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ADOPTION OF DRONE TECHNOLOGY: A PRELIMINARY STUDY AMONG RICE FARMERS IN KADA, KELANTAN

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Abstract:

Despite increasing government support for precision agriculture, empirical evidence on the determinants of drone technology among Malaysian paddy farmers remains limited. This preliminary study addresses this gap by examines the early-stage drivers of drone technology adoption among paddy farmers in Malaysia's Kemubu Agricultural Development Authority (KADA) region. Drawing on the Unified Theory of Acceptance and Use of Technology (UTAUT), the study investigates the role of performance expectancy and social influence in shaping adoption intention. A quantitative survey involving 50 systematically selected farmers were analysed using descriptive statistics, Pearson correlation, and chi-square tests. As a pilot study, the research aimed to evaluate the feasibility of the research instrument and generate preliminary evidence for a larger empirical investigation. Results indicate that social influence demonstrated a stronger positive association with adoption intention than performance expectancy ($r = 0.57$, $p < 0.001$). Younger farmers (<40 years) and those with larger farm sizes (>5 acres) reported significantly higher adoption intention, suggesting demographic disparities in uptake. This study extends the application of UTAUT to precision agriculture by providing preliminary evidence from smallholder paddy farmers in Malaysia, a context that remains underexplored in the technology adoption literature. The findings suggest that agricultural extension programmes should leverage peer influence and demonstration farms to accelerate drone adoption, particularly among older farmers and those operating smaller farms. This study offers important groundwork for refining Malaysia's agricultural modernisation strategies under the National Agro-Food Policy (2021-2030).

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Introduction

In Malaysia, paddy farming, also known as rice farming, is a vital agricultural endeavor. Rice is a staple food in Malaysia, where it accounts for about 65% of domestic consumption (Department of Statistics Malaysia, 2025). Divergent trends in rice productivity across Malaysia's granary areas have been revealed by recent statistics as shown in Table 1. Despite using 30% less area for cultivation, Integrated Agricultural Development Area (IADA) Barat Laut Selangor had quantifiable advances between 2022 and 2023, whereas Kemubu Agricultural Development Authority (KADA) in Kelantan saw stagnant yields (Department of Agriculture, 2023). Between 2022 and 2023, both regions saw little decreases in the area under cultivation (-1.1% and -0.9%, respectively), but the results of their production were substantially distinct. KADA maintained stable yields of 4.1 metric tons per hectare despite a 1.2% decrease in output to 210,237 metric tons. IADA Barat Laut Selangor, in contrast, increased production by 5.1% to 161,271 metric tons, increasing its yield by 6% to 4.58 metric tons per hectare.

Table 1: Cultivation Area and Paddy Production in Malaysia's Key Rice Granaries (2022-2023)

Granary Area	2022		2023	
	Area (ha)	Yield (mt)	Area (ha)	Yield (mt)
KADA (Kelantan)	51,939	212,740	51,342	210,237
IADA Barat Laut Selangor	35,539	153,492	35,236	161,271

Source: Department of Agriculture, 2023

The higher performance of IADA Barat Laut Selangor is attributed to the systematic deployment of precision agriculture technologies, according to peer-reviewed studies. According to Azizul et al. (2023), 62% of farmers in this area use at least one digital farming tool, while only 18% do so in KADA. Puppala et al. (2023) refers to these discrepancies as "institutional readiness gaps," whereby urban-proximate regions enjoy the advantages of more robust technical support networks. This is consistent with Bernama's (2020) report on SMART SBB projects, which shows that drone-assisted farming in Selangor can save 25% on inputs.

The difficulties faced by KADA are also well-documented. Zaman et al. (2023) ascribes low technology uptake among Kelantan's farmers to insufficient extension services and financial availability. The Star's (2024) report on KADA's "missing middle" in agricultural modernization echoed these conclusions. Significant potential costs are suggested by economic evaluations; according to Ruzzante et al. (2021), closing just half of the yield gap in KADA may boost national rice production by 1.8% yearly.

