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A SUSTAINABLE URBAN FARMING INDEX ASSESSMENT MODEL FOR EVALUATING FOOD PRODUCTIVITY THAT APPLIES MULTI-CRITERIA DECISION-MAKING METHODS — A CASE STUDY IN MALAYSIA

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Abstract: Governments need a reliable farming technique to feed the ever-growing population of the world, which is sustainable and responsive to the environment, ecosystem, society, and economy. Urban farming can significantly protect urban lands while balancing the natural environment for self-reliant food production. The essential need for a tool able to quantify and evaluate the performance of the urban farm's sustainable food production has persuaded us to develop the Sustainable Urban Farming Index Assessment (SUFIA) Model. The research has applied the critical literature review and identified three criteria and fifteen sub-criteria handling sustainable farming, and Analytical Hierarchy Process (AHP) measured the weights. AHP revealed reducing air pollution ($W_{C1.1.}$=29.3224), soil health and water cleaning ($W_{C1.2.}$=29.2454), and food sovereignty ($W_{C3.1.}$=25.6442) are critical in food productivity. The model was implemented to a case, Zenxin Organic Farm, for validation. The case earned Grade C, means, Zenxin Organic Farm is a usable urban farm while some features need substantial improvements regarding soil health and water cleaning, dynamic site design and selection, and supportive community environment. The model is a universal and multi-functional decision support tool that helps urban managers, local authorities, and policy-makers to minimize urban's food production impairments through a systematic and consensus-wise decision-making mechanism.

Keywords: Urban farming, sustainable ecosystem, Analytical Hierarchy Process (AHP).

The growing population of the world needs more agricultural lands to produce food, which causes the ecosystems converting to farmlands (Imang and Ngah, 2012; Armanto *et al.*, 2013; Keyvanfar *et al*., 2018). According to Bourblanc (2014), agriculture may cause environmental complications, such as loss of biodiversity, water pollution, soil pollution, destruction of natural habitats, compromised health, and climate change (*et al.*, 2016; Karimi *et al.*, 2018). Significantly, agriculture may trigger negative consequences in food security and productivity (Al-Amin and Ahmed, 2016; Karimi *et al.*, 2018). Therefore, food production has been recognized as a threat to humanity, nature coexisting, and land development (Tirado *et al.,* 2010; Dimitri *et al.*, 2012). For these reasons, the governments have been looking for a reliable farming solution to feed their city-bound populations, which is more sustainable and responsive to the environment and ecosystem, society, and economy (Carolan, 2011). Weerakoon (2013) state that governments can protect the green areas and use urban lands for balancing their urban environment, especially for fresh nutrient foods. Therefore, urban farming is one of the best sustainable models which is currently practicing by many cities for self-reliance in food productivity (Jankowski & Richard, 1994). Weerakoon (2013) states that urban farming contributes to "local economic development, poverty alleviation, and social inclusion of the urban poor."

Ching (2002) expresses that "a sustainable farm must produce adequate high-quality yields, be profitable, protect the environment, conserve resources and be socially responsible in the long term." The food industry is one of the critical industries look into aspects of sustainability (Fritz and Schiefer, 2008; Yakovleva *et al.*, 2012). Veisi *et al.* (2016) state that sustainable farming aims "to improve ethical standpoints in agricultural activities to make them more environmentally, socially, and economically viable and compatible". Veisi *et al*. (2016) and Jennings (2010) state that sustainability is an essential value throughout food supply chains, while the modern urbanism replaces natural green areas to the infrastructures and built environment. Indeed, the modern urbanization needs to understand the urban's potentials for sustenance and food production (Weerakoon, 2013), and to pay more attention to these advantages, due to economic crisis and the new market mechanism. The modern and rapid urban development has to make the decision-making process sure for the experts and stakeholders to exploit the urban areas for farming and agriculture effectively. Therefore, the urban farming has become a productive and sustainable land-use system for fulfilling people's daily food usage in different environmental conditions (Tirado *et al.*, 2010; Ye *et al.*, 2016; Intasen *et al.*, 2017). Urban farming has a systematic procedure that can harmonize the relationship between farm productivity and the sustainable utilization of farmlands (Dhehibi *et al.*, 2014).

