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Foresight Study on Artificial Intelligence in Smart Dustbin

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ABSTRACT

As a developing country, Malaysia is still struggling with the waste management. It is impossible to maintain the same amount of waste that need to be disposed every day. Thus, smart dustbin with Artificial Intelligence (AI) is one of the solutions to ensure waste management able to be disposed effectively. By considering the importance of waste management, this study aims to identify issues and drivers related to AI in smart dustbin among service providers in Malaysia and examine future trends of AI in smart dustbin among service providers in Malaysia. Respondents are among top management of waste management company in Selangor. Qualitative and quantitative method were used by analysing data using descriptive analysis, scenario building and impact-uncertainty. Two drivers selected from impact-uncertainty analysis are outstanding performance of AI and problems on managing waste. In examining future trends, there are four scenarios were projected, which are expertise on AI application, prioritize current waste management practices, effective use of smart dustbin, and Research and Development financial constraint. The findings of this study benefits to the stakeholders as they able to plan and prepare with effective planning in managing the waste in future.

1. Introduction

Maintaining the same amount of garbage disposed every single day is quite impossible, such the waste collector crews only follow their own schedule with respected scheduled area. Thus, on certain occasions the scheduled collection routine, the dustbins can become overflow before the collection time. Therefore, with the exposed garbage, it will further cause diseases such as dengue, typhoid fever and so on. Due to the fact, it is important to have prediction on the amount of waste produced, in order to manage the wastes. According to a research, data on garbage levels are very beneficial for providing optimized route for the waste collectors. Thus, it was said that if the waste collector keeps on coming to collect the garbage even though it is not full yet, this will cause waste of time and

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inefficient working hours [1]. Moreover, the good part of producing garbage in big cities are recyclables. It is important to know and apply reuse methods that might bring advantages or at the minimum to lessen environmental problems [2]. The existence of techniques or models that guide people in sorting the garbage that has become important in the precise dispose of the materials. Even though there are different types of recycling categories, but people will still get confused or does unable to identify about how to determine correctly where to dispose each garbage at the right dustbin [3].

Despite the people's lives have been improved with Artificial Intelligence (AI) [4], yet, they are urged to adapt with the challenges [5] such as breaking the work routine and required new skills. Therefore, smart dustbin with AI is a great solution to be considered. It can be used to scan the types of categories of recyclable materials, thus, can differentiate between waste and the recyclable garbage. Also, it can help the waste collectors to know when to collect a properly full dustbin. The sorting of each category of waste can use the image recognition. According to a research, they use image database on garbage which contains about 400 images for each category which are paper, glass, plastic and metal [3].

There are benefits to incorporate AI in smart dustbin. It has created various powerful and sensible tools for overcoming troublesome issues in various fields and untangle complicated issues in real-world applications. Furthermore, several researchers have applied AI due to its easy use, high speed operation, and acceptable accuracy without the demand to know the physical problems [6].

The smart dustbin with AI will mainly involve in the waste management system. This means that all the information data received from the household waste in the smart dustbin will be sent to the service provider's system. This information will help the AI system to make predictions, hence, also as an indicator to detect a full waste in the smart dustbin. Once, the service providers detect a full garbage in smart dustbin, a waste collector will come to collect the household waste. Hence, as the smart dustbin has already sorted the recyclable wastes, this makes it easier for the waste collectors to throw away the non-recyclable wastes to the landfills and take the recyclable wastes to the recycle centre.

The main issue that motivated this study to be conducted is the application issue of AI in smart dustbin in Malaysia. As overflowing amount of waste arise, the research recommends to overcome the overflowing issue by implementing the AI in smart dustbin. The service provider can help the residential community to manage household by using the smart dustbin. Unfortunately, in implementing the smart dustbin, there are also problems that arises. The first problem is price of implementing the AI in smart dustbins. In making transformations by having innovation in smart dustbin definitely will incurring some cost. This is due to the benefits that will be having such as improved efficiency, safety and so on [7]. Therefore, this will be a huge challenge in making sure that the implementation of AI in smart dustbin to be within the price that is reasonable for the creator to create. If the price is expensive, not everyone can afford it and the whole reason of managing the waste problem cannot be properly implemented.

Furthermore, the second problem is user friendliness of smart dustbin. It is very important for smart dustbin to be user friendly. This is because, when it is complicated for people to use it compare of using traditional dustbin, people will start to go back of using traditional dustbin. Hence, this will affect the business of smart dustbin in getting profit for what they have invested in. Moreover, third problem is the awareness and readiness of people towards AI. The approach of measuring the readiness of adopting Industry 4.0 is on the base of the standards proposed that allows companies to evaluate themselves on how prepared they are in reaching their goals. Thus, at the same time, they can identify the opportunities for the development of actions that can put them in a more likeable position [8]. If the company is not ready to implement the technology, then the use of smart dustbin will be useless. Hence, household residential also have to be aware and ready for new technologies. When majority of people does not have the knowledge of the technology, it is hard to explain to every single person. Thus, it will be time consuming to just give explanation to people and capture their attention to be interested in AI used in the smart dustbin.

Lastly, the fourth problem is whether the technology implemented in smart dustbin is suitable for every generation to use it. AI related technologies are more familiar by the new generations compared to the old generation. Old generation is related to Baby Boomers. The Baby Boomers are anyone born between 1943 and 1960. They grow up without the dependent on technology compared to the new generation [9]. Hence, new generation is related to the Millennials, which are born between 1980 and 2000. They are called Millennials due to their closeness to new millennium and raised in a more digital age [9].

