

Foresight Study on Drone Adoption in Malaysia's Agriculture Sector

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Abstract

The drone is one of the technologies that is applied by most sectors in the country, for the purpose of automating the daily operations of the sector, reducing the burden of employees, and minimising the cost in the sector. Currently, drones have been adopted in the agriculture sector. The purpose of the study is to identify the issues, challenges, and trends of drones in the agriculture sector, to study the key drivers of drones in the agriculture sector, and to analyse the future image of drones in the agriculture sector. There are 384 respondents selected, including stakeholders in the agriculture sector. The research applied the quantitative methods, in which this research is proceeding with the foresight instruments. For instance, the STEEPV analysis and SPSS analysis. STEEPV analysis is used to identify the issues, challenges, and trends of drones in the agriculture sector, while the SPSS analysis is applied in the research, with the purpose of displaying the results of the key drivers of drones in the agriculture sector in the second phase of the research, with impact-uncertainty analysis. This research is evaluating and identifying 10 merged key drivers. This study also used the impact-uncertainty analysis to determine the future image of drones in the agriculture sector.

1. Introduction

The Industrial Revolution 4.0 (IR4.0) was increasing the usage of technology and resulting in rapid growth in technological development among the sectors in the countries. For instance, the adoption of drones in the agriculture sector in various countries. The developed countries were starting to apply drone technology in their own agricultural production activities. For instance, the countries used drone technology for crop monitoring with a camera and sensor and as a sprayer to spray the agricultural chemical (Dutta & Goswami, 2020). Usually, the countries implement the technical analysis with the drone in the agriculture sector, for the purpose of analysing the operation of agriculture, such as estimating the height of crops, analysing the soil and field in the agricultural cropland and spraying pesticides.

Drones, as one of the advanced technologies, which are applied to implement the daily operations and innovation development, are improving the productivity of the agriculture sector in various countries. Based on the information from (Peter Kipkemoi, 2023), the adoption of drones in the agriculture sector is being applied by the stakeholders, especially the farmers who are applying the drone in the agriculture sector, for the purpose of accurately monitoring the information effectively and keeping up with information about crops. The drones are

easy to use and operate in the agriculture sector in Malaysia, in which the employees are only necessary for selecting the route drawing on the devices, deploying the drones and obtaining the monitoring scene to perform the drones' route planning function. In addition, the adoption of drones can map functions; it would assist the farmers to map the farmland, surveying and measuring the land in the agriculture sector in Malaysia (Peter Kipkemoi, 2023).

Despite the adoption of drones providing various advantages to the agriculture sector in Malaysia, there are still some drawbacks in the adoption of drones faced by the agriculture sector in Malaysia.

Although there are various advantages that drones provide in the agriculture sector in Malaysia, there are several disadvantages to drone adoption in the agriculture sector in Malaysia. The agriculture sector adopts the drone to provide assistance for farmers to manage the cropland at a high cost, which requires an amount between MYR46687.57 (\$10000) and MYR93375.15 (\$20000) (Peter Kipkemoi, 2023). The disadvantage of being inexperienced in drone operation will affect new users or new workers. Thus, the new and advanced drones are reducing the tedious process and concentrating on proceeding with the intelligent planning of scenarios, for the purpose of ensuring the users and farmers have expert abilities in adopting the drone to apply in the agriculture sector in Malaysia (Peter Kipkemoi, 2023).

The disadvantage of drone adoption in the agriculture sector in Malaysia is the timing and range of the drone flight. According to (Pathak *et al.*, 2020), the drones that are used in the agriculture sector are facing the issue, in which they are only able to operate for around an hour as the maximum time, since the cost of the drones increases depending on the flying time. In addition, another of the drawbacks is the initial cost, which requires a higher cost for the feature image sensors, software, hardware, and equipment for the adoption of drones in the agriculture sector. Besides that, the disadvantages that might influence the adoption of drones in the agriculture sector in Malaysia are the cost of maintenance and assistance. According to Kushwaha *et al.* (2023), the drones require maintenance and repair to ensure technical support to reduce the interference of daily operations in the agriculture sector with the adoption of drones. According to Shah (2023), the issue of a lack of knowledge on using drones is one of the drawbacks in the drone adoption in the agriculture sector, since the majority of farmers in the agriculture sector are not accepting any training regarding using drones. In summary, the stakeholders of drones and the agriculture sector in Malaysia are suggesting implementing the response measures, in which cooperation with each other, for the purpose of mitigating the drawbacks and preventing issues from happening in the agriculture sector in Malaysia based on drone adoption in the future.