To address these challenges, the Malaysian government has promoted the adoption of modern agricultural technologies, including drones, under initiatives such as the National Agro-Food Policy (2021–2030). Drones offer significant advantages, such as precision spraying, real-time crop monitoring, and reduced dependency on manual labor (Harun et al., 2024). Despite these benefits, adoption among smallholder paddy farmers in KADA remains limited, with many still relying on traditional farming methods (Azizul et al., 2023). Therefore, by adapting the Unified Theory of Acceptance and Use of Technology (UTAUT) as a framework, this preliminary study examines the early-stage drivers of drone technology adoption within the KADA environment, concentrating on farmers' perceptions of performance expectancy and social influence.

Literature Review

Given that Malaysia consumes 2.7 million metric tons of rice per year, the paddy and rice industries are crucial to the country's food security (Khazanah Research Institute, 2016). However, imports from Thailand, Vietnam, and Pakistan are required because domestic production only meets 67% of this need (Sarena et al., 2019). The necessity of improving local rice production through technical innovation is highlighted by this dependency, as stated in Malaysia's National Agro-Food Policy 2021-2030 (NAP 2.0, 2021). To tackle issues that threaten food security, especially in developing countries, such as climatic variability and declining arable land, the strategy places a strong emphasis on smart agricultural frameworks (Food and Agriculture Organization, 2011). Despite these efforts, Malaysian farmers continue to adopt technology at a low rate, with smallholders and older farmers showing reluctance because of financial constraints and technophobia (Mat Lazim, 2020; Omar et al., 2024).

The KADA region in Malaysia offers a significant chance to improve sustainability and productivity using agricultural drones by rice farmers. When compared to other technology acceptance models in agricultural contexts, the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) has shown superior predictive power (74% accuracy), offering a solid framework to comprehend this adoption process (Dissanayake et al., 2022). Four fundamental constructs—performance expectancy, effort expectancy, social influence, and facilitating conditions—are included in the adapted UTAUT model for drone adoption, as illustrated in Figure 1, with age and farm size being as key moderators.

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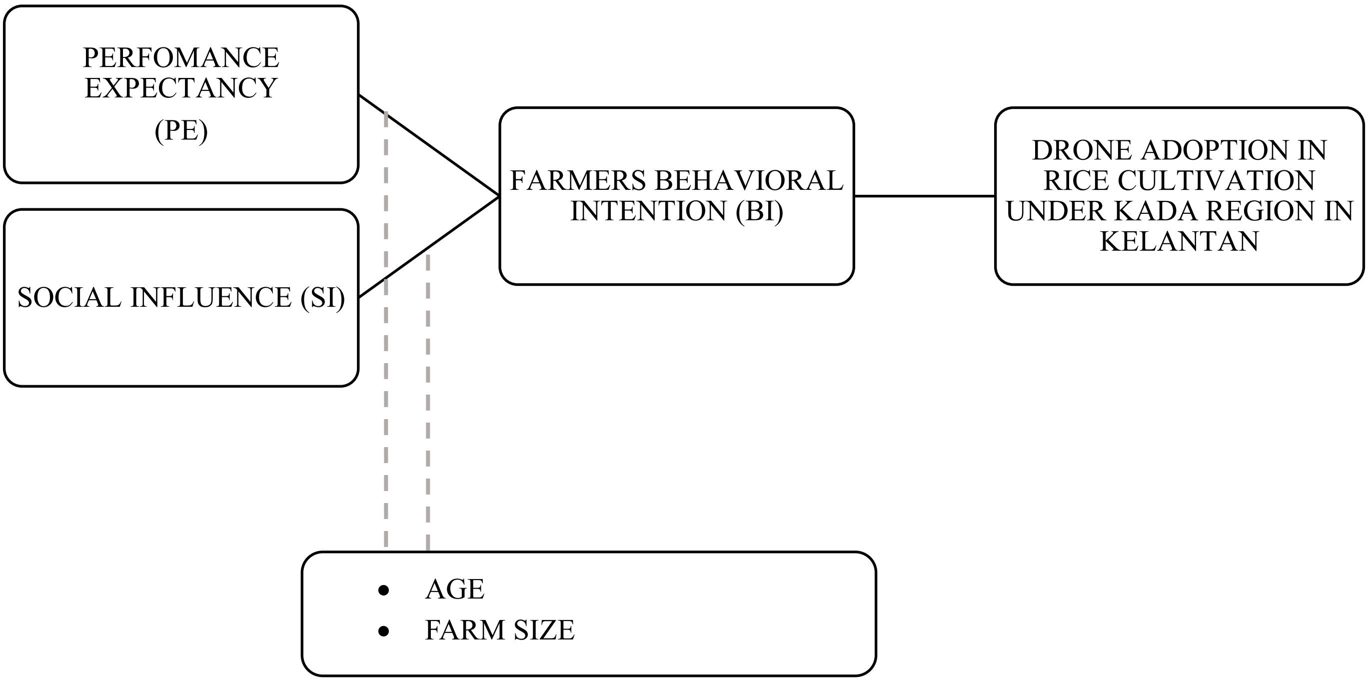

