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Sustainability of Rooftop Gardening Adoption in Urban Residential Areas from Future Homebuyers' Perspective in Malaysia

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Abstract: Malaysia's agriculture sector has been gradually declining over decades due to the increasing food imports and lack of land for agricultural activities. This study aims to identify the issues, drivers, and future trends of rooftop gardening adoption in urban residential areas from future homebuyers' perspective in Malaysia, which will be derived from the target respondents based in the Kuala Lumpur, since Kuala Lumpur has become a focal point in Malaysia. Descriptive questionnaire developed based on social, technological, economic, environmental, political, and values (STEEPV) drivers will be used to collect the data from respondents. In this study, four types of data analysis will be used which are STEEPV analysis, descriptive analysis, impact-uncertainty analysis, and scenario building, and the data will be analysed using the Statistical Package for Social Science (SPSS) version 26. The analysed data will identify the sustainability and future trends of implementing rooftop gardening in urban residential areas. This research signifies whether the rooftop gardening adoption is gaining acceptance among future homebuyers.

Keywords: Agriculture, Rooftop, Urban residential, Sustainability

1. Introduction

Growing vegetables on the rooftop seem to be just a little contribution to the environment, but it can help us live a better life. Terraces receive lots of sunlight, and gardening is an excellent form of exercise and a way to connect with nature. Furthermore, this garden will collect carbon dioxide and aid in the reduction of heat in our home's surroundings (Dash & Deole, 2020). Corresponding to the United Nations (UN) (2008), the global urban population will increase by more than a billion people between 2010 and 2025, while the rural population will barely grow. Regarding this scenario, as rapid urbanisation has been the norm in many developing countries, urban agriculture is becoming increasingly crucial in resolving the world's food insecurity issue (Edmondson *et al*., 2020). This is

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because a substantial proportion of people have been cut off from food production due to urbanization, and they have become increasingly reliant on food imported from increasingly distant regions (Satterthwaite, McGranahan, & Tacoli, 2010). Therefore, peri-urban, and urban agricultural activities are growing worldwide, offering citizens local, fresh vegetables grown in abandoned urban sites (Mok *et al*., 2013). Many urban residents are experiencing difficulties due to a lack of vegetation space. The contemplative dilemma of urbanization and the depletion of fertile soils gladly invites rooftop gardening as a remedy (Kumar J.R. *et al*., 2019).

According to the Department of Statistics Malaysia (2021), the agriculture sector was one of the economic pillars of Malaysia's economy in its early stage of development from 1970 to 1980, with a share of 28.8% and 22.9%, respectively. However, the figure was gradually declining, and as of 2020, the percentage stood at 7.4% of overall GDP (DOSM, 2021). This evidenced the share of the agriculture sector in Malaysia in the economy was somewhat small compared to our neighboring countries, for instance, Indonesia and Thailand. This caused the food imports in our country to soar up to a total of more than RM50 billion, with higher raw material costs, particularly for supplies related to food products, that may obstruct the agriculture sector's performance (DOSM, 2021). In other cases, the increasing population growth in Malaysia indicated the importance of ensuring food security for people living in urban areas, primarily low-income households (Alam *et al*., 2015).

The boost of urban agriculture, principally the adoption of rooftop gardening, might help aid the food safety issue in urban residential areas (Orsini *et al*., 2014). Until 2014, 58% of Malaysian citizens lived in urban areas, and this number is projected to rise to 60% by 2025 and the trend is expected to continue with population growth and rapid urbanization (Rabu & Muhammad, 2015). DOSM (2021), mentioned that the efforts to revitalize the food-based agriculture sector through technological adoption would be able to boost the agricultural production. According to The Economist Intelligence Unit (EIU), Malaysia has been ranked 39th out of 113 countries in the Global Food Security Index (GFSI) in 2021, compared to ranked 43rd in 2020. This significant improvement displayed our country's effort to strengthen the food security while improving the position in the GFSI in the future. However, problems arose when Malaysia's natural resources and resilience record remained low, due to the country's high dependency on imported foods, and significant reliance on natural resources for economic productivity, as well as elevated exposure to climate-related risks and adverse weather phenomenon (Bank Negara Malaysia, 2021).

In Malaysia, the recorded number of imported fruits and vegetables has increased yearly. The rapid urbanization and the increased in urban population affected fresh local food production in Malaysia to degenerate, forcing our country to import fruits and vegetables from other countries, as reported by Federal Agricultural Marketing Authority (FAMA, 2019). Malaysia is becoming increasingly reliant on food imports, primarily fruits and vegetables, from other countries, especially Thailand and China (Rabu & Muhammad, 2015).

Based on the report by the Department of Statistics Malaysia (2021), Malaysia has spent a significantly higher amount on food imports, which amounted to RM55.5 billion, than RM33.8 billion on exports in 2020. The lack of land for agricultural activities in our country and the high production cost to implement any agricultural activities caused this issue (Ruban, 2016). According to Rabu and Muhammad (2015), this trend emphasized the importance of urban farming in meeting the needs of city dwellers, particularly those who were more vulnerable to food shortages than people in rural areas. Malaysia's Import Dependency Ratio (IDR) in 2020 proved that our country was depending on food imports (Department of Statistics Malaysia, 2021). What is more important is the fact that Malaysia always focuses on rural agriculture activities rather than urban agriculture, despite the latter being one of the most strategic solutions for future farming (Rozhan, 2015), shows that it needs to change for the better.

These factors also led to physiological stress and health issue towards people especially the low-income households which were very much affected. Malnutrition and adverse health consequences were linked to food insecurity within elderly. Lack of food may cause adult women to have inadequate nutrition, elderly women to perform less physically, adults to have multiple chronic conditions, and adults to become obese (Shahar *et al*., 2019). Therefore, this study tends to determine the sustainability of rooftop gardening adoption in urban residential areas from future homebuyers' perspective in Malaysia which might be an acceptable answer for sustaining the city's fast-growing population.