Therefore, to achieve the research objectives, the trends, issues, and challenges in the agriculture sector in Malaysia are determined. Furthermore, the key drivers of drone adoption in the agriculture sector in Malaysia were also determined. Consequently, the future image of drone adoption in the agriculture sector in Malaysia was also identified.

2. Research Methodology

2.1 Research Design

This study uses descriptive research as the research design. The research is choosing the quantitative method and applying it in the data collection process. The questionnaire is being developed by the researcher based on the drivers of drone adoption in the agriculture sector, using the STEEPV analysis. The questionnaire forms are distributed to the respondents, who are the stakeholders of drones and the stakeholders of the agriculture sector in Malaysia. The analysis of impact-uncertainty is implemented to analyse the development of scenarios in the study. This study consists of 2 phases. Phase 1 is discussing how the researcher collects the data by using the STEEPV analysis, while Phase 2 is discussing how the quantitative method is applied by the researcher to gather the primary data. Fig. 1 represents the process flow for conducting a study, beginning with the identification of the problem statement. This flowchart assists the researcher in conducting this study and gaining a deeper comprehension via the flowchart's summary.

The purpose of this study is to focus on identifying the drivers of drone adoption in the agriculture sector in Malaysia. The researcher selects the agriculture sector in Malaysia for the purpose of understanding more about the acceptance of drone adoption in the agriculture sector. The respondents who contribute to this research are the stakeholders who relate to drones and the agriculture sector in Malaysia. This research gathers, applies, and analyses the information based on the books, journals, and articles, for the purpose of identifying the drivers that adopt the drone in the agriculture sector in Malaysia. The questionnaire form will be distributed to the stakeholders of the drone and the agriculture sector in Malaysia.

2.2 Data Collection

Data collection is the way in which data is prepared and collected by the researcher. In this study, the primary and secondary data were used to investigate the foresight study on the adoption of drones in the agriculture sector.

The researcher is necessary to collect the secondary data related to the research topic to achieve the research objectives of this study.

2.2.1 Primary Data

Primary data is information which is gathered by the researcher firsthand. Primary data is available to gather the data with various types of methods, such as interviews and surveys. The objectives of primary data collection are to ensure that the data collected is accurate for the research study (Maione, 2024). Research is applying the methods and displaying them in this chapter. Primary data is information that an organisation will obtain because it was not collected and made publicly available. In this study, the researchers are gathering the primary data through a survey method using questionnaire designs. The descriptive analysis will be used on analysing the data that obtain from questionnaire form by survey the stakeholders of drones and the agriculture sector and generate to the impact-uncertainty analysis to create the scenarios about the drone adoption in the agriculture sector in Malaysia and attain the goal of this study, which is to conduct a foresight study on the adoption of drone in agriculture sector in Malaysia. Besides that, the researcher is using the SPSS software to analyse data and generate the impact-uncertainty analysis, for the purpose of achieving the research objectives of this study, which is a foresight study on the adoption of drone technology in the agriculture sector in Malaysia.

2.3 Data Analysis

STEEPV stands for social, technological, economic, ecological, political, and values. It is a structured analytical framework used to identify and analyse the driving forces affecting urban development and other strategic planning contexts. This comprehensive approach considers multiple dimensions of influence, enabling a holistic understanding of future trends and potential scenarios (Szpilko *et al.*, 2020). In this study, the literature resources are applied to the journals, articles and websites that were published within five years from 2020 to 2024. Furthermore, this study is obtaining future-oriented data from other websites since the data provides an overview of future emerging technology, especially the adoption of drones in the agriculture sector. Based on Danuta Szpilko *et al.* (2020), STEEPV is an analytical tool used to identify and evaluate the driving forces behind sector development. It comprises six key areas, which are social, technological, economic, environmental, political and value. This framework enables a comprehensive analysis of both the internal and external factors influencing a phenomenon and facilitates informed future planning and decision-making in the development of the country's sectors. All the related issues, challenges, and trends of the drone adoption in the agriculture sector in Malaysia that were obtained from secondary data were categorised in STEEPV. The researcher must arrange and evaluate the data gathered during the data collection phase to comprehend it. Data analysis is used to identify study findings and whether the research will fulfil its goals. Data will be gathered from primary sources through the distribution of questionnaires.

