# Farmers' Perception on Precision Farming Technologies: A Novel Approach

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ABSTRACT

Precision agricultural technology is an evolving sector concentrated on improving productivity and rural development. Therefore, studying the adoption process of the technology is essential to recognise a possible strategy that could affect the adoption and dissemination of a precision farming system. This paper reports an investigation into the perception and attitudinal characteristics of farmers who intend to adopt these technologies in the Batticaloa district in Sri Lanka. The primary data were composed of randomly selected farmers from February to April 2020 using a well-designed questionnaire survey. A Technology Acceptance Model (TAM) was applied to explain the farmers' adoption and use of precision agricultural techniques. A Structural Equation Model (SEM) following a Confirmatory Factor Analysis (CFA) was used to identify the relationship between the factors. In the proposed model, the prediction accuracy of constructs is signified by the coefficient of determination ($R^2$) value for Attitude Towards Usage which is 0.34, which means that Perceived Usefulness and Perceived Ease of Use explain 34 per cent of the variance in Attitude Towards Usage. The findings suggest that respondents have positive perception of adopting precision agricultural techniques. Perceived usefulness positively impacts attitude, and attitudes affect behavioural intention.

Keywords: Digital agriculture, Innovation adoption, Farmers' attitudes, Information technology, Technology transfer

JEL: Q11, Q13, Q16, Q18

I

INTRODUCTION

Environmental issues and worldwide concerns toward the consequences and side impacts of traditional agricultural frameworks and agricultural practices on the environment brought about within the perspective, have necessitated the need for changing mental designs for precision farming frameworks. The concept of Precision Agriculture (PA), based on data innovation, is becoming an appealing thought for overseeing the characteristic assets and realising advanced sustainable rural improvement (Maohua, 2001). A system methodology conceptualises PA to improve the entire agricultural system towards a minimum resource, maximum efficiency economic agribusiness. PA gives a perfect apparatus for agricultural risk appraisal and sound farm-work planning (Kolady *et al*., 2021; Zhang *et al*., 2002). The fundamental objective of PA is to optimise the yield with the least input and diminish the

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environmental pollution, which is highly required for developing nations confronting the challenge of sustainability (Mondal and Basu, 2009). Therefore, PA is an important technology that will enable the improvement of the farmers' productivity and living standards.

Over the past decades, ICT technologies have been implemented in the agricultural sectors to improve the farmers' agricultural production (Nikkila *et al*., 2010). The availability of such up-to-date information can improve the farmers' quality decisions about which crops to grow, given the past climatic conditions, available resources, and the market supply chain (Rahman, 2009; Suresh *et al*., 2021a). However, these resolutions have been slow due to several key challenges for ICTs in agriculture, which relate to adequate communication, either in specific areas or along the supply chain, (Sørensen *et al*., 2010). The Agricultural Development Report suggests that a global food shortage is imminent if farming communities do not embrace ICTs (World Bank, 2008).

To improve the use of technology, Sunding and Zilberman (2001) suggested that the future technological innovations in agriculture should take place in an international context and not at the national level. Also, encouraging farmers to implement new agricultural technologies remains a crucial idea of agricultural extension (Muddassir *et al*., 2016). Under the Ministry of Agriculture (DOA), the Department of Agriculture has developed many projects for the agricultural sector in Sri Lanka. DOA has already launched several e-agriculture programmes to overcome the challenges (Sri Lanka E-Agriculture Strategy, 2016). In order to adopt this technology, producers must make financial investments and invest in the acquisition of new skills. The complexity and compatibility of new technologies with the current practices and existing equipment are the other factors in the decision-making process (Rogers, 1983). Research has shown that attitudes of both the usefulness and complexity of information technology in organisations affect individuals' adoption and use of information technology (Orr *et al*., 2001). The holistic objective of the study was to analyse the relationship between the farmers' intention to use e-agriculture and selected concepts such as their attitude, perceived utility, perceived ease of use, and behavioural intention usage based mainly on the Technology Acceptance Model (TAM).