Therefore, to achieve the research objectives, the issues, challenges, and trends of the rooftop gardening adoption in urban residential areas from future homebuyers' perspective in Malaysia are discovered, and the key drivers for the implementation of rooftop gardening is determined. Consequently, the future trends of rooftop gardening in urban residential areas are predicted.

The scope of this study will be aimed at the future homebuyers, specifically in urban residential areas in Malaysia, to help them better understand the opportunities in considering this method to be implemented in their future residences. The limitation of this research was based in Kuala Lumpur, since Kuala Lumpur had become a focal point in Malaysia and have attracted many of the young generations because of the job opportunity offer (Mentaza Khan, Azmi, Juhari, Khair, & Daud, 2017). This study also looked at the benefits and drawbacks of rooftop gardening to enquire about the positive and negative aspects of this approach.

This research study aimed to discover the issues, challenges, and trends of the rooftop gardening adoption in urban residential areas from future homebuyers' perspective in Malaysia, to determine the key drivers for the implementation of rooftop gardening in urban residential areas from future homebuyers' perspective in Malaysia, and to identify the future trends of rooftop gardening in urban residential areas from future homebuyers' perspective in Malaysia.

Thus, this foresight study was also to help home developers increase their perception of the positive and negative issues in the future in the agricultural field in Malaysia. This study also determined future homebuyers' acceptance of rooftop gardening as a new amenity in residence. Thus, the future researcher or developer can refer to this study as their guild because it provided evidence on the impact and uncertainty of urban agriculture. So, it can help magnify the positive effect of rooftop gardening to help in the agricultural field in the future. However, this study also helped fix or avoid the negative subsequence to rooftop gardening in the agricultural field. Finally, hoping that rooftop gardening will benefit a lot in urban areas in Malaysia and worldwide and creates a better future for the younger and new generation as soon as possible.

2. Research Methodology

Research methodology makes the research process go more smoothly by ensuring that the analysis is well-planned, and that the data collected is relevant to the study's goals. Meanwhile, the methodology is a set of methods or processes to find out a more detailed study as a solution to a specific problem. In a nutshell, a comprehensive research methodology will allow the research process to collect and analyse data effectively.

2.1 Research Flowchart

A flow chart is a diagram that depicts the movements and actions of a complex system. This visual preview process is a framework that helps researchers at all levels grasp the technique and work. In addition, the flowchart assisted the researcher in adequately conducting the investigation. Figure 1 shows the flowchart of the study.

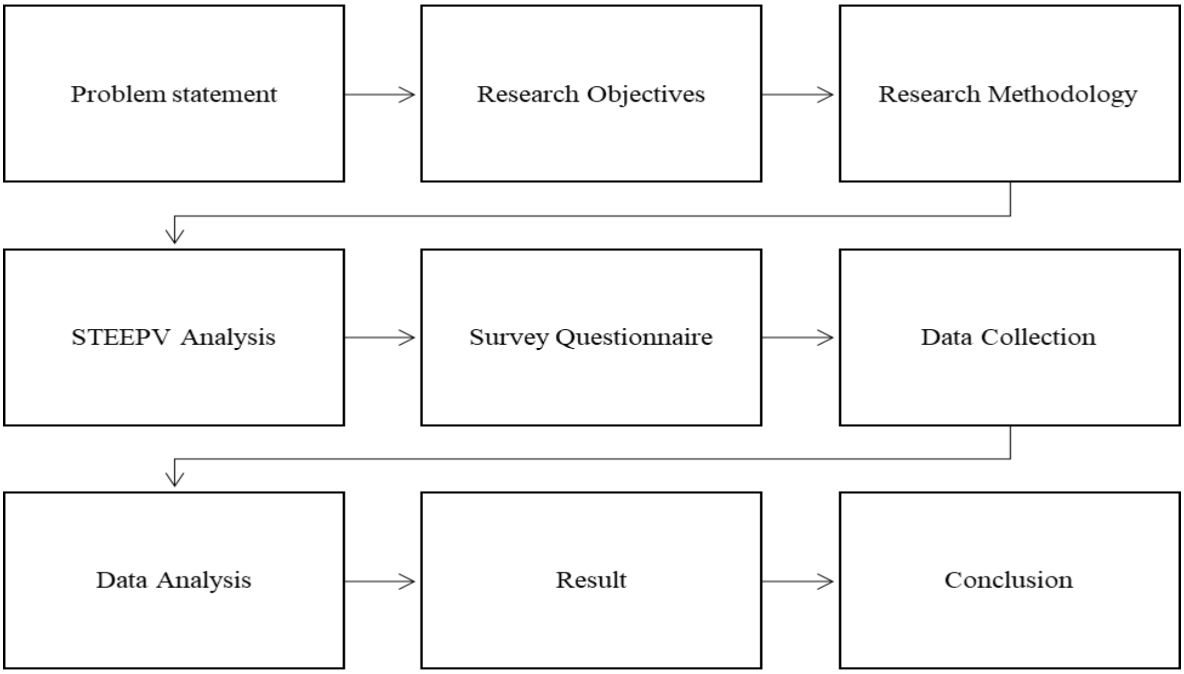

Figure 1: Research flowchart

2.2 Data Collection

This study used a descriptive questionnaire via online to collect data from respondents. The descriptive survey items were developed based on the drivers identified from the STEEPV analysis. Questionnaires were distributed through social medias and emails. The collected data provided useful insights from the respondents' perspective on the key issues and drivers which were crucial to shape up future trends in implementing rooftop gardening adoption.

(a) Primary data

Primary data is the data that have been collected and explicitly combined for a research project. On the other hand, this form of data is unique data that is more reliable and accurate in representing analysis in the study. In this study, the primary data were obtained through a survey of structured questionnaires that were given to respondents who will be purchasing a house in the next 5 to 10 years.