Urban farming is the primary source of agricultural production, maintains the balance of ecological environments, and plays host to tourists, visitors, and resources (Tirado *et al.*, 2010; Napawan & Townsend, 2016; Al-Amin & Ahmed, 2016). Urban farming has the capacity and potential to borrow principles of other farming typologies that are adaptable to the urban texture and fabric (Richardson & Moskal, 2016). Particularly, urban farming guarantees healthy food and healthy farming, water quality, and soil protection (Pessoa & Lidon, 2013; Dhehibi *et al.*, 2014; Tirado *et al.*, 2010; Cetin, 2016). It may significantly help minimize external inputs, including pesticides and chemical fertilizers, which reduce environmental damage while increasing the potentials to extra food production (Hendrickson *et al.*, 2008). Urban farming improves the air quality significantly, minimizes the impact of global warming, reduces ecological footprints, decreases the urban heat island (UHI), prevents greenhouse gas emissions (mostly, CO_2), cools down the urban microclimates (Weerakoon, 2013; Shafaghat *et al.*, 2016a), and recycles urban wastes (Kamyab *et al.*, 2016). Heather (2012) expresses the urban farming benefits significantly in air pollution removal. The urban developers are pursuing a variety of strategies to mitigate air pollution through urban agriculture; including, green roofs, community gardens, vertical gardens, and living walls. For example, a 4,000 m.sq. green roof in Singapore can remove approximately 6% particulate matter and 37% acidic gaseous chemicals (Yang *et al.*, 2008). Alternatively, in Canada, 109 ha of green roofs can remove 7.87 metric tons of air pollutants annually (Yang *et al.*, 2008). In a green urban, trees can reduce air pollution effectively, almost 711,000 metric tons annually (Yang *et al.*, 2008).

Global urban farming requires that farmland ecosystems not only meet functional products but also sustain food production. Sustainable development of urban farms can provide the high-efficient use and access to adequate food security of future generations through quantifying the socio-economic, cultural and scientific, and environmental aspects (Tian *et al.*, 2013; Shafaghat *et al.*, 2018). Edwards (1990) states that sustainable food systems are dealing with several indicators; soil degradation, depletion of non-renewable resources, inequity, health and environmental effects of chemicals, loss of traditional values, decline of rural communities, workers' safety, food quality, decreasing number of farms, and decline in self-sufficiency. These indicators are the benchmarks to lean sustainable farming, and of course, sustainability indicators reflect the consensus among stockholders who have different values. In this regard, the researchers have developed a few models or tools to evaluate and quantify sustainable farming cross sustainability domains (socio-economic and environment) and sustainability indicators. However, these models have limitations in different aspects such as topological environment, climatic, geospatial, and geophysical (Kamkar *et al*., 2014). They have applied different decision-making methods or techniques for different purposes. The most prevalent techniques are; Expanding the classification or scoring methods (Hoffman & Schniederjans, 1996); Linear programming (LP) (Brimberg & Revelle, 1999), Heuristic (Rönnqvist *et al*., 1999), Simple Additive Weighting (SAW) method (García *et al*., 2014), expert systems, and artificial intelligence (Banar *et al*., 2007). The researchers have used the number of multi-criteria mapping techniques for diverse purposes; such as Analytical Network Process (ANP) (Felice *et al*., 2012) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (Semih & Seyhan, 2011).

Regarding farm site selection, the researchers have employed different Multi-Criteria Decision Making (MCDM) methods, mainly, Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) (Brans *et al.*, 1984), and the ELimination Et Choix Traduisant la Realité (ELECTRE) (Roy, 1966). Sánchez-Lozano *et al.* (2016) have coupled the Geographic Information System (GIS) and Fuzzy Analytical Hierarchy Process (FAHP) to visualize the best site selection of wind farms. Tan *et al.* (2017) have employed the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) method to achieve a compromise solution in farm assessment. Tan *et al.* (2016) stated that TOPSIS logic is rational, its weight computation process is straightforward, and it depicts each criterion in a simple mathematical form. Moreover, Noorollahi *et al.* (2016) employed the Geographical Information Systems (GIS) as one of the spatial policy instruments for identifying suitable areas for wind farms. Noorollahi *et al.* (2016) state that GIS "affords the functionalities of integrating a large amount of geospatial data into the decision-making of wind resources evaluation and development." Regarding the ecological and biological aspects of farms, there are a few studies that have adopted the environmental assessment methods and techniques. For example, Battaglini *et al.* (2014) and Salvador *et al.* (2016) have employed the Life Cycle Assessment (LCA) to assess the environmental impacts of farms. Gorsevski *et al.* (2013) employed GIS for wind farm site selection using spatial analysis and interactive mapping group decision making. Regarding the environmental protection of farms, Meul *et al.* (2008) applied LCA as a DSS (decision support system) to support dairy farms. They developed a four-step process method using MOTIFS (Monitoring Tool for Integrated Farm Sustainability, developed by Meul *et al.*, 2008). MOTIFS "offers a visual aggregation of indicator scores into an adapted radar graph, considering ten sustainability themes related to environmental, economic, and social aspects" (Meul *et al.*, 2008). Application of Meul *et al.*'s (2008) method can identify the critical factors for LCA implementation in farm development. Meul *et al.* (2008) stated that LCA could be applied in production systems by optimizing the environmental performance of farms. Moreover, Hewett *et al.* (2016) developed the decision support matrix (DSM) for modelling agricultural land use management, which aids stakeholders in making farm landscapes stronger using holistic solutions at multiple scales.