II

LITERATURE REVIEW

For the purpose, the Technology Acceptance Model (TAM) developed by Davis (1989) was applied to measure the intention to adopt PAs. Davis (1989) based his demonstration on the psychological model known as the Theory of Reasoned Action (TRA). The Technology Acceptance Model (TAM) could be a system for foreseeing the utilisation of data innovation, based on attitudes towards innovation and is considered valid and reliable (Venkatesh and Davis, 1996). The latter focuses on the hypothesis that individual attitude has an important role in determining behaviour

towards adopting a certain technology (Ajzen and Fishbein, 1980). This model has been used to explain both short-term behaviours (acceptance and adoption) and long-term behaviours (use) (Morris and Venkatesh, 2000). Davis (1989) defines PU from the helpful word, which means "capable of being used to advantage", while PEOU follows the definition of ease, which means "free from difficulty or great effort". In the context of TAM, attitude towards use (ATT) is "the positive or negative feeling that an individual has about the performance of the target behaviour", and behavioural intention (INT) is "the degree to which a person has made conscious plans to perform future behaviour". Davis (1989) based TAM on TRA by defining the perceived utility and perceived ease of use as constructs that predict behavioural intention and technology use.

- *Perceived usefulness (PU):* Davis (1989) defined perceived usefulness as the belief that using a particular technology will enhance the potential user's job performance.
- *Perceived Ease of Use (PEU):* Davis (1989) defined perceived ease of use, another variable that influences the intention to adopt information technologies, as the belief that using a particular technology will be free of physical and mental effort.
- *Attitude to Use (AU):* Attitude is an essential concept in agricultural systems research. It is also an important construct for information systems researches, since the Technology Acceptance Model (TAM) predicts the use of perceived ease of use, attitude, intention, and use. The original TAM (Davis, 1989) indicated that attitude positively affects behavioural intention.
- *Intention to Adaptation (IA):* According to Fishbein and Ajazen (1975) the behaviour intention is defined as a measure of the strength of one's intention to perform a specific behaviour. Behavioural intention refers to an individual's willingness to perform or not to perform a specific future behaviour (Konerding, 1999).

III

DATA AND METHODOLOGY

3.1 *Data Collection and Survey Procedures*

This study was conducted with the primary data collection from 250 farmers who live in the Batticaloa district in Sri Lanka. It was performed through a questionnaire survey among randomly selected farmers (The following formula was used to determine the samples size (n); $n = N*X / (X + N – 1)$, where, $X = Z\alpha/22 -*p*(1-p) / MOE2$, and $Z\alpha/2$ is the critical value of the Normal distribution at $\alpha/2$ (e.g. for a confidence level of 95 per cent, $\alpha$ is 0.05 and the critical value is 1.96), MOE is the margin of error, p is the sample proportion, and N is the population size (Daniel, 1999) from February to April 2020. The questionnaire had already been tested for its

reliability and validity and verified by interviewing 25 farmers in the region (who were not part of the sample which was studied).  Besides secondary data were collected from the Agrarian Service Center and Divisional Secretariat in the Batticaloa District, Sri Lanka.

## 3.2 *Research Model*

The model for this study is mainly based on the technology acceptance model presented by (Davis, 1989). Based on previous research, a theoretical model was developed. Figure 1 represents a theoretically interesting model to test and analyse. The arrows connecting the constructs (latent variables) specify the hypothetical causal relationships in the direction of the arrows. The arrows between the constructs and the indicators (observed variables) symbolise the validity of the measurement. In this study, a survey was developed to measure the constructs of the perception of the utility, the perception of ease of use, the attitude of trust, and the perception of net benefit (see Table 1).