Based on the abovementioned problems, this study aims to explore issues and drivers that related to AI in smart dustbin among service providers in Malaysia. It also furthers foresight future trends of AI in smart dustbin among service providers in Malaysia. The remainder of the paper is structured as follows. Key literature review on AI and smart dustbin will be discussed in next section. Then, followed by explanation of research methodology and presentation of results. The conclusion provides with discussion of four scenarios pertaining to future trends of AI in smart dustbin.

2. Literature Review

2.1 Artificial Intelligence (AI) and Smart Dustbin

Artificial Intelligence (AI) in general is a technology that can execute work that demands for human intelligence including decision making, speech recognition and visual perception. AI can be applied in many different ranges such as recycling, cleaning and also waste management. AI in waste management has become popular in public infrastructure due to its efficiency in collecting and sorting wastes [10].

AI application is able to perform useful functions in smart dustbin. Firstly, the camera and AI system can give specific information on wastes. Thus, it can also record the deposited wastes in the bin. This bin is named Kitro smart food bin introduced by Anastasia Hofmann and Naomi MacKenzie. The smart dustbin was designed for reducing food waste mainly in food business. Hence, by identifying what food was the most common thrown in the bin, uneaten food item can be reduced and save food cost [11]. The concept of analysing most thrown item can be used to reduce the use of same type of item. Moreover, AI in smart dustbin is able to give signal if there is a problem with the bin or if the garbage has reached the full limit for emptying [12]. This will be very beneficial to prevent overflowing wastes that could cause pollutions such as air pollution.

Smart waste bins have been used by few other countries. In South Korea, they use smart bins with solar powered to help cities monitor the waste level by each bin. In Seoul, 6000 automated bins with Radio Frequency Identification (RFID) were utilized. RFID is responsible for weighing wastes and charge the residents using an ID card. Presently, some startups are testing on city wastes solutions in the emerging markets of Latin America [12].

Furthermore, in Singapore, they also used solar powered smart bins named Bigbelly bins made by Jurong Town Corporation (JTC). Bigbelly bins are competent of crushing five times more garbage with internal compactor and they are wireless, therefore, monitoring wastes are simpler. Hence, Singapore is planning to place more smart bins throughout the city [12].

Moreover, in Poland, a Poland-based startup is progressing to establish world’s first intelligent bin named Bin.E. The bin is incorporated with image recognition, sensors and AI that identifies paper, glass or plastic. Later, the materials will be crushed and located in container. Not only Poland, other European cities also testing on smart waste management solutions [12].

2.2 IR 4.0 in Malaysia's Waste Management

According to the latest report by International Solid Waste Association (ISWA), technologies of the Industry 4.0 revolution including AI, big data, automation and internet of things (IoT) will be an important contribution for waste management transformation. Hence, ISWA perceives that Industry 4.0 will create opportunities for wastes prevention, reduction and termination at certain areas and streams. This will help to achieve improvement in resources and high quality treatment and disposal which will decrease pollutions [13].

Furthermore, high tech businesses are currently testing to prepare latest material for stakeholders and building awareness among society by applying "polluter pays" which develop a lifestyle that people take responsibility on the garbage they produce. Thus, the idea of connecting big data, IoT and AI will allow the government to customize analytic controller. This will guide to understand the wastes better and develop smarter resource recovery programs. Also, the technology combination will be useful for automated recycling activities known as 'robotic recycling'. The 'robotic recycling' is estimated to be popular in the next 10 years [13]. Moreover, the data gained from the Industry 4.0 technologies will be beneficial for analysing customer's utilization and disposal pattern which will help companies to achieve demands and control for environmental requirements [13].

In conclusion, Malaysian government has been struggling with waste management and many companies are prepared for technology solutions [13]. Therefore, Industry 4.0 technologies will be necessary for waste management solution in Malaysia.

2.3 Identification of Issues and Drivers

The issues and drivers were classified into Social, Technological, Economic, Environmental, Political and Values (STEEPV) as depicted in Table 1.

Table 1
Key Terms of Issues and Drivers

Social	Technological	Economic	Environmental	Political	Values
1. Solid waste characteristic	1. Waste treatment methods	1. Poor economy	1. Types of solid waste	1. Development of plan and policies	1. Source-sorting adjustment
2. Urban areas solid waste management practices	2. Ontology studies in Society 5.0	2. Treatment and disposal waste effect on production cost	2. Solid waste heterogeneity	2. Successful planning by effective stakeholders' involvement	2. Sustainable waste management based on 3R
3. Lack of resources in developing countries	3. Challenges of collecting automated processes information	3. Huge economic impact of changes in waste management method to other sectors	3. Plastic waste unsustainability	3. Municipal solid waste (MSW) rising quantities	3. Effective municipal waste (MSW) management