2.3.1 Descriptive Analysis

The Statistical Package for Social Sciences (SPSS) Version 26 was used to analyse the survey data for this study. Advanced statistical analysis, a large library of machine learning algorithms, text analysis, open-source extensibility, big data integration, and simple application integration are all features of the SPSS software platform. SPSS is accessible to users of all skill levels because of its ease of use, versatility, and scalability.

2.3.2 STEEPV Analysis

STEEPV is stands for social, technological, economic, ecological, political, and values. It is a structured analytical framework used to identify and analyse the driving forces affecting urban development and other strategic planning contexts. This comprehensive approach considers multiple dimensions of influence, enabling a holistic understanding of future trends and potential scenarios (Szpilko *et al.*, 2020).

The objectives of STEEPV are to identify the driving forces, which recognise the key factors influencing urban development in different areas of STEEPV, and develop the future scenarios, in which the STEEPV can help in creating the possible future scenarios by understanding the interplay of various factors in the STEEPV. The functions of the STEEPV in this study are to collect data from existing sources across the STEEPV dimensions and analyse the trends, issues, and challenges regarding the drone adoption in the agriculture sector in Malaysia within each STEEPV category to predict possible developments (Szpilko *et al.*, 2020).

In this study, the secondary data is applying the journals, articles and websites that were published within five years from 2020 to 2024. Furthermore, this study is obtaining future-oriented data from other websites since the data provides an overview of future emerging technology, especially the adoption of drones in the agriculture sector.

Based on Danuta Szpilko *et al.* (2020), STEEPV is an analytical tool used to identify and evaluate the driving forces behind sector development. It comprises six key areas, which are social, technological, economic,

environmental, political and value. This framework enables a comprehensive analysis of both the internal and external factors influencing a phenomenon and facilitates informed future planning and decision-making in the development of the country's sectors. All of the related issues, challenges, and trends of the drone adoption in the agriculture sector in Malaysia that were obtained from secondary data were categorised in STEEPV categories.

2.4 Research Population and Sample

According to Marcus (2022), the term population refers to the totality of individuals, objects or data points that are the subject of a statistical analysis or research study. In the context of demographic studies, a population includes all individuals residing in a specific geographic area, which is often measured by a census. The populations of this study were all stakeholders related to the drone and the agriculture sector in Malaysia. According to Sample, A. (2020), the sampling method is a technique used to select a subset of individuals, groups or data points from a larger population for the purpose of conducting a study. This method is essential because studying an entire population is often impractical, costly and time-consuming. Sampling is the process of selecting and matching a sample of the population. The sampling method will be used to select the respondents. There are 1.6 million agricultural farmers involved in the activities of the agriculture sector. Therefore, 384 respondents from the stakeholders of the agriculture sector will be involved in this study. Table 1 shows the sample size of the population table derived from Krejcie & Morgan (1970).

Table 1 *Determining sample size method*

<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	100000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970

2.5 Research Instrument

Research instruments could be described as the generic term that is applied by the researchers for measuring devices, such as surveys, questionnaires, etc. Thus, the research instrument is a key part and is used to proceed with the study. The main instrument used in this research is a questionnaire. The questionnaire consists of four sections, which are Section A, Section B, Section C, and Section D. Section A is used to measure the demographic background of the respondents, such as gender, age, race, etc. Section B discusses the importance of factors and drivers for the adoption of drones in the agriculture sector in Malaysia. The decision of the respondent can be classified through a Likert scale, which is ranked from "1=strongly disagree" to "5=strongly agree". The impact of factors and drivers towards the adoption of drones in the agriculture sector in Malaysia is included in Section C. Lastly, Section D mainly focuses on the uncertainty of factors and drivers towards the adoption of drones in the agriculture sector in Malaysia.