(b) Secondary data

Secondary data were acquired from the journal, websites, articles, news, etc. For the study, the data obtained regarding the topic were used to gather the key issues using the STEEPV approach, which was separated from social, technological, economic, environmental, political, and values aspect. The gathered key issues were then be merged to find the key drivers. The merged issues and drivers were used to form questionnaires.

2.3 Research Population

In this study, the target population is 8,420,000 since it is the total number of Malaysian citizens residing in Kuala Lumpur (MacroTrends, 2022), specifically among those who plans on buying a house in urban areas, particularly those aged between 25 to 40 years old since the median age of property buyers from 2000 to 2019 is between 34 to 35 years of age (The Star, 2020). The sample for this study were drawn at random from a list of all people in the population.

(a) Sampling

This research used a simple random sampling technique to collect, analyse, and interpret the data. To help effectively determine the number of samples needed to represent a population, this study used the Krejcie and Morgan method. Based on Krejcie and Morgan (1970), the sample size for the population of 8,420,000 is 384. It is based on the computation of the sample size by Krejcie and Morgan, which is identical to the calculation table for samples by Krejcie and Morgan. The sample size calculation for the Krejcie and Morgan sample is based on $p = 0.05$ with fewer than 5% to $p < 0.05$.

(b) Research instrument

There are two common research methodologies which are quantitative and qualitative. Quantitative analysis is used by the different interviewees to evaluate the data collected via questionnaire. The analysis of data collection by interviews and observations is done through qualitative research. For this study, the instrument used was questionnaire, which was divided into four parts as shown in the table 1 below.

Table 1: Parts in questionnaire

Part	Content
Part A	Respondents' demographic
Part B	The impact of drivers towards rooftop gardening adoption
Part C	The uncertainty of drivers towards rooftop gardening adoption
Part D	The readiness of drivers towards rooftop gardening adoption

The questionnaire was designed in a scale rating format and selection of answers provided to help ease the respondents. Multiple choice, close-ended and scale rating questions were used for the questionnaire. Likert scale method was used to identify the level of agreement of respondent, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) that was used in part B, part C, and part D.

2.4 Reliability Test

Reliability is a measurement which provides consistent results and equal values in accordance with Blumberg et. al. (2005). The alpha is measured on the same scale and typically ranges from 0 to 1. The closer the alpha is to 1.00, the better the internal consistency of items in the instrument being evaluated (George & Mallery, 2003). Table 2 demonstrates the range of coefficient of Cronbach's Alpha and its reliability level.

Table 2: Table of reliability (George & Mallery, 2003)

Cronbach's Alpha	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

2.5 Pilot Test

Pilot test is a strategy to test survey questionnaire before collecting the data. Cronbach Alpha was used in pilot test to test the reliability and validity of the questionnaire before conducting the actual study. For this study, the data of the first 30 respondents were used to analyse. By using SPSS to test out the reliability of the questionnaire, the Cronbach's Alpha for each part was 0.918 (Part B), 0.927

(Part C), 0.945 (Part D). Since the value of Cronbach's Alpha score is above 0.7, it is considered acceptable (George & Mallery, 2018) and the collection data for the actual study can be proceed. Table 3 shows the pilot test analysis for this study.

Table 3: Pilot test analysis

Parts in Questionnaire	Cronbach's Alpha	Internal Consistency
Part B (Impact of Drivers)	0.918	Excellent
Part C (Uncertainty of Drivers)	0.927	Excellent
Part D (Readiness of Drivers)	0.945	Excellent

2.6 Data Analysis

In this study, four types of data analysis were used namely STEEPV analysis, descriptive analysis, impact-uncertainty analysis, and scenario building. Data that have been collected were analysed using the Statistical Package for Social Science (SPSS) version 22. SPSS was used for statistical analysis of the results of each of questionnaire and the data were then determined and concluded the results of the study.

(a) STEEPV analysis

This study adopted a STEEPV method for its analysis. STEEPV is a tool frequently used to develop new ideas or forecast what will happen in the future (Pestleanalysis Contributor, 2020). The researcher used STEEPV to analyse, identify, and arrange all rooftop gardening drivers. It is also utilized in this research to identify the key drivers, challenges, and future trends of rooftop gardening adoption in urban residential areas in Malaysia. The STEEPV analysis is divided into six categories: social, technology, economic, environmental, political, and values.

(b) Descriptive analysis

Descriptive research designs can be used to find out the answers to the questions of who, what, when, where, and how associated with a particular research problem (Anastas, Jeane W., 1999). Descriptive research is a theory-based design; hence, it helped assist others in comprehending the need for the research as the results were more precise and reliable. Table 4 shows the table of mean score interpretation.

Table 4: Table of mean score interpretation

Mean score	Interpretation
1.00-1.80	Very Low
1.81-2.60	Low
2.61-3.20	Medium
3.21-4.20	High
4.21-5.00	Very High

(a) Impact-uncertainty analysis

This analysis was used to identify the uncertainties in predicting the future trend of rooftop gardening adoption in urban residential areas in Malaysia. The list of STEEPV analysis drivers provided insight into the future development and implications that decide the uncertain terms. All factors were displayed based on their impact and level of uncertainty on the future trend of homebuyers' perspective of rooftop gardening adoption in Malaysian urban residential areas. The Impact-Uncertainty Grid is a matrix with two dimensions: Uncertainty on the x-axis and potential impact (for future performance) on the y-axis *(b) Scenario building*

Scenario building is the process of creating a statement about the possible condition of an observation at a future time. A common way of scenario building is the two-by-two technique, in which the drivers of uncertainty serve as the framework for the scenarios. Based on the impact uncertainty analysis, two main drivers that have the highest impact and uncertainty were identified by the researcher. Then, the scenario building was identified to know what will happen in the future.

3. Literature Review

This chapter focused on reports, writing, and past research findings relevant to the study that was conducted. The objective of a literature review is to educate oneself on a topic and comprehend the literature before forming an argument or justification. An overview of rooftop gardening, a definition of rooftop gardening, types of rooftop gardening, benefits and drawbacks of rooftop gardening, challenges in implementing rooftop gardening, and technical requirements for rooftop gardening are all included in the literature review. For the further research study, below will be using horizon scanning and STEEPV analysis to gather all the information relevant to rooftop gardening.