4. Rapid industrialization and urbanization	4. Adapt innovation with market changes	4. GDP influence on municipal waste (MSW) quantity	4. Solid waste categories	4. Reliable waste generation data	4. Waste sorting in recycling
5. Source segregation practice in developing countries	5. Integration of Artificial Intelligence (AI)	5. High solid waste management costs	5. Uncontrollable municipal waste		5. Managerial attitudes on food waste management practices
6. Food waste in developed countries	6. Efficient municipal waste (MSW) processing	6. Affordability on high-cost technology	6. Methane emission from waste management		6. Open dumping practices in poor
7. Population growth effect on waste	7. Automated sorting techniques	7. High management costs causing abandoned landfills	7. Ontology studies align with global sustainability		7. Pollutions from waste management practices
8. Food waste estimation	8. Optical sorting	8. Cost inconvenience by younger people	8. Municipal waste (MSW) rich in recyclable materials		8. Public perception on solid waste management
9. Human health risk through solid waste generation	9. High-end waste monitoring technologies		9. Global issue on food waste		9. Same attitudes and habits on solid waste management
10. Diseases to residents near waste disposal yards	10. Rapid technology advancement		10. Pollutions from solid waste		10. Preference on manual sorting than automated sorting
11. Poor countries unavailability on high-end waste monitoring technologies	11. Difficulties of incorrect forecasting		11. Strong connection between solid waste and greenhouse gases		11. Self-waste sorting household preference
12. Global utilization on land filling	12. Municipal solid waste (MSW) forecasting methods		12. Municipal solid waste (MSW) and landfills effect on CH4 emission		12. Positive willingness to pay services
13. Malaysia highly dependent on landfilling	13. Artificial Intelligence abilities		13. Convenience of landfilling		13. Less sorting motivation by incineration
14. Improper collection services in developing countries	14. Artificial Intelligence’s flexible predicting time		14. Severe pollution from abandoned landfills		14. Modern lifestyle raising waste generation
15. Malaysia solid waste management	15. Artificial Intelligence superiority		15. Open dumping effect on ecosystem		15. Consumption habits increasing

and recycling limited information			waste generation
16. Lack of public participation and commitment	16. High expectation on AI products	16. Number of open dumbs worldwide	16. Personal ethics encourage waste management
17. Ineffective education	17. AI's flexible adaptation	17. Odour pollution	17. Culture influence AI adoption limitations
18. Social threats on unsustainability	18. AI reaching human abilities	18. Nuisance animal breeding from illegal dumping	
19. Rural areas self-reliant solid waste management	19. AI technologies influence increasing new jobs	19. Separation method for higher quality recyclables	
20. Increasing interest on AI products	20. Outstanding AI efficiencies than manual processes	20. Domination of municipal solid waste	
21. Important factors to cause consumer's acceptance on AI products		21. Beneficial of future municipal solid waste estimation	
22. Potential AI product users decision dependence on others		22. Limited resources	
23. Build trust on early stage of AI products acceptance		23. Bio-waste large quantity in overall household waste	
24. The role of psychological motivation on AI products adoption		24. Inconvenience of household bio-waste sorting	
25. Average residents choose recycling over incineration		25. Hazardous waste crucial on environmental risk	
26. High income household preference on incineration than recycling		26. No relationship between income and recycling rate	

27. Higher opportunity cost of time for household higher income			27. Travel distance impact low recycling site visit rate		
28. High income household preference on incineration than recycling			28. No relationship between income and recycling rate		
29. Higher opportunity cost of time for household higher income			29. Travel distance impact low recycling site visit rate		
30. Older people and male uninterested in food waste recycling program			30. Greenhouse gas emission reduction by effective waste management		
31. Higher educational level interest on food waste recycling program			31. Greenhouse gas emission reduction by promoting waste prevention		
32. Social influence on recycling			32. Unavailability for certain recycling bins causes recycling difficulties		
33. Developed and developing countries increasing concern on household waste					
34. Lack of AI technology knowledge					
35. Residents weak association with waste management policies					
33	20	8	30	4	17
TOTAL = 112					

2.4 Merging Issues and Drivers

A total of 112 issues and drivers that related to the AI in the smart dustbin among service providers in Malaysia has been merged together. After merging all the issues and drivers, 18 key terms were identified as reported in Table 2.

Table 2
Key Drivers of Merged Issues and Drivers

No.	Key drivers
1.	Different solid waste management practices in urban and rural areas
2.	Lack of resources for recycling
3.	Increasing waste generation
4.	Economic influence the type of waste management available
5.	Problems on managing waste
6.	Demographic influence on managing waste
7.	Society educational knowledge on environment
8.	Society educational knowledge on technology
9.	AI technology convenience to human work
10.	Motivation for AI adoption
11.	Pollutions produced from unsustainable waste management
12.	Income level preferences on waste management
13.	Promote recycling in households
14.	Negative impact from waste generation
15.	Accurate wastes information
16.	Outstanding performance of Artificial Intelligence
17.	Development of plan and policies
18.	Authority actions on open dumping and open burning

3. Methodology

This section discusses on methodology used to conduct the research. For this research, unit of analysis were on organizations which focuses on service providers which are the waste management companies. Furthermore, time horizon is short period due to research conducted in short period of time. Moreover, research sampling design is judgemental sampling which is non-probability sampling that represents non-random sampling [14]. The judgemental sampling is selective kind of sampling where the researcher can choose the respondents that is found suitable for the researcher [14]. This is because not all respondents have the criteria that a researcher needs for the data collection.

Moreover, measurement that can be used in the research is nominal, interval, and ratio [15]. The nominal measurement is based on names which in this research it can be used for age, gender and so on [15]. Hence, interval can be used in the questionnaire for Likert Scale questions [15]. Lastly, ratio measurement can be used to determine the ratio of waste being recycled properly and so on [15].