2.6 Pilot Study

A pilot test is a small-scale, preliminary study that assesses the feasibility, timeliness, cost, risk, and negative consequences of a larger research project. Pilot testing is used to determine the validity and reliability of research instruments and procedures (Gani *et al.*, 2020). According to Pearson *et al.* (2020), the importance of pilot testing lies in determining the feasibility of larger implementation studies. This includes evaluating recruitment efforts, data collection methods and resource allocation. Reliability is the result based on consistency and stability. For instance, the outcomes that are analysed by the research are considered reliable if the results have been obtained in similar situations but in different environments. The most suitable method to measure the internal consistency is Cronbach's Alpha, which can be used on the Likert scale points. Generally, the Alpha range is around 0 to 1 since it is easy to interpret based on the data. Most of the researchers agree that at least 0.070 or more of an alpha coefficients is enough for the scale.

2.7 Impact - Uncertainty Analysis

The Impact-Uncertainty Analysis is implemented based on the descriptive result since the Impact-Uncertainty Analysis investigates and evaluates the uncertainty in the issues, trends, and challenges of adopting drones in the agriculture sector in Malaysia. Based on the list of variables that originate from the STEEPV analysis, the main drivers that influence the impact-uncertainty analysis are the variables with the highest impact and uncertainty.

2.8 Scenario Building

The Impact-Uncertainty Analysis is implemented based on the descriptive result since the Impact-Uncertainty Analysis investigates and evaluates the uncertainty in the issues, trends, and challenges of adopting drones in the agriculture sector in Malaysia. Based on the list of variables that originate from the STEEPV analysis, the main drivers that influence the impact-uncertainty analysis are the variables with the highest impact and uncertainty. Figure 1 shows the scenario building of this study.

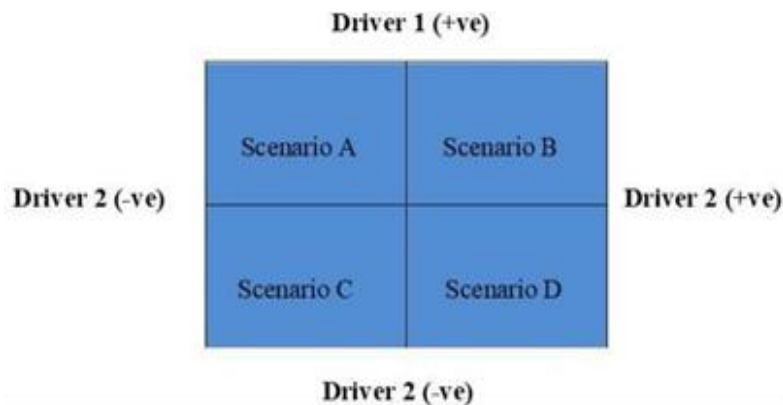


Fig. 1 Scenario building of this study

3. Literature Review

3.1 Definition of Drone

Drones in agriculture are unmanned aerial vehicles (UAVs) used for various agricultural activities, such as monitoring plant health, irrigation, crop spraying, planting and soil analysis. These drones help to increase crop yields, reduce costs and improve the efficiency of agriculture (Dutta & Goswami, 2020). Based on the Rejeb *et al.* (2022), Agricultural drones are UAVs that are used for precision agriculture. The drones collect and analyse data using advanced imaging and sensor technologies, providing actionable insights for crop management and field monitoring. In addition, the drones are able to improve decision-making and operational efficiency in agriculture. Agricultural drones are UAVs designed for applications such as crop reconnaissance, spraying, mapping and monitoring. They provide detailed aerial imagery and data on crop health, soil conditions and environmental factors, facilitating efficient farm management (Kalamkar *et al.*, 2020). According to Pathak *et al.* (2020), drones are used for various agricultural purposes, including precision agriculture, crop health assessment and resource management. They use advanced technologies to optimise agricultural operations and improve productivity.

3.2 Definition of Agriculture

According to (Ren *et al.*, 2020), the agricultural sector can be defined as the part of the economy that focuses on the production, processing and distribution of food, fibre and other products derived from plants and animals.

This sector encompasses various activities, including agriculture, livestock farming and the use of technology to increase efficiency and productivity. According to Shah *et al.* (2023), the agriculture sector includes the direct cultivation of crops and the rearing of livestock. This includes a variety of practices such as planting, harvesting, breeding and animal husbandry aimed at producing food and raw materials.