TABLE 1. OPERATIONALISATION OF THE VARIABLE

| Variable (1) | Measurement (2) |
|---|---|
| Perceived Usefulness (PU) | Precision agriculture tools can increase profits. |
| | Precision agriculture tools can increase productivity. |
| | Precision agriculture tools can provide information for better decision making. |
| | Precision agriculture tools are effective. |
| | Precision agriculture tools support work quickly. |
| Perceived Ease of Use (PEU) | Precision agriculture tools are controllable. |
| | Precision agriculture tools are flexible. |
| | The uses of precision agriculture tools are clear and understandable. |
| | Learning to use precision agriculture tools will be easy. |
| | It will be easy for me to remember how to perform tasks |
| Attitude to Use (AU) | Farming through e-agriculture is a good idea. |
| | It positively influences me to use precision agriculture on the farm. |
| | I think it is a trend to use precision agriculture on the farm. |
| Behavioural Intention to Adopt (BI) | I intend to use a precision farming (PA) system. |
| | I would recommend the adoption of the PA system for other farmers in my region. |
| | I will also adopt PA if the neighbouring farmers adopt. |

*Source*: Author's own compilation.
*Notes*: All items were measured using a 7-point Likert Scale ranging 1-Extremely Unlikely, 2 - Moderately Unlikely, 3 - Slightly Unlikely, 4 - Neutral, 5 - Slightly Likely, 6 - Moderately Likely, and 7 - Extremely likely

In accordance with the previously stated objectives and consistent with related literature, this study tested the following hypotheses:

*H1: Perceived Usefulness statistically, significantly impacts Attitude towards using Precision Agriculture Technologies.*
*H2: Perceived Ease of Use statistically, significantly impacts Attitude towards using Precision Agriculture Technologies.*

*H3: Attitude towards using Precision Agriculture Technologies statistically, significantly impacts Behavioural Intention to use Precision Agriculture Technologies.*

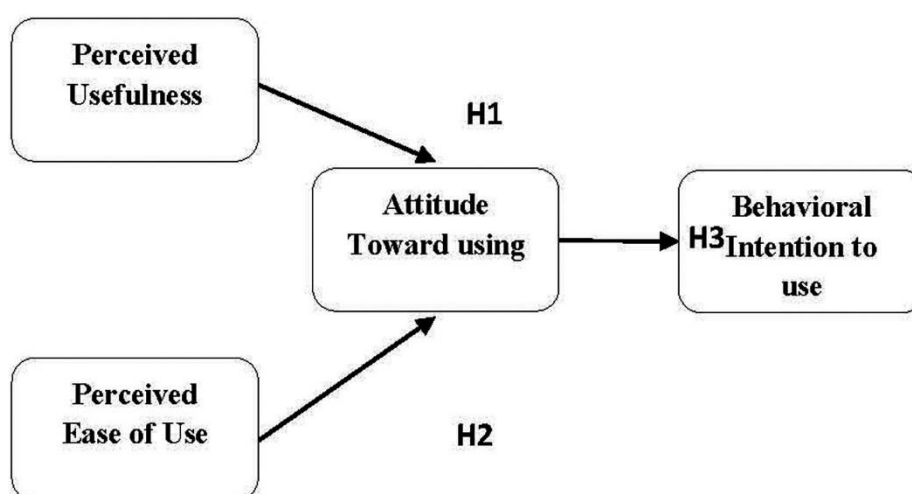The research model shown in Figure 1 is derived based on the proposed relationships.



Figure 1. Research Model.

IV

RESULTS AND DISCUSSION

The data analysis was performed, through the use of IBM SPSS 25 and AMOS 24. Profiles of the respondents were obtained by using descriptive statistics. The proposed model was evaluated in two stages; evaluation of the measurement model and evaluation of the structural model.

4.1 *Socio-Economic Characteristics of Farmers*

Table 2 presents the respondents' socio-demographic characteristics and farm structure in the study area. The results indicate that 40.5 per cent and 53.2 per cent of respondents belonged to the 25-44 age group and 45-64 age group, respectively. Only 1.3 per cent of respondents were under 25, and 5.1 per cent were between the 65-84 age group. It was also revealed that 5.1 per cent of respondents were illiterate, 15.2 per cent, 65.8 per cent, and 6.3 per cent respectively had primary (grade 1-5), intermediate (grade 6-11), and advanced level (grade 12-13) education. Only 6.3 per cent had completed high school (degree level). The data also shows that 52.1 per cent of respondents were landowners who farmed their land. Similarly, renters accounted for