Furthermore, data collection is done using quantitative research by conducting survey questionnaire to respondents and qualitative research from STEEPV analysis. Each STEEPV analysis acronym represents different perspective of factor. The literature review uses STEEPV analysis and the analysis used secondary data. Thus, STEEPV analysis results in drivers which will find trends and issues in order to have full understanding on the research [16]. Once each STEEPV analysis acronym has categorised its key drivers, key drivers then themed into merged issues and drivers. Drivers and issues are important to determine questions for surveys.

Moreover, data analysis that can be used are descriptive analysis, scenario building and impact-uncertainty. Descriptive statistics are from the questionnaire given to respondents. Thus, the questions that are created in the questionnaire is from the drivers/factors that were determined from STEEPV analysis. Hence, the descriptive statistics are considered in this data analysis due to its abilities to summarize the samples and measures. Hence, in research the number of respondents may be many to measure. Therefore, the descriptive analysis helps to simplify the large data reasonably [17] and can be categorized under the univariate analysis. Univariate analysis methods are distribution, central tendency and the dispersion. The central tendency has three categories which are mean, median and mode [17]. Lastly, the dispersion is the development of values throughout central tendency. The two most usual measurement are standard deviation and range [17].

The impact-uncertainty is used in determining the uncertainties in the research. The word "impact" refers to effect from the issues and drivers while "uncertainty" is the incomplete information that the issues or drivers may develop in the future [18]. Once the most important issues or drivers are chosen, the impact-uncertainty analysis will start its process [18]. The statistical means that is determine from the descriptive statistics will help to coordinate the issues or drivers on the Cartesian plane. Thus, the arrangement is from the selection of the top two issues or drivers that give high impact and uncertainty. The impact-uncertainty is an important method in this research as the top two issues or drivers discovered then used to develop scenario building. Also, this method uses to answer the first research objective which is identifying the issues and drivers in this research.

The scenario building is used to predict future scenarios. From the impact-uncertainty, the top two issues or drivers then be used to develop scenario building [18]. Hence, four different alternative scenarios have developed in reflect to the future outcome related to the events and trends of the research with regardless to either favourable or unfavourable outcomes [18]. The upper right quadrant labelled 'Scenario 1' is evaluated based on both high in issues and drivers while lower left quadrant labelled 'Scenario 2' is based on both low in issues and drivers. Next, upper left quadrant labelled 'Scenario 3' is issues and drivers that vertically high and horizontally low while lower right quadrant labelled 'Scenario 4' is vertically low and horizontally high in issues and drivers. This method become the determinant to answer the second research objective which is examining future trends.

Furthermore, the population is from a large collection which sample is taken to represent large collection in the population. In this research, the study requires respondents from Malaysia's service providers, specifically in Selangor. Sampling used in determining the respondents is non-probability method which is judgemental sampling [14]. The research requires specific criteria of respondent therefore it is better for the researcher to choose their respondents. Hence, sampling frame which is target population is the top management of waste management company.

Other than that, research instrument is tools used to measure data in order to make analysis and gain results from the analysis. Hence, in this research the instruments used was quantitative research. The quantitative used survey questionnaires with five sections, which are section A, B, C, D, and E. Section A is related to respondent's demographic profile, while section B, C, and D are questions constructed based on merged issues and drivers. Lastly, as for section E is open-ended questions. Open-ended questions are questions that let the person to answer in free-form [19].

Reliability test is used to measure stability and consistency of a measurement. Reliability test also concerns on the repeatability such as that the measurement is repeated but still have similar results in constant condition will be defined as reliable [20]. Thus, the most usual reliability test for internal consistency is by measuring with Cronbach Alpha coefficient. Measuring the reliability test on pilot or exploratory study, the reliability is preferred to be equal to 0.70 or above it.

Moreover, the pilot study was conducted with 22 respondents answered the questionnaire. Pilot study or also known as the feasibility study that does trials on the research instruments such as interviews and questionnaire before the actual study is conducted [21]. The reliability analysis for this research has three variables which are importance, impact and uncertainty. The measurement used for reliability analysis is the Cronbach Alpha. In the research, the reliability of pilot study for importance is 0.863, impact is 0.835, and uncertainty is 0.956 in which are all 0.70 and above. Therefore, importance, impact and uncertainty have high level of internal consistency. As for the reliability of actual study, 20 respondents were used in the research. As for actual study, reliability for importance is 0.70, impact is 0.79, and uncertainty is 0.96 in which are all 0.70 and above. Therefore, importance, impact and uncertainty have high level of internal consistency.