Modern agriculture utilises advanced technologies to increase efficiency and yield. Drones, for example, are used for aerial monitoring, crop monitoring, soil analysis and the precise application of inputs such as fertilisers and pesticides. These technologies enable precision agriculture that optimises the use of resources and increases yields (Inoue, 2020). Agriculture is described as a practice of crop production, soil cultivation, livestock raising and preparing or promoting the final products in the market in the countries. (Velasco-Muñoz *et al.*, 2021). Malaysia was developing continuously due to the contribution from the agriculture sector.

The agricultural sector also emphasises sustainable practices to ensure long-term productivity and environmental health. These include the use of drones and sensors for sustainable weed control and the application of precision agriculture to minimise waste and environmental impact (Emimi *et al.*, 2023). Agriculture is an important part of the global economy as it creates jobs and provides livelihoods, especially in rural areas. It is also fundamental to food security as it provides the raw materials for various food products and industries (Hafeez *et al.*, 2023).

3.3 Table with Merged Issues, Challenges and Trends

Table 2 shows Issues, Challenges, and Trends that merged with the STEEPV analysis, in which the table has issues, challenges, and trends for social, technological, economic, environmental, political and value. for the STEEPV analysis, journals, websites, books, online newspapers, and other internet sources were analysed to determine the key issues, challenges, and trends about the drone adoption in Malaysia’s agriculture sector.

Table 2 Table with Merged Issues, Challenges and Trends

No.	Issues, Challenges, and Trends	Drivers
D1	The materials of drones that can be renewed are being developed continuously for the purpose of reducing waste and contamination	Sustainable materials innovation
D2	Acceptance of farmers, since they lack the technical knowledge and need for training to operate drones	Acceptance of stakeholders
D3	Advances in drone capabilities, in which the drones face the challenges of efficiently processing, managing, and analysing data	Production cost
D4	Advances in drone capabilities, in which the drones face the challenges of efficiently processing, managing, and analysing data	Technology capability
D5	The drone can assist in reducing the burden of daily operation in the agriculture sector, but the frequent use of pesticides and fertilisers through the adoption of drones might have caused pollution in soil and water. Besides that, it would influence the wildlife or flora if the drone were to spread the chemical in non-agricultural areas	Environmental pollution
D6	Regarding the issues that happened in the environment, nowadays, drones are starting to adopt renewable energy sources. For instance, the establishment of solar-power charging stations	Sustainable practices
D7	The governments are providing subsidies and financial incentives for the purpose of encouraging the use of drones in the agriculture sector. This is due to the government's realising that the adoption of drones in the agriculture sector is offering various potential benefits in the future	Support and subsidies from the government
D8	The adoption of drones represents the growth and modernisation in the agriculture sector, encouraging farmers to apply drone technology to implement operations in the agriculture sector in future	Innovation and progress
D9	The interaction between drone technology with other agricultural equipment is one of the challenges in the agriculture sector, since it is hard for the drone to integrate with the management system in the agriculture sector	Integration with the existing system in the agriculture sector
D10	The application of drones requires professional knowledge to control them. However, most of the farmers in agriculture are facing the issue of a lack of technical knowledge. Thus, the training is necessary to develop the ability of farmers	Complexity and expertise of drone technology

4. Results and Discussion

4.1 Survey Return Rate

The sample size for the targeted respondents is 384 and has been selected for this study. According to the data, which was collected from the questionnaire form, 220 out of 384 valid questionnaires were collected with a response rate of 57.29%. The survey response rate is summarised in Table 3 as follows:

Table 3 Survey return rate

Population	Sample Size	Questionnaire Distribute	Questionnaire Returned	Percentage
1600000	384	384	220	57.29%

4.2 Reliability and Validity Analysis

To test the internal consistency or reliability of a collection of questionnaire items, the Cronbach's Alpha (α) coefficient was utilised. The test was performed for both the pilot and major studies. The questionnaire design is good if the Cronbach's Alpha (α) coefficient is greater than 0.7. Therefore, if the research returns greater than 0.7, it can be conducted. Table 4 displays the value of the dependability coefficient.