12.3 per cent, while homeowners and renters accounted for 35.6 per cent. Property status revealed that 1.3 per cent, 3.8 per cent, 3.8 per cent and 7.6 per cent of respondents had properties with an area 0.6 to 1.0 acre, 1.1-2.0 acres 2.1-3.0 acres and 3.1-4 acres respectively. Experience is very important in any field of life to gain benefits and quality. According to the study results, the maximum number of respondents had less than 25 years of experience in agriculture, 28 per cent between 25 and 44 years and only 1.3 per cent had between 45-64 years of experience in agriculture. According to the data, the 14.1 per cent income of respondents (LKR/Rs) ranged from less than 10,000 per month. Similarly, 30.8 per cent of respondents have Rs.10,001 to Rs.20,000 head of household's income per month, 23.1 per cent of respondents Rs.20,001 to Rs.30,000 per month, 26.9 per cent of respondents Rs.30,001 to Rs.40,000 per month and 3.8 per cent of respondents earned more than 40,000 head of household's income per month. Furthermore, a maximum of 69.7 per cent of respondents was engaged in occupations other than agriculture (crop farming and animal husbandry), such as government job, private/NGO job, business, day-wage labour, household work and working out of the country and only 32.3 per cent were fully engaged in the occupation for farming activities.

TABLE 2. DEMOGRAPHICS OF THE RESPONDENTS

| Age of the respondent (years) (1) | Percentage (2) | Education (3) | Percentage (4) |
|---|---|---|---|
| Below 25 | 1.3 | Primary | 15.2 |
| 25 – 44 | 40.5 | Intermediate | 65.8 |
| 45 – 64 | 53.2 | Advanced | 6.3 |
| 65 – 84 | 5.1 | Higher | 6.3 |
| | | None | 5.1 |
| Ownership of the Land | | Land Extent for Paddy (acres) | |
| Own | 52.1 | 0.6-1.0 | 1.3 |
| Lease | 12.3 | 1.1-2.0 | 3.8 |
| Own and Lease | 35.6 | 2.1-3.0 | 3.8 |
| | | 3.1-4.0 | 7.6 |
| | | Above 4.0 | 83.5 |
| Farming Experience (Years) | | Monthly Income of Household Head (Rs.) | |
| Below 25 | 70.3 | Below Rs.10,000 | 14.1 |
| 25 – 44 | 28.5 | 10,001-20,000 | 30.8 |
| 45 – 64 | 1.3 | 20,001-30,000 | 23.1 |
| | | 30,001-40,000 | 26.9 |
| | | Above 40,000 | 3.8 |

*Source*: Author's estimation based on field survey data.

Souza Filho *et al.* (2011) analysed the determinants of technology adoption in agriculture. The authors state that four sets of factors such as socio-economic conditions and characteristics of the producer, aspects of production and land ownership, attributes of the technology, and systemic factors may influence the decision to adopt technological innovations in agriculture. Another research has suggested that the adoption of precision agricultural technologies has been influenced by socio-economic characteristics, such as farm size (Khanna, 2001; Suresh *et al.*,

2021b), farming experience, education (Hudson and Hite, 2003) and access to information (Daberkow and McBride, 2003). Therefore, an analysis of socio-economic characteristics is very important for developing the TAM.

## 4.2 *Structural Equation Modelling*

The two-stage Structural Equation Modelling (SEM) was used to validate the measurement and structural models to test the hypotheses. The measurement model was first assessed, and the structural modelling was then conducted (Byrne, 2016). A test for model fitness was conducted for the measurement model to evaluate the constructs' reliability and validity. The two phases in SEM are the Confirmatory Factor Analysis (CFA) and the evaluation of the structural model test (Hair *et al.,* 2010). The association between the variables and their measurements was calculated using CFA, while the structural model test determined the theorised relationships among the variables. Tey and Brindal (2012) and Pierpaolia *et al*. (2013) stated that understanding the adoption of precision agriculture technologies by farmers is very important because they consolidate the main determinants of adoption of technological innovations and precision agriculture technologies and go beyond their findings to explain why farmers adopt or abstain from these technologies.