4. Data Analysis and Results

4.1 Demographic Information Analysis

The demographic profile is measured in terms of the frequency and percentage of each type of demographic. Hence, this demographic profile represents the respondents that answered the questionnaire. Firstly, the position in the company highest frequency and percentage is director with frequency of 6 and percentage of 30%, and the lowest frequency and percentage are represented by two positions in the company which are general manager and supervisor with the frequency of 1 and percentage of 5% each. Hence, the second highest frequency and percentage are managing director, department manager, and others with the frequency of 4 and percentage of 20% each. Secondly, the job function highest frequency and percentage are shared by two job functions which are corporate executive and operation/production with the frequency of 8 and percentage of 40% each. Hence, as for the lowest frequency and percentage are represented by two job functions which are engineering and others with the frequency of 1 and percentage of 5% each. Thus, the middle frequency and percentage is planning with frequency of 2 and percentage of 10. Moreover, third is the years of experience in current job highest frequency and percentage is represented by between 5 to 10 years with frequency 10 and percentage of 50%, while the lowest frequency and percentage is by less than 5 years with frequency of 4 and the percentage of 20%. As for the middle frequency and percentage, it is more than 10 years with the frequency of 6 and percentage of 30%. Fourth, is the company ownership which all of the respondents are Malaysia owned, in which all 20 respondents represents the frequency of 20 and 100% of percentage. Fifth is the company’s establishment in Malaysia with highest frequency and percentage is by more than 6 years with frequency of 17 and percentage of 85%, while the lowest frequency and percentage is by less than 3 years with frequency of 1 and percentage of 5%. Thus, as for the middle frequency and percent, it is represented by between 3 to 6 years with frequency of 2 and percentage of 10%. lastly, the sixth is the number of full-time employees with majority of frequency and percentage by between 1 to 74 with the frequency of 12 and percentage of 60%, while the minority of frequency and percentage is by more than 201 with frequency of only 3 and percentage of 15%. Hence, the middle frequency and percentage are between 75 to 200 with frequency of 5 and percentage of 25%.

4.2 Descriptive Analysis

The descriptive analysis had analysed the mean of importance, impact and uncertainty in this research. The importance level is as 1- Very Unimportant, 2- Unimportant, 3- Undecided, 4- Important, and 5- Very Important. Thus, the mean for importance in Table 3 illustrates that the highest mean is 5.00 which the scale is very important, also the highest scale. Thus, there are four drivers with the mean of 5.00. The four drivers are lack of resources for recycling (μ=5.00, σ=0.000), demographic influence on managing waste (μ=5.00, σ=0.000), pollutions produced from unsustainable waste management (μ=5.00, σ=0.000), and authority actions on open dumping and open burning (μ=5.00, σ=0.000). Moreover, as for the lowest mean for importance is represented with the mean of 3.85 which is in the range of important. The driver that represents this mean is income level preferences on waste management (μ=3.85, σ =1.040).

Table 3
Descriptive Analysis on Importance Variable

No.	Drivers	Mean (μ)	Standard Deviation (σ)
1.	Different solid waste management practices in urban and rural areas	4.85	0.366
2.	Lack of resources for recycling	5.00	0.000
3.	Increasing waste generation	4.50	1.147
4.	Economic influence the type of waste management available	4.35	1.137
5.	Problems on managing waste	4.35	0.745
6.	Demographic influence on managing waste	5.00	0.000
7.	Society educational knowledge on environment	4.90	0.447
8.	Society educational knowledge on technology	4.50	0.761
9.	AI technology convenience to human work	4.40	0.681
10.	Motivation for AI adoption	4.20	0.768
11.	Pollutions produced from unsustainable waste management	5.00	0.000
12.	Income level preferences on waste management	3.85	1.040
13.	Promote recycling in households	4.85	0.366
14.	Negative impact from waste generation	4.95	0.224
15.	Accurate wastes information	4.95	0.224
16.	Outstanding performance of Artificial Intelligence	4.40	0.821
17.	Development of plan and policies	4.65	0.813
18.	Authority actions on open dumping and open burning	5.00	0.000

Furthermore, the mean for impact with impact level includes 1- No Impact, 2- Slight impact, 3- Neutral, 4-Considerable Impact, and 5- Great Impact. The results in Table 4 are that the highest mean is 4.90 that represents the highest scale which is Great Impact. There are two drivers that have the same value of highest mean which are drivers demographic influence on managing waste (μ=4.90, σ=0.308), and authority actions on open dumping and open burning (μ=4.90, σ=0.308). The lowest mean of impact is 3.80 in which represents the scale of Considerable Impact. The driver that has the lowest mean is income level preferences on waste management (μ=3.80, σ=1.105).

Lastly, the mean for uncertainty variable shown in Table 5. The uncertainty level is 1- Very Low Uncertainty, 2- Low Uncertainty, 3- Neutral, 4-High Uncertainty, and 5- Very High Uncertainty. The research resulted that the highest mean is 3.35 which represents the Neutral scale. Hence, the driver that has the highest mean is by outstanding performance of Artificial Intelligence (μ=3.35, σ=1.137). As for the lowest mean of uncertainty, it is shown that the mean is 2.45 which represents the Low Uncertainty scale. The driver which has 2.45 as mean is promote recycling in households (μ=2.45, σ=1.605).

Table 4
Descriptive Analysis on Impact Variable

No.	Drivers	Mean (μ)	Standard Deviation (σ)
1.	Different solid waste management practices in urban and rural areas	4.60	0.598
2.	Lack of resources for recycling	4.70	0.657
3.	Increasing waste generation	4.25	1.164
4.	Economic influence the type of waste management available	4.15	1.226
5.	Problems on managing waste	4.15	0.988
6.	Demographic influence on managing waste	4.90	0.308
7.	Society educational knowledge on environment	4.65	0.671
8.	Society educational knowledge on technology	4.35	0.875
9.	AI technology convenience to human work	4.30	0.865
10.	Motivation for AI adoption	4.10	0.852
11.	Pollutions produced from unsustainable waste management	4.80	0.410
12.	Income level preferences on waste management	3.80	1.105
13.	Promote recycling in households	4.70	0.657
14.	Negative impact from waste generation	4.75	0.444
15.	Accurate wastes information	4.80	0.523
16.	Outstanding performance of Artificial Intelligence	4.30	0.865
17.	Development of plan and policies	4.45	0.945
18.	Authority actions on open dumping and open burning	4.90	0.308