Table 4 Reliability coefficient value

Cronbach's Alpha (α)	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.9 \geq \alpha \geq 0.8$	Good
$0.8 \geq \alpha \geq 0.7$	Acceptable
$0.7 \geq \alpha \geq 0.6$	Be Disputed
$0.6 \geq \alpha \geq 0.5$	Bad
$0.5 \geq \alpha$	Unacceptable

4.2.1 Reliability and Validity Analysis of Real Study

In this study, Cronbach's Alpha is in the range from 0 to 1, giving low to very high internal consistency. Therefore, the coefficient Cronbach's Alpha requires a value of more than 0.6 to assess the inter-item consistency for measurement items in a construct. Therefore, if the Cronbach's alpha is less than 0.6, the possibility of the question being developed is not clear, and there is repetition. Thus, the question that is not at a satisfactory level should be reorganised or removed from the instrument to be reliable.

A pilot test was used to test the reliability of the study. A total of 30 respondents were involved in the test by using a reliability test. The Cronbach's Alpha classification was used to measure the reliability and obtain the Cronbach's Alpha value.

Based on Table 5, the Cronbach's Alpha value for the pilot test is 0.892. The number of respondents is 30. From the value of Cronbach's Alpha indicated in Table 5, it is good because the value exceeded 0.8; therefore, the study was reliable and could be continued. The Cronbach's Alpha value for the real study is 0.700 with a total of 220 respondents. Hence, this study illustrates a good and high reliability of the variable.

Table 5 Reliability test for real study

No	Number of respondents	Number of items	Cronbach's Alpha (α)
1.	30	30	0.892
2.	220	30	0.700

4.3 Demographic Analysis

The questionnaires were distributed to the agriculture sector from a variety of backgrounds in Malaysia. Table 6 illustrates the demographic information that was profiled and given in Section A for the respondents. The respondents' profiles contained the following information: Gender, Age, Education Level, Occupation Sector, Respondents' Working Experience, Activity Using by Drone Technology in the Agriculture Sector, and Usage of Drone Technology in the Agriculture Sector. The data analysis will help to give a clear distribution of respondents. The next section will go over each thing in detail.

Table 6 Summary of demographic analysis

Demographic	Classification	Frequency (N)	Percentage (%)
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Gender	Male	145	65.9
	Female	75	34.1
Age (years old)	Less than 40	69	31.4
	40 – 45	86	39.1
	45 – 50	44	20
Education Level	More than 50	21	9.5
	SPM	33	15
	STPM	27	12.3
	Diploma	41	18.6
	Degree	71	32.3
Occupation Sector	Master	34	15.5
	PHD	14	6.4
	Private	116	52.7
	Government	51	23.2
Respondents' Working Experience (years)	Self-Employed Business	53	24.1
	Less than 1	36	16.4
	2 – 5	101	45.9
	6 – 10	65	29.5
Activity Using Drone Technology in the Agriculture Sector	More than 11	18	8.2
	Spraying Pesticide	33	15
	Analysing Soil and Field	49	22.3
	Estimating Height of Crops	55	25
Usage of Drone Technology in the Agriculture Sector	All Above		
	Daily	83	37.7
	Weekly	74	33.6
	Monthly	80	36.4
		66	30

4.4 Descriptive Analysis

This section discusses the results of the voting for each driver based on the level of impact and uncertainty. Descriptive analysis examines the characteristics of each variable. At the end of this chapter, an approach based on impact-uncertainty analysis was constructed to determine the top driver that contributed significant impact and uncertainty in the future. The Likert scale used in this section ranges from 1 (strongly disagree) to 5 (strongly agree).

4.4.1 Descriptive Analysis for Means of Drivers on the Level of Impact

Table 8 displays the mean value of the level of impact for each driver. The highest mean represents the highest impact towards drones in the agriculture sector, as the respondent thinks that complexity and expertise of drone technology are needed before the implementation of drone technology in future, with a 4.16 mean value. The mean result will be brought forward to the next analysis of impact and level of uncertainty.

Table 8 Means of Drivers on the Level of Impact

No	Drivers	Mean
D1	Sustainable Materials Innovation	2.8000
D2	Acceptance of stakeholders	3.3455
D3	Production cost	3.5773
D4	Technology capability	3.5091
D5	Environmental pollution	3.7455
D6	Sustainable practices	3.6455
D7	Support and subsidies from the government	4.1636
D8	Innovation and progress	4.0455
D9	Integration with the existing system in the agriculture sector	3.9091
D10	Complexity and expertise of drone technology	4.1636

4.4.2 Descriptive Analysis for Means of Drivers on Level of Uncertainty

The progress of analysis is followed by analysing the level of uncertainty for each driver and their mean value. Table 9 indicates the mean value according to the rating scale for each level of uncertainty by respondents through the questionnaire. The highest mean value shows the most uncertainty for the drivers. All mean values for the level of uncertainty will be brought forward to construct the impact-uncertainty analysis.