3.1 Definition of Rooftop Gardening

Rooftop agriculture can be defined as developing farming activities on the rooftops and terraces of buildings by utilizing the available space on ceilings and balconies (Sanyé-Mengual, 2015). Rooftop farming is a type of urban agriculture that occurs on the roof of a structure. It cultivates fresh vegetables, herbs, and fruits on rooftops for local consumption with environmental benefits such as reduced rainwater runoff, temperature benefits such as potential reductions in heating and cooling requirements, biodiversity, and improved aesthetic value and air quality (Marielle Dubbeling, Edouard Massonneau, 2012). As the city grew, suitable land for agricultural production was scarce. The city's lands are more valuable for residential or commercial development, and as a result, people started moving agricultural activities to rooftops, a practice known as Rooftop Gardening.

3.2 Types of Rooftop Gardening

According to A. Quesnel, J. Foss, and N. Danielsson, 2011, food-producing green roofs can be divided into three types. Firstly, agricultural green roofs, also known as direct-producing green roofs. The crops are grown directly into shallow beds in a soil-based growing medium, which may be placed on a waterproof membrane or additional layers such as a root barrier, drainage layer, and irrigation system (Dubbeling & Massonneau, 2012; Dash & Deole, 2020). Next is rooftop container gardens. It consists of cultivating vegetables, herbs, and flowers in soil-based growing media in pots, buckets, containers, bottles, or raised beds. Mixtures of soil, compost, or woodchips can be used to create this medium. Rooftop containers can be as simple as pots or as complex as elaborate systems. Thirdly, rooftop hydroponic systems. These systems use water-based fertilizer solutions instead of soil to grow plants. Exposed hydroponic systems are utilized in open-air environments, and hydroponic systems are grown under cover (glass or plastic) to help enhance yields and extend growing seasons (Dubbeling & Massonneau, 2012; Dash & Deole, 2020).

Another alternative is aquaponics. Aquaponics, a pesticide-free farming system that combines aquaculture, for example, growing fish and hydroponics, i.e., growing plants without soil, could be the answer to redeveloping the country's many empty units and office buildings. Aquaponics is a soilless farming method in which fish eat and produce waste to do most of the work. Beneficial bacteria in the water will convert waste into nutrient-rich water, then be fed to soilless plants (Yeo A., 2021).

3.3 Advantage of Rooftop Gardening

The adoption of rooftop gardening can generate lots of potential benefits. This study has already highlighted some benefits of rooftop gardening based on the brief introduction in chapter one, including reducing food insecurity issues and the solution to the problem of land scarcity. Nevertheless, rooftop gardening has other advantages that can foster homebuyers to request this method in their future residences, such as environmental benefits and creating functional community space. Firstly, rooftop gardening has the potential to reduce carbon emissions. Rooftop gardening is a brilliant idea for pitching a road towards sustainability through urban farming (Smit, J., Nasr, J., Ratta, A. 2001). It can reduce carbon in the atmosphere significantly and also helps urban areas by reducing stormwater management costs (Kumar J.R. *et al*., 2019). For example, 22% of carbon dioxide emissions in the United Kingdom might be reduced if the food was produced and consumed locally (Grewal & Grewal, 2012).

3.4 Disadvantages of Rooftop Gardening

Despite the apparent advantages of rooftop gardening, there are some downsides. According to a previous study, not all types of structures can withstand the weight of a rooftop farm. The weight constraints, position, location, orientation of the building, ground-high height, maintenance, and sustainability are all factors that must be met (Wilkinson *et al*., 2013). Most building roofs will require sufficient reinforcement before a roof garden can be planted securely, and high winds will damage plants and early seedlings, which will be a concern for high roof gardens (Allen J., 2016). Secondly, rooftop gardening is not cost-effective to implement. The installation cost might range from 2 to 6 times typical roof systems (Wong *et al*., 2003). For reference, the installation cost of a rooftop farm at Luca Farm in Montreal is estimated to be between \$1 million and \$2 million (Busicchia, 2011).

3.5 STEEP Analysis of Rooftop Gardening Adoption

Specific data collection procedures/methods require to be described clearly. The STEEPV analysis is divided into six categories: social, technological, economic, environmental, political, and values. The table will include detailed information about the paper, such as authors, country, issues and trends, and drivers based on the literature review. This method allows the researcher to gain a broader perspective on the research by not focusing solely on a single driver. The key drivers of the findings will be categorized, and their frequency will be displayed. Table 5 shows the results of output from STEEPV analysis.

Table 5: Results of STEEPV analysis

Factors	Total	Source
Social	20	Bay Localize (2007), Islam &Ahmed (2011), Tarmiji *et al.* (2012), Bradley & Galt (2013), Ghatak & Mookheriee (2014), Thomair *et al.* (2014), Eleventh Malaysian Plan (2016), FAO-FCIT (2018), Kirkpatrick & Davidson (2018), Kunpeuk *et al.* (2019), Whitmell, (2012), UN (2020), Gallagher *et al.* (2013), Asomani B. (2002), Tibesigwa *et al.* (2016), Galhena (2013), Appolloni *et al.* (2021), Rezai & Mohamed (2016), Sara & Sumita (2015), Gundula Proksch (2011)
Technological	9	Astee & Kishmani (2010), Asaduzzaman *et al.* (2015), Oliver Wyman (2018), Paul Teng (2020), Paul Teng (2020), Harry (2020), Viani (2016), Safayet *et al.* (2017), Aaron (2021)
Economic	13	E. Kim *et al.* (2018), Wu & Smith (2011), Appolloni*et al.* (2021), Buehler & Junger (2016), Opitz *et al.* (2016), FAO (2017), FAO (2000), Lang & Barling (2012), Oberholtzer *et al.* (2010), Roberts & Hall (2001), Padin (2016), Rezai & Mohamed (2016), Tilman *et al.* (2011)
Environmental	11	Wu & Smith (2011), Barreca (2016), US EPA (2021), Mughrabi *et*