Table 5
Descriptive Analysis of Uncertainty Variable

No.	Drivers	Mean (μ)	Standard Deviation (σ)
1.	Different solid waste management practices in urban and rural areas	3.20	1.240
2.	Lack of resources for recycling	3.20	1.436
3.	Increasing waste generation	2.75	1.482
4.	Economic influence the type of waste management available	3.05	1.317
5.	Problems on managing waste	3.25	1.209
6.	Demographic influence on managing waste	2.85	1.461
7.	Society educational knowledge on environment	2.75	1.410
8.	Society educational knowledge on technology	2.90	1.210
9.	AI technology convenience to human work	2.55	1.191
10.	Motivation for AI adoption	2.80	1.281
11.	Pollutions produced from unsustainable waste management	2.70	1.625
12.	Income level preferences on waste management	2.85	1.268
13.	Promote recycling in households	2.45	1.605
14.	Negative impact from waste generation	2.90	1.553
15.	Accurate wastes information	3.05	1.504
16.	Outstanding performance of Artificial Intelligence	3.35	1.137
17.	Development of plan and policies	3.20	1.473
18.	Authority actions on open dumping and open burning	2.85	1.663

4.3 Impact-uncertainty Analysis

Impact-uncertainty were analysed by plotting the mean of variables impact and uncertainty in a graph. Two drivers with the highest mean value of variables impact and uncertainty then used to forecasting future scenario. The mean of impact and uncertainty variables are illustrated in Figure 1. According to graph in Figure 1, D16 and D5 have the highest impact and uncertainty in which D16 is the driver of outstanding performance of Artificial Intelligence and D5 is problems on managing waste.

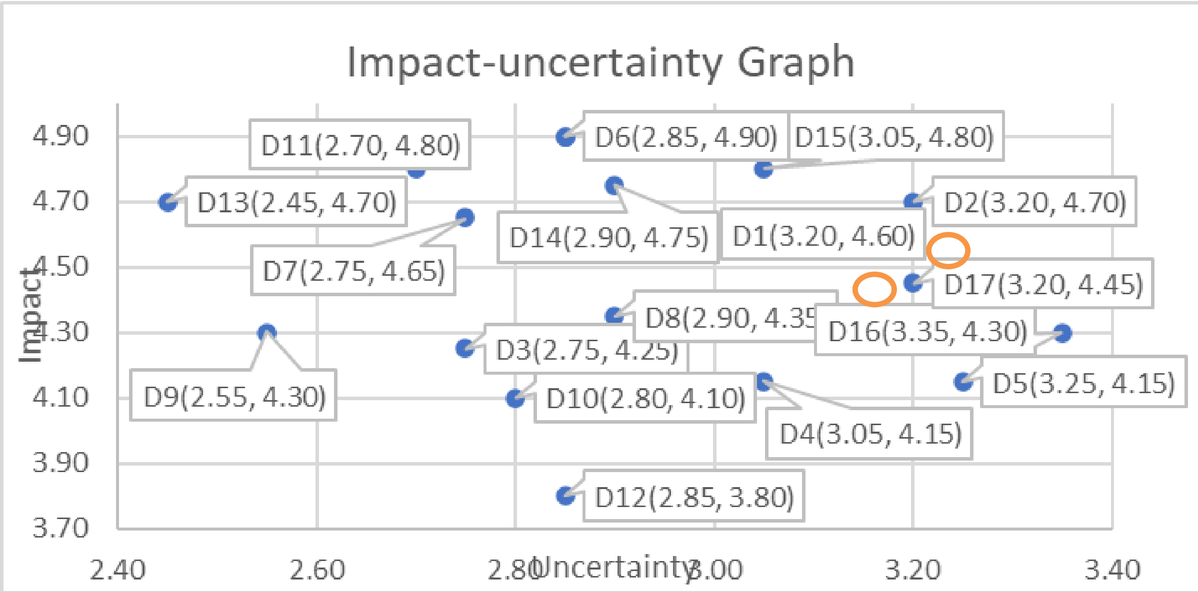

Fig. 1. Impact-Uncertainty Graph

4.4 Open-ended questions

From the data collection, open-ended questions were distributed to 20 respondents in order to know the respondent's opinions.

Firstly, there were many findings on the waste management practices that the companies used to manage wastes. Some answered that to practice recycling, also some of the respondents does waste segregation. Hence, other respondents do the usual waste collection which is by collecting the waste and throw it at the dumping site and landfilling. Moreover, there were multiple findings on main wastes that companies usually found. Hence, the findings are non-biodegradable waste, domestic wastes, recyclable wastes, food waste, mixed material wastes such as paper, metal, plastic, and organic wastes.

Other than that, findings on company's opinion in adopting Artificial Intelligence (AI) in smart dustbin in the future. Some of the responses were that they show agreement to the AI in smart dustbin adoption as they think can help the community for a clean environment, ease of operation, promote waste separation n recycle, and improve productivity of waste management. Hence, they find that AI adoption in smart dustbin is interesting, also some service providers are also willing to be trial users of this technology and willing to use smart dustbin if the government give grant support. However, there are also service providers that show disagreement to the AI adoption in smart dustbin due to the expensive technology of AI, the cost to manage the smart dustbin itself, and the uncertain effectiveness of smart dustbin. Also, there is also a respondent that think that we should master the basics of disposing wastes properly first.