However, the above-mentioned quantitative and statistical methods are hindered by limited reproducibility of the results, insufficient knowledge of experts, and weight subjectivity of the criteria (Park *et al.*, 2011). The quantitative methods may proceed with prohibitive required data; hence they are moving towards simplification (Gomez & Kavzoglu, 2005; Park *et al.*, 2011). To resolve these limitations, new techniques such as AHP can be applied in urban agriculture studies (Liu *et al.*, 2008). The urban agriculture researchers have yet combined the AHP method with other decision-making methods or statistical methods for different purposes. For example, Bozdağ *et al.* (2016) have merged AHP with GIS for evaluating agricultural land use suitability. They have used AHP to understand better the reasons defecting lack of forested areas, insufficient water resources, the existence of barren lands, discharge of domestic and industrial waste, and low precipitation. Tian *et al.* (2013) have applied the AHP method for evaluating sustainable coastal beach exploitation on three dimensions; economic-social value, suitability, and ecosystem. Besides, some researchers have applied AHP in the domain of moral decision-making and ethics in sustainable urban agriculture (Veisi *et al.*, 2016; Stein & Ahmad, 2009) based on different criteria; resilience of farming systems, equity, self-reliance, productivity, quality of life, land quality, food security, and resource management. Some researchers, such as Akinci *et al.* (2013) and Mishra *et al.* (2015), have employed AHP in site suitability analysis of organic farming. They state that AHP is one of the promising decision-making methods for analysing the agricultural land suitability based on quantitative analysis of group of criteria and the individual criterion. Moreover, the AHP method has been used for landfill site selection. For instance, Sener *et al.* (2010), Gorsevski *et al*. (2012), and Rahmat *et al.* (2017) have applied an AHP-GIS multi-criteria decision analysis for evaluating the suitability of landfill sites for solid waste management in urban areas. Indeed, urban farming professionals declare that AHP has numerous obvious advantages (Tahri *et al.*, 2015; Watson & Hudson, 2015). Briefly, the AHP method can handle simply the complex and complicated policy-making and decision-making problems, which are extremely simple to be understood with non-professionals as well (Tian *et al.*, 2013). The AHP method has high validity while it can handle the uncertainty of the unavailable or incomplete data (Tian *et al*., 2013). Kauko (2004) states that the majority of the multi-criteria modelling methods work based on the assumption utility functions, while the AHP method raises the assumption that "the criterion quantification with pair-wise comparison secures better results."

On the other hand, benchmarking is a valuable tool used for total quality management, continuous improvement of organizational performance (at tactical, strategic, and operational levels), and competitive advantage (Manning *et al.*, 2008). To date, several benchmarking tools have been developed, such as European Foundation for Quality Management (EFQM) business excellence model, service quality (SERVQUAL) framework, computational geometry, the Operational Competitiveness Ratings Analysis (OCRA), cause-effect diagrams, and so on. AHP has been employed to benchmark and measure the sustainability performance of food supply chains and food productivity (Yakovleva *et al.*, 2012). In comparison with other benchmarking tools, AHP capable to distinctively ponder multiple attributes and criteria and measure both quantitative and qualitative data, which is exceptionally advantageous in sustainability measurement (Chan, 2003; Yakovleva *et al., 2012*). Technically, AHP is one of the most appropriate methods to evaluate problems involving a set of uncertain indicators (Chatterjee *et al.*, 2015). Saaty (1996) states that the purpose of developing the AHP is to introduce a simple method that can prioritize ranking for general decision-making situations. Velasquez and Hester (2013) state that the AHP method is such a scalable and easy-to-use method, and its "hierarchy structure can easily adjust to fit many sized problems, not data-intensive." AHP is aplicable in "performance-type problems, resource management, corporate policy and strategy, public policy, political strategy, and planning" (Velasquez and Hester, 2013). Additionally, it can be used for both group and individual decision-making problems (Saaty, 1996; Goepel, 2018). The AHP is a plausible and systematic multi-criteria method can measure the dominance of one criterion over another criterion, while covering both scientific and logical approaches (Banai-Kashani, 1990; Kumar *et al*., 2009; Bhatta & Doppler, 2010; Lamit *et al.*, 2013, Keyvanfar *et al.*, 2014; Phillips-Wren *et al.*, 2009). Therefore, the AHP method is an appropriate decision-making and policy-making method could be employed in the current research.