		al. (2020), E. Kim *et al.* (2018), E. Kim *et al.* (2018), Pittaluga, Schenone & Borelli (2011), RIES (2014), Frazer (2005), Sanyé-Mengual *et al.* (2015), Higher Ground Farm (n.d.)
Political	8	The Straits Times (2020), The Straits Times (2020), Filippini *et al.* (2019), Talavera (2019), Appolloni *et al.* (2021), Indraprahasta (2013), Wei (2015), Orissa International (2021)
Values	9	Nitol *et al.* (2021), Gasperi *et al.* (2016), Cumbers *et al.* (2017), Mousier & Danso (2006), Purnomohadi (2001), Keshtkaran *et al*., (2017), Engelman (2010), Gallagher *et al.* (2013), Holland (2004)

3.6 List of Merged Issues and Drivers

Specific data analysis procedures/methods require to be described clearly. There were a few merged drivers and issues that had been developed which can be used to develop questionnaires for data collection in Chapter 4. Table 6 below is the merged drivers and issues for this study. For the questionnaire, the questions and rubrics were developed based on the merged drivers and issues.

Table 6: Merged issues and drivers

No	Merged Key Issues	Key Drivers
1	Rooftop gardens can increase food production.	Economic
2	Rooftop gardening enhance the use of urban agriculture technology.	Technological
3	The quality of life will improve because rooftop gardening adoption is convenient and efficient.	Social
4	Higher-income households have more advantage for practising rooftop gardening.	Social
5	Consumers who care about environment will choose to implement rooftop gardening method.	Environmental
6	Adoption of rooftop gardening can strengthen community relation.	Social
7	Adoption of rooftop gardening in urban areas is a great attraction.	Economic
8	Widely use of rooftop gardening adoption in future can increase more job opportunities.	Economic
9	Government should increase subsidies for urban agriculture support incentives.	Political
10	Rooftop gardening can improve the ecosystem.	Environmental
11	Rooftop garden can freshen our mind for better physiological restfulness.	Values
12	Rooftop gardens can lower down the risk to land scarcity issue.	Environmental
13	Making the agro-food industry more competitive and sustainable.	Policy
14	Change public's negative perception of agriculture as low-income career	Social
15	Rooftop garden as advanced technology to resolve food security issue.	Technology
16	The rooftop garden aesthetic is essential for a building's appearance.	Values

4. Results and Discussion

This chapter presented the result and data obtained from the research. The data collected from the questionnaire were analysed using Statistical Package Social Science (SPSS) version 26 to answer all the research questions and objectives of this study. The questionnaire was distributed through online by using Google Form as the platform to obtain respondents' demographic information as well as individual mean drivers. The computed mean was sorted in descending order and the drivers with the highest mean were used to build impact-uncertainty analysis. Then, the future scenario will be based on the two drivers with the highest impact and uncertainty.

4.1 Response Rate

The data for this research had been collected among future homebuyers in the time horizon of next 5 to 10 years who lives in Kuala Lumpur, Malaysia. Based on the Krejcie & Morgan table, the sample size of 384 respondents were required to take part in this study. However, the number of successfully return survey is 311 respondents, with the response rate of 80.99% as shown in Table 7.

Table 7: Survey response rate

Items	Total
Sample size	384
Total respondents	311
Response percentage (%)	80.99%

4.2 Actual Test Analysis

The actual study was conducted after the previous pilot test study established its validity and reliability. From the total of 311 respondents, the Cronbach's Alpha for each part is 0.808 (Part B), 0,837 (Part C), and 0.850 (Part D). The result of the reliability test and the Cronbach's Alpha values for each tested item indicated strong internal consistency for the actual study as the Cronbach's Alpha is more than 0.8. Table 8 shows the Cronbach's Alpha value and internal consistency of the actual test analysis.

Table 8: Actual test analysis

Parts in Questionnaire	Cronbach's Alpha	Internal Consistency
Part B (Impact of Drivers)	0.808	Good
Part C (Uncertainty of Drivers)	0.837	Good
Part D (Readiness of Drivers)	0.850	Good

4.3 Respondent Demographic Information

This section discussed the respondents' demographic information where in the questionnaire, the respondents' demographic part consists of questions of respondents' gender, age, race, educational level, occupation, passion towards gardening, knowledge of rooftop gardening, and consideration on implementing rooftop gardening in the future. The demographic analysis was used to describe the respondents' tabulation.

4.4 Descriptive Analysis

In this section, the results of the vote for each driver were reviewed, depending upon the three different aspects, which were the level of impact, uncertainty, and readiness. These three aspects were used to identify the top drivers with the highest level of impact and uncertainty. To ease the process, a table of mean of each driver arranged in descending order were prepared so that the drivers with the highest mean can be identified easily. At the end of this chapter, an impact-uncertainty analysis was used to identify the most significant driver of future impact and uncertainty. Table 9 shows the mean of drivers on level of impact, uncertainty, and readiness.