Furthermore, there were findings on difficulties that a company has to face when managing the wastes. The answers were that encountering unproper segregation of waste, unrecyclable material and waste policy, society's awareness to solid waste management, people's mindset, people's attitude, leachate problem, shortage of bins provided, proper dumping site, limited dumping sites maintenance cost, insufficient number of dumping sites, waste collection not following schedule, and the workers working ethics.

Lastly, the findings were on the company's future plans in waste management. The answers were to continue on their proper waste management plan, turning valueless into valuables, Improving the management and innovation, engaging with public authorities to implement proper rules &

regulations, improving logistics, cooperate with the authorities and public to make awareness on importance of waste management, increase venues to dump the segregated wastes, improving the trained workers, educate customers the right way to do waste management, segregation start from the source, track carbon and plastic footprint, waste diversion to landfill by implementations of new technology, dedicated avenues for the public to practice recycling, full scale material recycling facility (MRF), and findings ways to actual treat residual wastes.

5. Discussion

All the issues and drivers found were gathered from STEEPV analysis. There were six categories all together which are Social, Technological, Economic, Environment, Political, and Values. All the issues and drivers from the six categories resulted in numerous numbers of issues and drivers. Therefore, the factors were merged according to the related issues so that the analysis could be simpler to be reviewed. Thus, 18 key drivers of merged drivers and issues were formed. These key drivers of merged issues and drivers were used to identify the major issues and drivers that are related to Artificial Intelligence (AI) in Smart Dustbin among the service providers in Malaysia.

Furthermore, the key drivers were measured in terms of importance, impact and uncertainty using mean from descriptive statistics. Each variable has their level in measurement. The importance level is as 1- Very Unimportant, 2- Unimportant, 3- Undecided, 4-Important, and 5- Very Important. Thus, the impact level includes 1- No Impact, 2- Slight impact, 3- Neutral, 4-Considerable Impact, and 5- Great Impact. Hence, as for the uncertainty level are as 1- Very Low Uncertainty, 2- Low Uncertainty, 3- Neutral, 4-High Uncertainty, and 5- Very High Uncertainty.

Research objective 1 is to explore the issues and drivers that related to AI in Smart Dustbin among service providers in Malaysia. Hence, the issues and drivers have been identified through data analysis of impact-uncertainty analysis. The impact-uncertainty analysis chose two drivers with highest mean of impact and uncertainty, thus, the two drivers that were chosen are outstanding performance of AI and problems on managing waste.

Moreover, outstanding performance of AI illustrated that its importance level is important, in which indicated that this driver and issue is important to the research. Hence, its uncertainty resulted that the driver and issue have neutral uncertainty level and its impact level has considerable impact. This driver was expected to be chosen as the research is mainly on AI in Smart Dustbin, in which the driver and the smart dustbin are linked to AI. Thus, this driver illustrates the superiority of adopting AI due to the outstanding performance that AI is able to perform compared to human abilities in conducting manual processes in work. The abilities of AI to have flexible adaptation [22] to the technology adoption will make the AI implementation process to be more realistic for future use. Also, AI has an outstanding performance in making predictions [23] and can predict from data correctly [24]. This will be very beneficial to avoid errors in predicting and better control in the waste management. Therefore, the abilities of AI will help forecast the future waste generation and service providers can be more prepared to handle the future wastes.

Other than that, the second driver which is problems on managing waste. This driver and issue importance level resulted that it is also important to the research. Thus, the uncertainty level shown that it has neutral and impact level has considerable impact. This illustrated that both drivers and issues chosen have the same level of importance, impact and uncertainty. Hence, this driver is also predicted to be chosen as the main reason to why smart dustbin with AI was suggested is because to help the service providers to manage their waste management. Every process in managing waste requires efficiency and effectiveness in order for the waste management to meet the goals of the company. However, if there are uncertainties in certain waste management process, it will cause problem to the whole process and make the process more complex to handle. Therefore, there should be solutions to prevent or lower the uncertainties in managing the wastes such as using forecasting methods. Thus, the requirements for improving the waste management can be achieve from the adoption of AI. The AI has the ability to do research and development which has the possibility in dealing with the problem [25].

In conclusion, both drivers which are outstanding performance of AI and problems on managing waste compliments each other as the problems on managing wastes needs solutions to manage the wastes better and that AI can deliver what the service providers needs in improving the waste management process. Therefore, this will give a positive impact towards the implementation of AI in smart dustbins.

The research objective 2 is to foresight future trends of AI in Smart Dustbin among service providers in Malaysia. This objective can be achieved by conducting a scenario building as in Figure 2.