Table 9 Means of Drivers on the Level of Uncertainty

No	Drivers	Mean
D1	Sustainable Materials Innovation	2.7318
D2	Acceptance of stakeholders	3.3682
D3	Production cost	2.3727
D4	Technology capability	3.6091
D5	Environmental pollution	3.8136
D6	Sustainable practices	3.5500
D7	Support and subsidies from the government	3.5273
D8	Innovation and progress	3.8727
D9	Integration with the existing system in the agriculture sector	4.1273
D10	Complexity and expertise of drone technology	4.0682

4.5 Impact - Uncertainty Analysis

Table 10 indicates the comparison of the mean value between the level of impact and the level of uncertainty. This table clearly shows the corresponding mean for each driver in the impact-uncertainty analysis. The main purpose of the analysis is to determine the highest outcome in terms of impact and uncertainty. All data were used to construct the impact and uncertainty analysis, as shown in Figure 10

Table 10 Mean of the 10 leading drivers on the level of impact and uncertainty

No	Drivers	Mean	
		Impact	Uncertainty
D1	Sustainable Materials Innovation	2.8000	2.7318
D2	Acceptance of stakeholders	3.3455	3.3682
D3	Production cost	3.5773	2.3727
D4	Technology capability	3.5091	3.6091
D5	Environmental pollution	3.7455	3.8136
D6	Sustainable practices	3.6455	3.5500
D7	Support and subsidies from the government	4.1636	3.5273
D8	Innovation and progress	4.0455	3.8727
D9	Integration with the existing system in the agriculture sector	3.9091	4.1273
D10	Complexity and expertise in drone technology	4.1636	4.0682

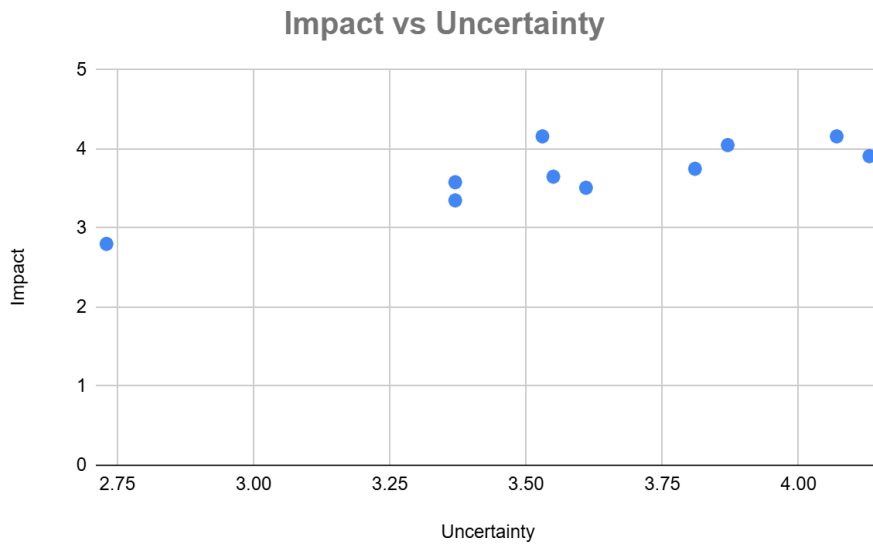


Fig. 2 Impact – Uncertainty analysis

5. Recommendations and Conclusion

The first objective of this study is to analyse the trends, issues, and challenges in the agriculture sector in Malaysia. This objective will be defined through the questionnaire form, which is distributed to the respondents. This objective is important for the study since the trends, issues, and challenges would be identified via the questionnaire form, and it might become the reference for the agriculture companies in Malaysia to mitigate and solve the problems they face based on the adoption of drones in the agriculture sector.