Figure 1: Adapted UTAUT Framework for Agricultural Drone Adoption from Venkatesh et al. (2003)

Note: Solid lines represent hypothesized direct relationships tested in this preliminary study.

The two constructs in this framework as illustrated in Figure 1 such as Performance Expectancy (PE) and Social Influence (SI) are independent variables, while socio-economic factors such as age, farm size and farmer behavioral intention (BI) are mediating variables, and drone adoption in rice cultivation under KADA region in Kelantan is the dependent variable.

Performance Expectancy (PE) in the context of this research is defined as the degree to which farmers believe that the use of drone technology will help them achieve gains in work performance, such as increased yields. Social Influence (SI) is defined as the degree to which farmers perceive that important individuals around them believe they should use drone technology.

They have since been successfully applied to agricultural technology adoption in Malaysia, accounting for 68% of the variation in ICT tool usage among paddy farmers (Ali et al., 2020). However, when applied to smallholder agricultural systems like KADA, the model's scant attention to socioeconomic aspects reflects a significant gap.

Recent studies emphasize the significance of socioeconomic considerations are as moderators of technology adoption. Research shows that technophobia causes 40% poorer adoption rates among senior farmers (>55 years) (Schukat & Heise, 2021), which is especially pertinent considering that 62% of KADA farmers are in this age range (KADA, 2020). Similar to KADA's average farm size of 1.8 hectares, tiny farms (less than 4 hectares) decrease the likelihood of adoption by 2.5 times when compared to larger businesses (McBride & Daberkow, 2003). Long-tenured farmers (>20 years' experience) exhibit higher resistance to change (Perrin & Winkelmann, 1976), while farmers with secondary education embrace technology 1.8 times faster (Ruzzante et al., 2021). Employment experience and educational attainment both have an impact on adoption patterns. Even though the extended UTAUT2 model (Venkatesh et al., 2012) acknowledges these socioeconomic elements, they need special validation in agricultural situations, especially for new technologies like drones.

Experience from throughout the world shows that, with the right adoption hurdles removed, drone technology has the potential to revolutionize rice cultivation. Food and Agriculture Organization (2021) and World Bank (2022) reports that drone usage reached 45% of rice farms in Thailand after government subsidies covered 70% of expenditures, leading to a 22% increase in output and a 50% reduction in pesticide costs. According to Nguyen et al., (2023), 80% of trained farmers in Vietnam adopted drone technology after just three sessions as a result to training programs that lowered skill barriers. In the Mekong Delta, peer-to-peer learning enabled farmer cooperatives to increase adoption of drone in agriculture (Tran et al., 2022). While highlighting the necessity of context-specific adjustments that take local socioeconomic constraints into consideration, these international examples offer insightful information for KADA. Therefore, to promote sustainable agricultural practices, increase farm output, and improve farmers' livelihoods, emphasis must be paid to socio-psychological issues related to technology adoption. This study bridges these gaps by preliminarily examining how KADA farmers' age and farm size moderate the relationship between UTAUT constructs and adoption intent.