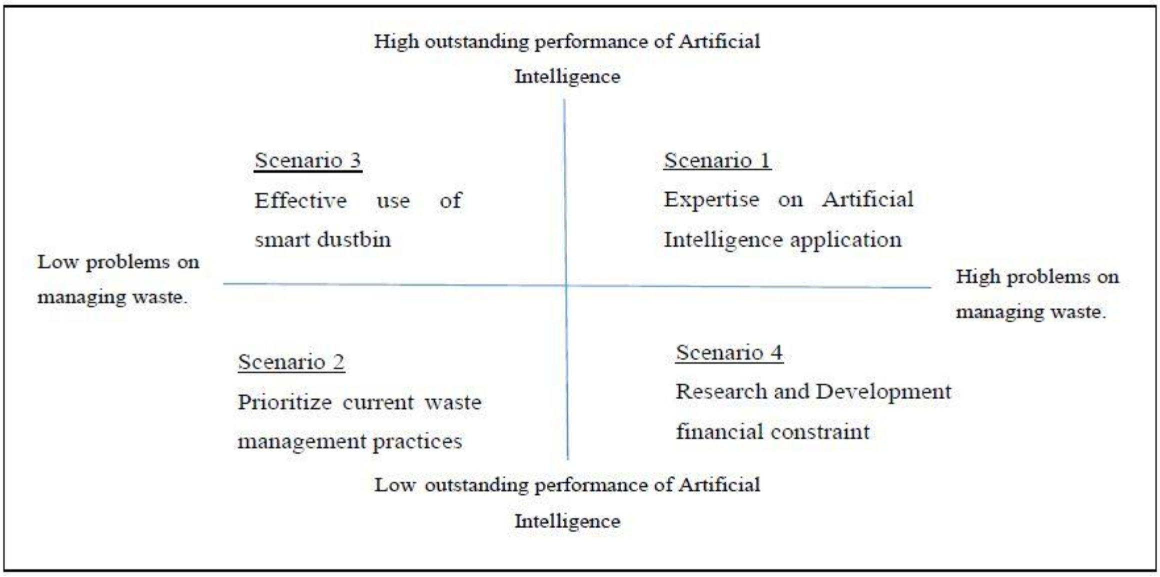

Fig. 2. Scenario Building

There are four future scenarios according to the scenario building quadrant. Firstly, scenario 1 is between high outstanding performance of AI and high problems on managing waste. The best scenario is that the use of smart dustbin may not be complicated, however, if there is an error in the smart dustbin with AI, it will be complicated if there are no qualified workers. When the AI adoption joins the operation of the company, the workers should be trained on the potential consequences that might happen [26]. Thus, experts are assumed can influence future vision that are applicable and innovative [27]. Therefore, smart dustbin with AI requires training to expertise in using smart dustbin, so that service providers can prevent any complication in managing waste and develop ideas for future waste management.

Moreover, scenario 2 is between low outstanding performance of AI and low problems on managing waste. The best scenario is that the service providers prioritize their current waste management practices than the use of smart dustbin with AI. This means that service providers do not use the smart dustbin fully to manage the waste. Hence, focuses more on managing the waste using their usual way of managing waste due to service provider’s assurance and security. Therefore, the outstanding performance of AI cannot stand out. Leaders will have to confront the established capabilities and management extent to take part and be prepared for AI’s potency [5].

Furthermore, scenario 3 is between high outstanding performance of AI and low problems on managing waste. The best scenario is that the smart dustbin is used effectively. AI make it possible for future analysis of the process data [28]. This illustrates that AI can make early prediction on waste which will help the company to make early preparations on the upcoming waste issue. Hence, with the development of AI application, tedious work can be transferred to AI application and professionals can concentrate on more sophisticated tasks [29]. Therefore, the future problems on waste management can be controlled and that the upcoming waste management can get more focus as the company has a clearer view on the predicted uncertainties.

Lastly, scenario 4 is between low outstanding performance of AI and high problems on managing waste. The best scenario is the application of smart dustbin is not efficient enough to handle the wastes. This may be due to not enough research and development on smart dustbin with AI. The research and development may have constraints that causes insufficient research on AI in smart dustbin. Hence, one of the constraints may be due to financial investment on research and development. The lower the volatility of cash flow, the lesser the failure and the solvency will increases [30]. If the research of implementing smart dustbin with AI cannot meet all the purpose of its implementation, therefore, the problems that were meant to solved in waste management cannot be achieved.

6. Conclusion

In conclusion, the first objective which is to identify issues and drivers that related to Artificial Intelligence (AI) in Smart Dustbin among service providers in Malaysia. Therefore, two drivers with the highest impact and uncertainty mean were chosen from impact-uncertainty analysis. The chosen drivers are outstanding performance of AI and problems on managing waste. Moreover, the second objective is to examine future trends of AI in Smart Dustbin among service providers in Malaysia. There are four scenarios on the future trends that were discovered from scenario building, which are expertise on AI application, prioritize current waste management practices, effective use of smart dustbin, and research and development financial constraint.

Furthermore, the research was considered a success, however, future improvements should be taken into considerations. Firstly, the first recommendation is to have a long period for the research. Longer time period will give enough time that the research needs in order to complete the research as according to plan. Hence, the research can take the extra time to revise the research report to make any changes and improvement. Therefore, long period for research is suggested for better research writing and finding. The second recommendation is to give simpler and shorter sentences in the questionnaire. The simpler and shorter the sentences in the questionnaire, the higher the tendency for the respondents to answer the questions on their best interest, as they do not have to keep repeating on reading the same question for understanding and feel that the questions are at ease to be completed faster. Moreover, the third recommendation is to get updated source of information. To get information that has not been updated by the admin itself is difficult. Therefore, the researcher can try to contact the responsible authority to request for the newly updated information. Updated information is really important as this will determine the next step to data collection and what decision makings that the researcher can do towards data collection. Lastly, the fourth recommendation is to widen the sample size of respondents. This can be achieved by involving variety of geographical area into the sample size research. Hence, this many variations of data collection will show many opinions given by respondents from different geographical areas. Also, larger sample size will be closer to reaching the population, therefore, more accurate data can be determined.

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