also provide