### 4.2.1 *Evaluation of the Measurement Model*

Two CFA evaluations to determine the model's validity are the evaluation of Goodness-Of-Fit (GoF) indices and the construct validity test (Hair *et al.,* 2010). The GoF is evaluated by taking various indexes into account. $\chi 2$ was initially used to determine the model's fitness, but because of its sensitivity to the sample size, it turned out not to be the best indicator (Hu and Bentler, 1999). Therefore, $(\chi^2/df)$, which is the ratio of $\chi^2$ to the degree of freedom (df), is used.

From Figure 3, it can be seen that the value of CMIN/DF $(\chi^2/df)$ of 2.772, which is $\leq 3$, i.e., is excellent (Hair *et al.,* 2010). The results for the other indices of fitness are GFI = 0.910; this is above the threshold value of 0.900, NFI = 0.926; which means it is greater than the 0.900 cut off, CFI = 0.951; ensuring its value was above the cut off of 0.950 and RMSEA = 0.069 which is below the ceiling value of $\leq 0.08$ (Byrne, 2016). Since all fitness indices are within the specified threshold value, the model's fitness is confirmed. The results of the CFA must be checked through the evaluation of the construct validity, which specifies whether the scales properly denote the basic concept of the variable (Bryman and Bell, 2011). The adequacy of the psychometric properties of the measurement model was evaluated using the convergent and discriminant validity tests in this study. Convergent validity is reached when the loading value of the factor is more significant than 0.50 (Hair *et al.,* 2010), Composite Reliability (CR) is established with a minimum value of 0.70, whilst the value of Average Variance Explained (AVE) is also larger than 0.50 (Hu and Bentler, 1999). From Figure 2, it can be seen that the factor loadings of each item are well above the threshold.
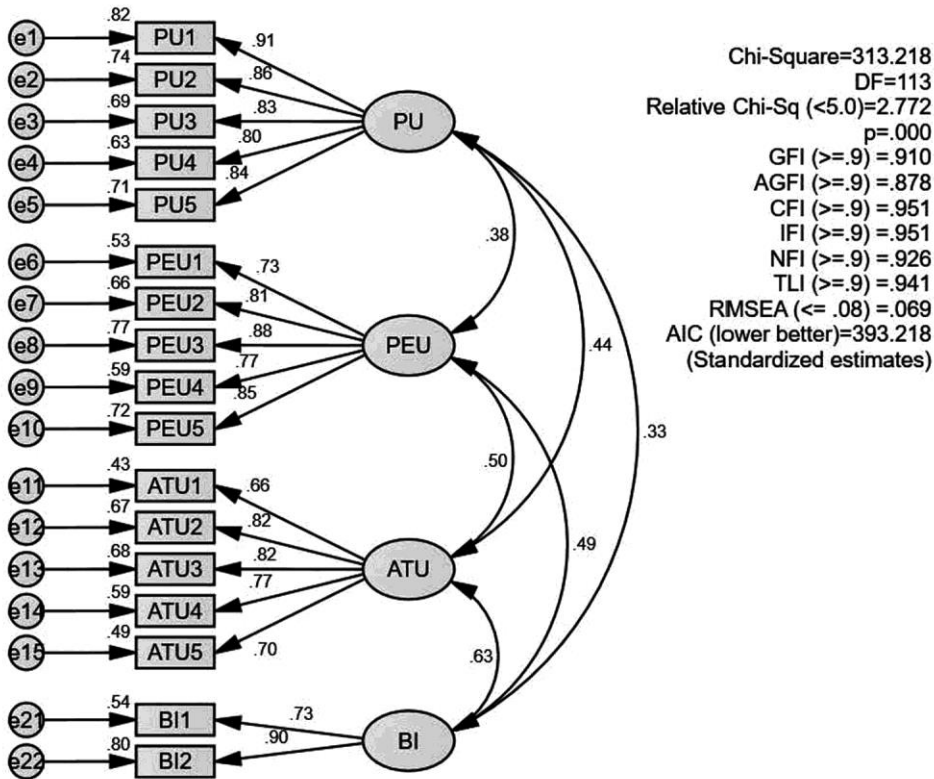
*Source*: Author's own compilation 2021.