Methodology

Research Design

This preliminary study used a quantitative research approach to investigate the factors impacting drone technology uptake among paddy farmers in KADA, Kelantan. The study modified the Unified Theory of Acceptance and Use of Technology (UTAUT) framework (Venkatesh et al., 2003) to emphasize performance expectancy (PE) and social influence (SI) as major constructs. A cross-sectional approach was employed for analysing data from a systematically selected subset of 50 farmers from a larger dataset of 200 respondents, ensuring representation across key demographic variables such as age groups (18-30, 31-45, 46-60, 61+ years) and farm size classifications (<5 acres, 5-10 acres, 10-20 acres, >20 acres). The research approach focused on early-stage findings that could inform both policy initiatives and the larger thesis study.

Data Collection

Primary data was gathered through structured questionnaires in KADA's six administrative districts (Kota Bharu Utara, Kota Bharu Selatan, Bachok, Pasir Puteh, Pasir Mas, and Tumpat). The survey tool used 7-point Likert scales (1 = strongly disagree, 7 = strongly agree) to measure Performance Expectancy and Social Influence. Demographic information on age and farm size was gathered as moderating variables. Prior to the major data collection, a pilot test with 20 farmers demonstrated instrument reliability, with Cronbach's alpha values of 0.89 (PE) and 0.91 (SI), which exceeded the 0.70 criterion indicated by Fornell and Larcker (1981). The questionnaire was administered in Malay by professional enumerators, and each interview lasted around 30 to 60 minutes.

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Data Analysis

For this preliminary study, the data was analyzed by using SPSS version 29. Descriptive statistics such as means, standard deviations, and frequencies were used to characterize major adoption trends and demographic characteristics of the study population. Pearson correlation analysis was used to investigate the correlations between several UTAUT components, providing information about how different factors influenced technology adoption. Cross-tabulations with chi-square tests were used to investigate connections between categorical variables such as age groups and the likelihood of adoption, providing a more in-depth knowledge of demographic influences. In addition, a reliability analysis was performed to check the internal consistency of all measuring scales, confirming the study's psychometric qualities. All statistical tests used a 95% confidence level ($\alpha = 0.05$) to assess significance. The analysis focused solely on the correlations between the primary variables of interest (PE, SI, age, and farm size), without including more advanced modelling techniques reserved for the entire thesis study. This multifaceted analytical technique enabled a full assessment of the data while preserving the methodological rigor expected of a preliminary investigation. This simplified approach is in accordance with the goals of the preliminary study, giving priority to early findings that can be used rather than extensive model testing.

Results

A preliminary analysis of 50 KADA farmers found significant trends in drone technology adoption. Performance expectancy was revealed as a significant predictor, with farmers having positive perspectives ($M = 5.2$, $SD = 1.1$) of drone benefits for paddy productivity. Social influence had a stronger effect ($M = 5.8$, $SD = 0.9$), supporting Nguyen et al.'s (2023) findings that peer recommendations greatly promote adoption in agricultural areas.

Table 2: Descriptive Statistics of UTAUT Constructs

Construct	Mean (M)	Standard Deviation (SD)	Minimum	Maximum
Performance Expectancy	5.2	1.1	3	7
Social Influence	5.8	0.9	4	7

Pearson correlation analysis found a moderate positive association between performance expectancy and adoption intent ($r = 0.42$, $p < 0.01$), while social influence showed a greater correlation ($r = 0.57$, $p < 0.001$). These results are similar with Dissanayake et al. (2022) UTAUT validation in agricultural contexts, in which societal considerations frequently exceeded individual perceptions.