Table 9: Mean of drivers on level of impact, uncertainty, and readiness

No.	Drivers	Impact	Uncertainty	Readiness
D1.	Rooftop gardening will improve the quality of life	4.26	4.42	4.44
D2.	Rooftop gardening adoption can strengthen community relation	4.19	4.16	4.26
D3.	Rooftop gardening will boost up the agriculture industry's perspective	4.23	4.41	4.41
D4.	Rooftop gardening enhance the use of urban agriculture technology	4.34	4.34	4.27
D5.	Rooftop gardening can resolve food insecurity issue	4.19	4.35	4.36
D6.	Rooftop gardening adoption increases job opportunities	4.22	4.45	4.45
D7.	Rooftop gardening can improve the ecosystem	4.37	4.57	4.49
D8.	Rooftop gardening can prevent land scarcity	4.32	4.37	4.50
D9.	New policy will boost economic growth	4.11	4.42	4.44
D10.	Government subsidies will help urban agriculture to grow	4.29	4.13	4.23
D11.	Rooftop gardening helps for a better physiological restfulness	4.44	4.43	4.44
D12.	Rooftop gardens enhances cities' appearance	4.37	4.50	4.48

4.5 Impact-Uncertainty Analysis

Appendix A shows the comparison of the mean value between the level of impact and the level of uncertainty of drivers towards the adoption of rooftop gardening. The main objective of this study is to figure out the driver which have the highest level of impact and uncertainty outcome. Figure 2 shows the impact-uncertainty analysis constructed using all the data. The two highest coordinates of impact and uncertainty selected were D7 (4.37, 4.57) and D11 (4.44, 4.43). D7 had the highest uncertainty and the second highest level of impact while D11 had the highest impact, and it surpassed the median line of uncertainty. D7 is "Rooftop gardening can improve the ecosystem" and D11 is "Rooftop gardening helps for a better physiological restfulness".

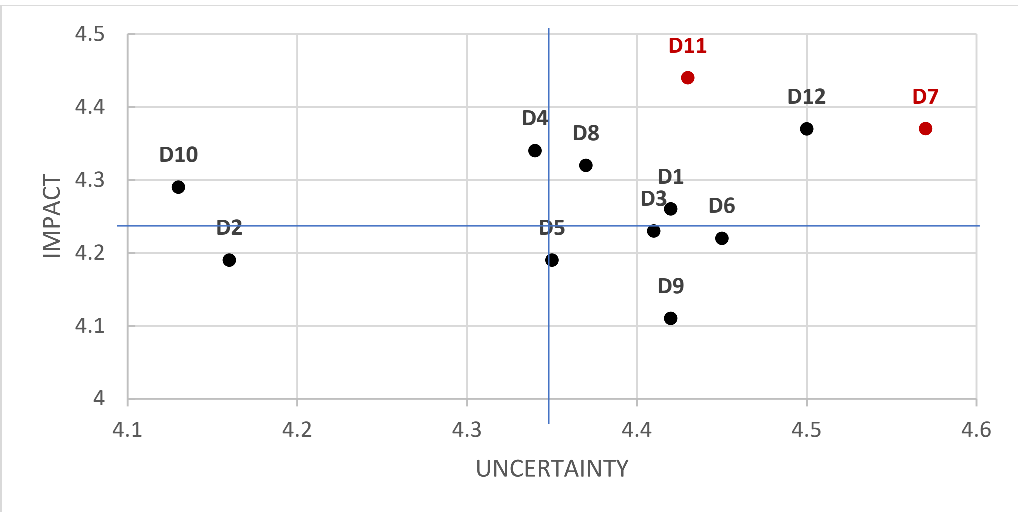

Figure 2: Impact-uncertainty analysis

5. Conclusion

The conclusion should summarize the main findings of the study, and restate the key points inferred from trends observed and discussed regarding the data. Some suggestions should be included to encourage the continuation of the current research. This chapter explained the study results obtained by conducting an impact-uncertainty analysis that had been assessed in previous chapter. The purpose of future scenario writing is to determine the expected outcome using the two highest drivers on the study of rooftop gardening adoption in urban residential areas in Malaysia in the coming time horizon of 5 to 10 years. Analysis of impact-uncertainty had been demonstrated to be closely linked to scenario development, where the two highest drivers of impact and uncertainty will be applied to construct four future scenarios. Any relevant suggestion and proposal for better rooftop gardening adoption in the future research were also explained in this chapter using the drivers.

5.1 Discussion on First Research Objective

The researcher had carried out three objectives throughout the process to set a clear goal on what will be achieve at the end of the study. The first objective of this study is to discover the issues, challenges, and trends of the rooftop gardening adoption in urban residential areas from future homebuyers' perspective in Malaysia. This objective was achieved through the literature reviews.

5.2 Discussion on Second Research Objective

The second research objective of this study is to determine the key drivers for the implementation of rooftop gardening in urban residential areas from future homebuyers' perspective in Malaysia. In this argument, the key drivers had been evaluated through the STEEPV analysis. Based on findings obtained through using the STEEPV analysis, the Social aspect is the most abundant driver in rooftop gardening adoption followed by Economic, Environmental, Technological, Values, and Political aspect.

5.3 Discussion on Third Research Objective

The third objective of this study is to identify the future trends of rooftop gardening in urban residential areas from future homebuyers' perspective in Malaysia. The trend which acts as driving forces were determined for future changes and future environment for rooftop gardening adoption in urban residential areas in Malaysia. The trends were accomplished by generating scenario analysis to four different alternative scenarios based on the two highest drivers selected from the impact-uncertainty analysis. The selected drivers were discussed in the next part, explaining the uncertainty of the drivers in the future development and the impact it will have on future rooftop gardening adoption in urban residential areas in Malaysia.