Figure 2. Measurement Model

Table 3 shows that the model has adequate convergent validity. The maximum variance amount shared between the latent variables is the Maximum Shared Variance (MSV). The validity of a construct is determined when its AVE value is larger than the MSV value shared with another construct. For the current study's model, all the constructs' MSV value is lower than the AVE value; therefore, the model's Discriminant Validity is confirmed (Hair *et al.,* 2010).

TABLE 3. VALIDITY ASSESSMENT

| Variable | CR | AVE | MSV | PU | PEU | ATU | AU | BI |
|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| PU | 0.927 | 0.718 | 0.195 | 0.848 | | | | |
| PEU | 0.905 | 0.656 | 0.253 | 0.379 | 0.810 | | | |
| ATU | 0.870 | 0.573 | 0.402 | 0.441 | 0.503 | 0.757 | | |
| AU | 0.933 | 0.823 | 0.005 | 0.044 | 0.034 | 0.067 | 0.907 | |
| BI | 0.799 | 0.668 | 0.402 | 0.333 | 0.489 | 0.634 | 0.068 | 0.817 |

*Source*: Author's estimation based on field survey data.

### 4.2.2 *Structural Model and Hypotheses Testing*

All the hypotheses were evaluated using the Path Estimate, t-values, and p-values. The relationships between the variables are considered significant when their t- values are higher than 1.96, and their p-values are lower than 0.05.
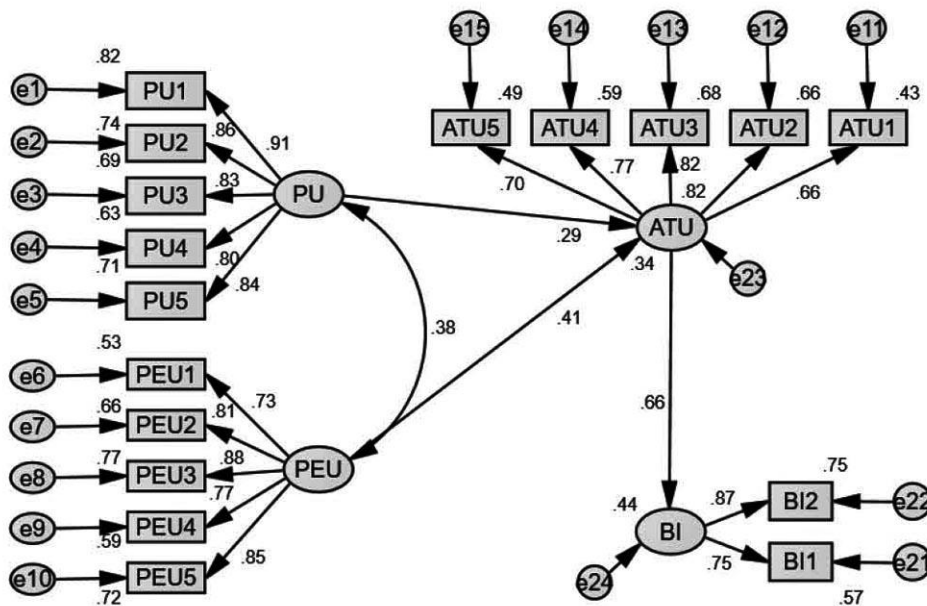


*Source*: Author's own compilation 2021.

Figure 3. Structural Model.

Table 4 describes the effects of the path estimation for the three suggested hypotheses. Considering that the t-value for each is greater than 1.96 and the p-value for each is less than 0.05, all three hypotheses show statistical significance. Therefore, H1 is accepted considering the significant correlation between Perceived Usefulness and Attitude towards Usage ($\beta = 0.292$, t-value = 5.195, $p < 0.001$). H2 is accepted considering the significant relationship between Perceived Ease of Use and Attitude towards Usage ($\beta = 0.410$, t-value = 6.593, $p < 0.001$). Finally, H3 is accepted considering the significant relationship between Attitude towards Usage and Behavioural Intention ($\beta = 0.660$, t-value = 8.655, $p < 0.001$).