Table 3: Pearson Correlations Of UTAUT Constructs

Variable	PE	EE	SI	FC	Adoption Intent
Performance Expectancy (PE)	1	0.64**	0.42**	0.31*	0.42**

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Variable	PE	EE	SI	FC	Adoption Intent
Social Influence (SI)	-	-	1	0.66***	0.57***

**p < .05, **p < .01, ***p < .001 (1-tailed)

Cross-tabulation analysis found substantial disparities in demographics as shown in Table 4. Farmers under 40 had 1.8 times greater adoption rates than older cohorts ($\chi^2 = 6.24$, $p = 0.04$). Farm size affects adoption likelihood, with larger enterprises exhibiting higher intent ($\chi^2 = 5.67$, $p = 0.03$), confirming McBride and Daberkow's (2003) economic scalability theory. However, the non-significant connection between farming experience and adoption ($p = 0.12$) contradicts some previous research but is consistent with Ruzzante et al.'s (2021) meta-analysis, which found that experience effects drop when adjusting for age.

Table 4: Adoption Intent by Demographic Groups

Demographic Groups	Category	Adoption Rate (%)	χ^2	p-value
Age Group	<40 years	68%	6.24	0.04*
	≥40 years	38%		
Farm Size	>5 acres	65%	5.67	0.03*
	≤5 acres	42%		

As shown in Table 5, the reliability analysis revealed excellent internal consistency for both constructs (PE $\alpha = 0.89$; SI $\alpha = 0.91$), exceeding the proposed criterion of 0.70 by Fornell and Larcker (1981).

Table 5: Reliability Analysis

Constructs	No. Items	Cronbach's α	CR	AVE
PE	5	0.89	0.91	0.72
SI	5	0.91	0.93	0.77

While preliminary, these findings strongly suggest that social networks and perceived benefits both drive adoption, with demographic factors causing meaningful inequalities. The non-significant findings on agricultural experience add considerably to ongoing discussions about whether tenure or generation gaps better predict tech resistance, implying that future research should consider cohort impacts rather than just experience duration. These findings give actionable information for KADA to adjust extension activities based on age and farm size rather than assuming uniform adoption hurdles for all farmers.

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Discussion

The outcomes of this study shed light on the factors driving drone technology adoption among paddy farmers in KADA, Kelantan. The findings show that social influence (M = 5.8, SD = 0.9) has a greater impact on adoption intention than performance expectancy (M = 5.2, SD = 1.1), which is consistent with the UTAUT framework's emphasis on social aspects in technology adoption (Venkatesh et al., 2003). This finding is validated by several investigations conducted in various agricultural environments. For example, Nafar et al. (2023) discovered that social influence was the largest predictor of drone adoption among Iranian farmers. These consistent findings across various regions indicate that social networks play a very crucial role in agricultural technology adoption, most likely due to the large perceived risks associated with new farming technologies.

This preliminary study also found a substantial association between social influence and adoption intention ($r = 0.57, p < 0.001$), which is consistent with prior studies on agricultural technology adoption. In Vietnam, Tran et al. (2022) discovered that farmer-to-farmer learning significantly increase drone adoption and highlighting the role of social networks in technology diffusion. These parallels indicate that extension services in KADA could benefit from embracing more peer-based learning methodologies rather than relying primarily on top-down information transmission.

Our study found a moderate but significant correlation between performance expectancy and adoption intention ($r = 0.42, p < 0.01$). While this effect was fewer than social influence, it remains a significant driver of adoption. This finding is consistent with Harun et al. (2024) research in Malaysia's Muda Agricultural Development Authority (MADA) region, where farmers who saw concrete benefits from drone technology were more willing to adopt it. However, our findings differ from those of research conducted in more commercialized farming systems, such as India, where performance expectations influenced adoption decisions (Sundar et al., 2023). This disparity may reflect the distinctive characteristics of smallholder paddy farming systems, in which social validation frequently takes precedence over individual cost-benefit evaluations.