The second objective of this study is to identify the key drivers of drone adoption in the agriculture sector in Malaysia. This objective was generated through the STEEPV analysis. It is important to identify the issue and drivers of drone adoption in the agriculture sector in Malaysia, which can contribute to the potential users in the sector. The issue and drivers will determine the use of drones in the agriculture sector in Malaysia in the future. Based on the STEEPV analysis, the technological factor is the most important driver of drone adoption in the agriculture sector, followed by economic, social, values, political and environmental.

The third objective of this research was to study the future image of drone adoption in the agriculture sector in Malaysia. The purpose is to identify the trend that acts as a driving force for the future changes and the future environment and market for drone adoption in the agriculture sector in Malaysia. The trend is achieved by generating scenario analysis for four different alternative scenarios based on the top two drivers selected from the impact uncertainty analysis. The selected top two drivers were discussed in the following section. It was explained how uncertain the future development is and what impact it will have on the adoption of drone technology in the agriculture sector in Malaysia in the future. The selected top two drivers had the highest impact and uncertainty compared to the other drivers. The highest value of 3.91 and 4.13 in the impact-uncertainty analysis is Integration with existing systems in the agriculture sector. This driver has the highest impact and becomes the most uncertain driver rather than the others. The strong integration with existing systems with drone adoption in the agriculture sector will enhance the drones equipped with advanced sensors to collect real-time data on crop health, soil conditions and pest infestations. This data enables precise monitoring and timely intervention, leading to improved crop yields and resource management when integrated with farm management software. Besides, strong integration with existing systems with drone adoption in the agriculture sector will improve resource management since the integration enables precise application of inputs such as water, fertiliser, and pesticides. For example, drones can identify specific areas that need attention, enabling targeted treatments that conserve resources and reduce environmental impact. Next, strong integration with existing systems, with drone adoption in the agriculture sector. The drones can cover large areas quickly, performing tasks such as planting, spraying, and monitoring more efficiently than traditional methods. This efficiency reduces labour costs and time, allowing farmers to focus on other critical aspects of farm management. In addition, strong integration with existing systems with drone adoption in the agriculture sector will improve decision-making in the agriculture sector, in which the strong integration of drone-collected data with existing systems provides farmers with comprehensive insight into their operations. This information supports informed decisions on crop planning, resource allocation and market strategies, ultimately improving farm profitability.

Excluding the strong integration with existing systems with drone adoption in the agriculture sector, this study will also focus on weak integration with existing systems with drone adoption in the agriculture sector. One of the key challenges is to ensure compatibility between drone-generated data and existing farm management

systems. Drones collect vast amounts of data, including high-resolution imagery and multi-spectral analysis, which must be seamlessly integrated into existing databases and software platforms. A lack of standardised data formats can complicate this process, leading to inefficiencies and potential data loss. Besides that, inadequate integration can also result in operational difficulties. Farmers may face challenges in determining effective drone data workflows and achieving the desired levels of data accuracy. Additionally, the initial investment in drones, coupled with the costs of software and training, can be prohibitive. These investments may not yield the expected returns, leading to reluctance in adopting the technology without proper integration. Weak integration may also lead to non-compliance with regulatory standards, resulting in legal consequences. For instance, the improper use of drones due to inadequate integration with existing systems can lead to accidents or violations of airspace regulations. Non-compliance can result in fines, legal issues, and the potential grounding of drone operations. The challenges of integrating drones into agriculture are compounded by technological limitations and infrastructure requirements. Drones require a robust infrastructure to operate, including reliable internet connectivity and adequate storage solutions for the large volumes of data collected. In regions where such infrastructure is lacking, integrating drones into existing systems becomes even more challenging.

This study provided a comprehensive discussion of the research findings, addressing the objectives of the study, identifying key drivers, and exploring the future image of drone adoption in the agriculture sector in Malaysia. The trends, issues, and challenges identified offer valuable insights for stakeholders in the agriculture sector to anticipate and mitigate potential obstacles. Technological advancements and economic considerations emerged as the most critical drivers, reflecting the significance of innovation and resource management in shaping the sector's future.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Lok Jiunn Heng, Norasmiha Mohd Nor and Hilyati Sabtu; **data collection:** Lok Jiunn Heng; **analysis and interpretation of results:** Lok Jiunn Heng; **draft manuscript preparation:** Lok Jiunn Heng, Norasmiha Mohd Nor. All authors reviewed the results and approved the final version of the manuscript.

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