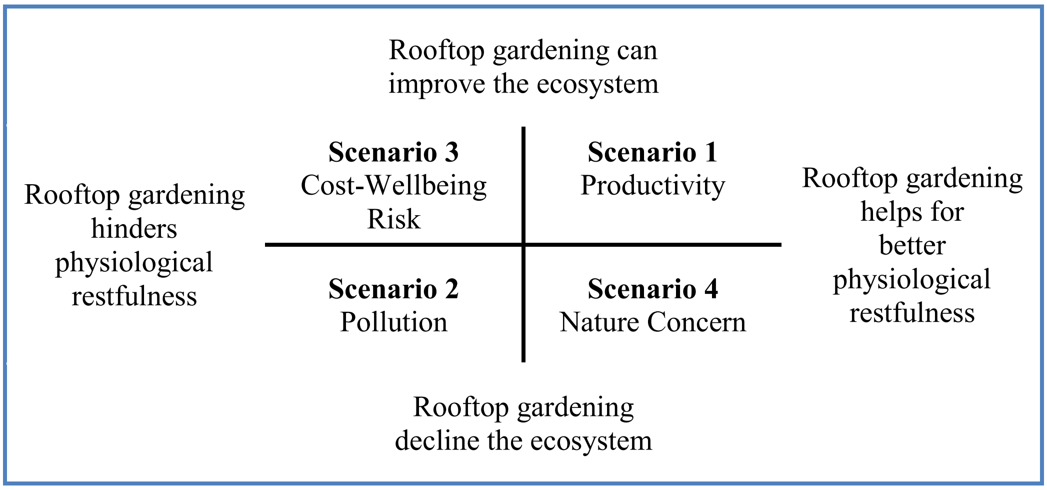

Figure 3: Scenario building development

(a) Scenario 1: Productivity

Based on the impact uncertainty analysis, two main drivers that have the highest impact and uncertainty will be identified by researchers. Then, the scenario building was identified to know what will happen in the future. The first scenario occurs when rooftop gardening improves the ecosystem and helps for a better physiological restfulness. This scenario is the best scenario and basically will increase the potential of adopting rooftop gardening in urban residential areas in Malaysia. Gardening can be a wonderful hobby and is very helpful to lower the stress levels, especially in stressful nowadays society where many people work quite long hours in the office every day, exclusively in urban areas. As jobs were becoming more technologically complex, the frequency of stress-related disorders in work environment increases (Sethi & Schuler, 1986). Research shows that gardening can significantly impact overall mental and emotional health by improving productivity and lowering the blood pressure (Lohr *et al*., 1996). This shows that rooftop gardening can be the new alternative for city dwellers to reduce stress level and increase physiological restfulness for better productivity.

By adopting rooftop gardening, the physiological restfulness of people living in urban areas will improve and be more productive as well as enhancing the ecosystem, through exploiting the unused rooftop spaces in house residences as there are many houses in urban areas. The unused spaces in housing areas like rooftop will be utilised more after this, and this is the most fitting for gardening apart from lands. Besides saving some spaces, it also helps preserve the environment as well as ecosystem. According to a German study, urban agriculture gives city dwellers, especially low-income families, easier access to a broad range of foods (Opitz *et al*., 2016). This way, people in the cities can get access to enough food supply without needing for unconventional food production from factories in which will damages the environment. Mass harvesting the crop for food processing in factories leaves the land barren, and unfriendly for the growth and development of new organisms and ecosystems (Maple Ridge, BC, n.d.). Thus, by adopting rooftop gardening technology, city residences can protect the environment along with having better physiological restfulness.

(b) Scenario 2: Pollution

The second scenario is pollution, and it occurs when rooftop gardening worsens the ecosystem and hinders the physiological restfulness. This scenario is the worst scenario and the least desirable situation which makes city dwellers to be sceptical and uncertain to develop the idea of rooftop gardening in their residences. This situation happens when incorrect technology was used for rooftop gardening. Based on research held in Singapore, inorganic hydroponics is considered the most ideal farming method for government housing structures than conventional soil culture since it produces a better yield, requires less labour, and requires only lightweight systems that can be quickly erected over an existing roof (Astee & Kishmani, 2010). However, by contaminating water, soil, and air, inorganic pollutants pose a serious threat to human health and the environment as it releases harmful micropollutants into the environment which causes water pollution (Wasewar *et al*., 2020). This kind of situation will worsen the ecosystems and hinders physiological restfulness.

Ecosystems and physiological restfulness should be aligned to give benefits for the community. Nevertheless, the chemical during fertilization of plants may perhaps have unwanted effects on environment and human body. Although fertilizer is a natural substance applied to soils to supply nutrients essential to plants growth, it also contains chemicals that have a widespread detrimental impact on the ecosystem (Khiatah, n.d.). It is found that the chemicals found in chemical fertilizers, specifically nitrate, are generally the main contributors to water pollution (Bijay-Singh *et al*., 1995). This will gradually bring negative impact towards our ecosystem and individual's physiological restfulness. Furthermore, towards human health, the effects of chemical fertilizers are serious in which the chemicals will causes DNA damage, oxidative stress, lipid peroxidation, and pro-inflammatory cytokine activation that might leads to increased cellular degeneration and death (de la Monte *et al*., 2009). Chemical fertilizers through sprays for gardening to avoid pests and weeds should only be used in a minimal and highly targeted way as it might affect the air quality and will impact life productivity.

(c) Scenario 3: Cost-wellbeing risk

Next, the third scenario is cost-wellbeing risk. This scenario happens when rooftop gardening adoption improves the ecosystems while hinders physiological restfulness. This forecast focuses on how as much as rooftop gardening adoption brings benefits towards the ecosystems, it could also cause damage towards physiologically. Rooftop gardening helps in reducing the city's temperature especially at night and lowers Urban Heat Island (UHI) as rooftop gardening increases the evaporation surface and reflecting the sun rays. Adopting rooftop gardening, it is important to consider site selection criteria, as well as application and design principles. Rooftop gardening adoption needs maintenance because they are living systems, and frequently depends on the type of vertical garden, climatic conditions, and plant varieties (Mir, 2011). Furthermore, maintenance can be costly. According to Perini *et al*., (2011), the elements used for rooftop gardens are expensive, such as the isolation material, irrigation system components, drainage system, and routine maintenance costs. So, it must be considered that maintenance and repairment works should not be ignored for the sustainability.