The demographic statistics provide valuable practical information for policymakers. Farmers under 40 years old had much greater adoption rates (68%) than those over forty (38%), with a statistically significant difference ($\chi^2 = 6.24, p = 0.04$), which aligns with global trends (Schukat & Heise, 2021). Similar age discrepancies have been observed in research from a variety of settings, including Iran (Nafar et al., 2023) and Germany (Schukat & Heise, 2021). This persistent pattern across different cultural and agricultural systems implies that age-related inequalities in technology acceptability are a global phenomenon, most likely caused by variable degrees of digital literacy and receptivity to innovation.

Similarly, farm size revealed as a key factor in adoption patterns. Farmers that cultivating larger area (>5 acres) reported considerably higher adoption intention (65%) compared to farmers cultivating smaller area ≤5 acres (42%). This 23-percentage-point difference was statistically significant ($\chi^2 = 5.67, p = 0.03$). This finding is consistent with economic theories of technology adoption that highlight scale as a significant factor influencing agricultural investment decisions (Feder et al., 1985). This discovery is particularly relevant to Malaysia's agricultural landscape, since typical farm sizes are tiny (2.1 hectares in KADA). Similar farm size effects

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have been identified in research from Taiwan (Guo et al., 2022) implying that this may be a global barrier to technology adoption in smallholder systems.

Interestingly, work experience had no significant effect on adoption intention ($p = 0.12$) in this preliminary study. This is consistent with findings from Ruzzante et al.'s (2021) meta-analysis of 87 adoption studies, which discovered that when controlling for age, experience effects were frequently reduced. This shows that the often observed "experience effect" in technology adoption may be skewed by age, with younger farmers being more open to innovation regardless of agricultural experience. The study's psychometric results indicate the reliability of the adapted UTAUT measures (PE $\alpha = 0.89$; SI $\alpha = 0.91$), indicating their usefulness in agricultural technology research.

These findings have significant implications for both KADA's extension services and Malaysia's agricultural modernization ambitions. The substantial social influence effect implies that farmer-to-farmer demonstration programs could be especially effective, as demonstrated in Vietnam (Tran et al., 2022). The age inequalities highlight the need for specialized training programs for elderly farmers, whilst the farm size impacts indicate the potential for equipment-sharing arrangements or cooperative ownership models.

Conclusion

This preliminary study offers valuable insights into the early-stage determinants of drone technology adoption among paddy farmers in KADA, Kelantan. The findings highlight social influence as the most predictor of adoption intention, followed by performance expectancy. These results reinforce the importance of leveraging peer networks and community dynamics when promoting agricultural technology in smallholder setting. Demographic analysis further reveals that younger farmers and those managing larger farm areas are more inclined to adopt drone technology, while farming experience shows no significant effect. These patterns suggest that generational and structural factors play a more critical role in adoption behaviour than traditional indicators like year of experience. The study contributes to the broader literature on agricultural technology adoption by validating the relevance of UTAUT constructs in a developing country context and by identifying age and farm size as key moderating variables. Practically, the findings call for KADA’s targeted extension services strategies as a peer-led demonstrations, cooperative ownership schemes, and age specific training programs that addressing the unique needs of different farmer segments. As a preliminary investigation, this study lays the groundwork for future research. Subsequent studies should expand the sample size, incorporate additional UTAUT variables (effort expectancy, facilitating conditions), and examine the transition from intention to actual usage. A more nuanced understanding of these dynamics will support the development of inclusive and effective policies aligned with Malaysia National Agro- Food policy (2021-2030), ultimately accelerating the digital transformation of the agricultural sector.

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Ethics Statement:	This study was conducted in accordance with ethical research standards. All procedures involving human participants were reviewed and approved by the Research Ethics Committee UKM, approval number JEP-2024-898. Informed consent was obtained from all participants prior to data collection. Participation was voluntary, and respondents were assured of confidentiality and anonymity. The data collected were used solely for academic purposes.
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