TABLE 4. RESULTS OF THE TEST OF HYPOTHESES

| Hypotheses | Relationship | Estimate | Beta | Standard error | T-Value | P-Value | Decision |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| H1 | PU --> ATU | 0.245 | 0.292 | 0.047 | 5.195 | 0.000 | Accepted |
| H2 | PEU --> ATU | 0.608 | 0.410 | 0.092 | 6.593 | 0.000 | Accepted |
| H3 | ATU --> BI | 0.925 | 0.660 | 0.107 | 8.655 | 0.000 | Accepted |

*Source*: Author's estimation based on field survey data.

Information systems research shows attitudes toward technology, particularly individuals' perceptions of their ability to learn to use technology (Chau, 2001). Adrian *et al.* (2005) demonstrated the impact of perception and attitudinal characteristics of farmers on the decision to adopt precision agriculture technologies. The direct effect of perceived ease of use on perceived usefulness is in accordance with the findings of Lee *et al.* (2007). Also, the results of Wu and Wang (2005) and Fu *et al.* (2006) indicated that perceived ease of use has an indirect effect on the behavioural intention to use through perceived usefulness. Koufaris (2002) showed that perceived ease of use is not a significant determinant for intention to use.

In a proposed model, the prediction accuracy of constructs is signified by the coefficient of determination ($R^2$) value (Owusu Kwateng *et al.,* 2019). As shown from Figure 3, the $R^2$ value for Attitude towards Usage is 0.34, which means that Perceived Usefulness and Perceived Ease of Use explain 34 per cent of the variance in Attitude towards Usage. The $R^2$ value for Behavioral Intention is 0.44, which indicates that Attitude towards Usage can explain 44 per cent of the variance in Behavioral Intention towards Precision Agriculture Technologies. A similar study was conducted by Wu and Wang (2005), who revealed significant positive relationships among perceived ease of use, perceived usefulness, behavioural intention, and attitude to use. Furthermore, Lee *et al.* (2007) investigated the relationship between perceived usefulness, perceived ease of use, attitude to use, and intention to use information technology. Moreover, Rezaei-Moghaddam and Salehi (2010) cited a positive and significant relationship between 'attitude to use and intention to use' and 'perceived ease of use and attitude to use'.

Adrian *et al.* (2005) showed that perceived usefulness positively has an indirect effect on the intention to adopt precision agriculture through perceived net benefit. Also, this variable has a positive and indirect impact on attitude to use and intention to extend variable rate technologies in tillage (Salehi and Rezaei-Moghaddam, 2009). Batte and Arnholt (2003) found that profitability was the most significant motivating factor in using precision agriculture tools. Many researchers suggested that TAM needed additional variables to provide an even more robust model (Legris *et al.*, 2003). The attitude of confidence towards using precision agriculture technologies; perceptions of net benefits, positively influenced the intention to adopt precision agriculture technologies (Onyango *et al.*, 2021). Also, the perception of usefulness positively impacted the perception of net benefit (Adrian *et al.*, 2005). Therefore, farmers are willing to adopt these emerging technologies in the study region.

## V

### CONCLUSION

Agriculture is one of the dominant areas of socio-economic development in Sri Lanka. Technological advances and innovations have served as tools to share knowledge and practices on agricultural activities and improve the living conditions of

farmers, traders, decision-makers, and society. The study concludes that respondents have positive perceptions of adopting precision agricultural techniques. Perceived usefulness positively impacts attitude, and attitudes affect behavioural intention. The study also recommends increasing the availability and accuracy of agricultural information by improving the awareness, education, and skills of the farmers, extension workers, herders, and other end-users in the sector to disseminate credible agricultural knowledge, improve research capacity, quality, credibility, and reach of extension advice using ICT, promote innovation in e-agricultural services, and improve the agricultural sector's financial, investment, and banking coverage.

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