Additionally, gardening plants comes with pests' threat and diseases and might affect people's wellbeing. Harmful insects known as vectors can pass pathogens to plants, which leads to plant disease, and even transmit diseases to humans if being bitten by these pests (Solutions, 2021). Likewise, gardening may cause injuries as it requires physical exertion, and these repetitive actions put strain on the back and joints (SF Gate, 2020). Moreover, residents will likely employ rooftop gardening adoption in a small scale because of the limited space on rooftops. For city residents with small houses, even with efficient use of space, a garden takes away a portion of area and creates less space for any other activities which are not that productive (SF Gate, 2020). Corresponding to research conducted in Bangladesh, excessive heat, lack of proper nourishment, and roof load are the most severe problems in rooftop gardening adoption, however it results in great contributions of rooftop gardening in urban areas in terms of environmental reclamation (Nitol *et al*., 2021). Thus, it troubles the city residents, mainly the low-income households to implement rooftop gardening adoption as it might affect them financially or on their wellbeing though it is beneficial towards the ecosystems.

(d) Scenario 4: Nature concern

Lastly, the final scenario is nature concern. This scenario occurs when rooftop gardening worsens the ecosystems while helps for better physiological restfulness. In this forecast, rooftop gardening adoption brings detrimental effect on ecosystems and environmentally unfriendly but is beneficial towards physiological restfulness. Rooftop gardening might cause plastic usage in the world to continue increase as it is easy to get and convenient for people to use for gardening. The usage of plastic for mulching process improves crop yield, decreases pesticide, and saves irrigation water but on the other hand, it results in polyethylene residues that contaminate agricultural soils and contribute to the massive plastic pollution, a serious environmental concern (Serrano-Ruiz *et al*., 2021). Plastic pollution can alter habitats and natural processes, reducing ecosystems' ability to adapt to climate change, directly affecting millions of people's livelihoods, food production capabilities and social well-being (UN, n.d.). Nevertheless, rooftop gardening promotes the idea of plastic reuse, and it is a great way to bring people or garden community together socially. Research suggests that 63% of people who garden experience improved moods when gardening (RTOR, 2021).

When rooftop gardening is implemented in a large scale, it may trigger for mass usage of pesticides on gardens. Pesticides benefits users by destroying insect pests for higher yields and better quality of plants, but on the other hand, it contaminates soil, water, turf, and other vegetation, as well as be toxic to a host of other organisms including fish, birds, beneficial insects, and non-target plants (Aktar *et al*., 2009). There are limits on the amount of residue that may remain on products sold for food because the application of persistent pesticides may produce illegal residues on rotational food crops (Bessin, n.d.). However, the usage of pesticides improves people's productivity due to the use of fertilizer, better varieties, and use of machinery (Aktar *et al*., 2009). Hence, the physiological restfulness can be a great driver in rooftop gardening adoption in the future as it benefits many individuals.

5.4 Limitation of Study

All things considered, there were some limitations when carrying out this research. Firstly, there were some of the respondents who were not familiar with the concept of rooftop gardening. In Malaysia, rooftop gardening is still a new concept of urban agriculture and majority of the respondents were lacking professional knowledge regarding rooftop gardening, and this may perhaps influence the results or data. In addition, the research scope was also a factor in limiting this study. For this study, the researcher focused on people who currently lives in Kuala Lumpur as the scope of study. This argument was not enough to represent a more general scope for its data as there are several other urban residential areas in Malaysia.

Next, the data collecting process of this study was fully done online through survey questionnaire by using online platforms like WhatsApp and Instagram. This might limit the degree of accuracy of the questionnaire results or data to be not as reliable compared to face-to-face, or interview session results, as the researcher did not get consistent information regarding rooftop gardening adoption from the respondents. Lastly, there were only few past research or articles and journals regarding rooftop gardening or urban agriculture. This issue gave a challenging time towards the researcher to get evidence, information, and other related sources from the past studies

5.5 Recommendation of Study

The current development of urban agriculture has the potential to drive and push forward the rooftop gardening adoption as a norm in the future. This study provided four different scenarios for the future based on the two highest drivers that had been identified through the impact-uncertainty analysis. These scenarios concluded the potential positive and negative outcomes for rooftop gardening adoption in urban residential areas in Malaysia. City residences should be concerned about the negative outcome of the future scenario and develop a strategy on resolving the negative prediction that occurred in the scenario building. For the positive outcome of the future scenario, urban cities residences should take the occasion to imply the rooftop gardening adoption that benefits them

5.6 Recommendation for Future Study

Upcoming research should attempt to overcome the indicated limitations. In the future, the scope of this study should be extended geographically to improve the accuracy of the data collection and gain a more reliable information from the respondents. For this study, the scope research was only limited to future homebuyers living in Kuala Lumpur. Thus, future research should attempt to broaden the scope in other urban residential areas in Malaysia such as cities in Johor Bahru and Pulau Pinang. This way, any biasness in the data collection could be avoided. Moreover, a qualitative method for data collecting process is recommended for future study by conducting face-to-face, or interview sessions with the respondents. Through interview sessions, respondents will be able to respond to the open-ended questionnaire that was designed to gather more feedback from respondents regarding rooftop gardening adoption in Malaysia. This way, the respondents might be able to provide relevant answers for the interview session and gain a broad understanding on rooftop gardening from the researcher

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Appendix A

Mean of Drivers on Level of Impact and Uncertainty

No.	Drivers	Impact	Uncertainty
D1.	Rooftop gardening will improve the quality of life	4.26	4.42
D2.	Rooftop gardening adoption can strengthen community relation	4.19	4.16
D3.	Rooftop gardening will boost up the agriculture industry's perspective	4.23	4.41
D4.	Rooftop gardening enhance the use of urban agriculture technology	4.34	4.34
D5.	Rooftop gardening can resolve food insecurity issue	4.19	4.35
D6.	Rooftop gardening adoption increases job opportunities	4.22	4.45
D7.	Rooftop gardening can improve the ecosystem	4.37	4.57
D8.	Rooftop gardening can prevent land scarcity	4.32	4.37
D9.	New policy will boost economic growth	4.11	4.42
D10.	Government subsidies will help urban agriculture to grow	4.29	4.13
D11.	Rooftop gardening helps for a better physiological restfulness	4.44	4.43
D12.	Rooftop gardens enhances cities' appearance	4.37	4.50