To sum up, a few urban farming assessment tools currently exist. Most of these tools are single-function and case-sensitive. The governments, authorities, urban designers and planners, and landscape architects need such a multi-functional urban farming assessment model, which can substantially minimize the ecological, biological, physical, social, and environmental impairments to sustainable urban development. Hence, the current research has aimed to develop a universal and multi-functional tool called Sustainable Urban Farming Index Assessment (SUFIA) Model. This model can significantly quantify and evaluate the performance of urban farm's in sustainable food production. To achieve the aim, the research has conducted two objectives. Objective one was to investigate and identify the food productivity features in urban farming by applying the critical literature review method. Objective two was to estimate the weights of the identified features and formulate the SUFIA index by employing the AHP method. The model was validated through a case study and has applied the Weighted Sum Method (WSM) to measure the model's feasibility.

Materials and Methods

Urban Farming's Food Productivity Features

The research needs to investigate and identify the features of urban farming's food productivity in order to develop the SUFIA model. Thapa and Murayama (2010) state that modelling criteria affect the dominance of urban farming or land-use changes, which is a challenging issue since various criteria play different roles in a specific location. These criteria may have a high degree of relationship as well (Zang & Huang, 2006). Kirchmann and Thorvaldsson (2000) state that the sustainable farming indicators can be classified into six clusters; i) high-quality agricultural products, ii) protection of agro-ecosystem (i.e., atmosphere, biospheres, and groundwater), iii) Resource conservation, iv) post-harvest procedures, v) landscape appearance, and vi) conditions treatment and evaluation. Applying these inputs, the current research has investigated the features in literature.

The research has applied the Critical Literature Review method to investigate and identify the features. The critical literature review method has several stages that have been conducted in the current research. The first step of the critical literature review is called identification. It starts with defining the list of keywords (single keyword or combination of keywords) corresponding to the research aim and objectives. This stage conducts an inclusive feature identification, which will proceed with the next stage as deductive feature identification (Jankowicz, 2002; Saunders & Rojon, 2011). In the literature, urban farming is denoted by different keywords; urban agriculture, urban gardens, food cities, and farming cities. Accordingly, the research has used the following keywords to get the potential articles for review; urban farming, urban agriculture, food productivity, food security, urban farming assessment, sustainable urban agriculture, and urban farm management. The second step is called screening. The research has conducted rounds of literature screening through the most scientific available databases; included, Food Security, Emirates Journal of Food and Agriculture, Journal of Integrative Agriculture, Journal of Agricultural Science and Technology, Agriculture, Ecosystems and Environment, Renewable Agriculture and Food Systems, Agricultural Systems, Agricultural Systems, Journal of Agricultural and Food Chemistry, and Agricultural Water Management. Accordingly, the researchers obtained the initial list of references. These references have been screened critically corresponding to the mentioned keywords in order to find clearly the knowledge gaps. In this stage, the researchers could roughly indicate that there is a critical knowledge gap in urban farming studies; which is the absence of a universal assessment tool for evaluating the food productivity performance of urban farming. In the third step, so-called eligibility, the keywords were redefined based on the information obtained in the second step. Some articles were dropped from the list because not meeting our research aim and objectives. According to Mingers (2003), Denyer and Tranfield (2009), the eligibility stage can be replayed as long as the researcher's thoughts matured, and the search outcome focuses very precisely. The last step, called synthesizing, was conducted after three rounds of eligibility studies. It resulted in the current list of references. The researchers have deeply reviewed the finalized references by summarizing, comparing, and contrasting their findings in order to achieve the key features of urban farming' food productivity.

By completing all steps of the critical literature review, the congruency and congruity of the outputs (i.e., features) were approved. According to the reviewed literature, farm functionalities, from a sustainable land use perspective, can be gathered into three (3) main criteria; environmental and physical, socio-cultural, and economical, which are inter-related. The following describes the criteria and the sub-criteria. In the next section, the weights of features will be determined by using the AHP method, which will be transferred into the SUFIA model.

- *C1. The environmental and physical function:*

  C1.1. Reducing Air Pollution: Urban farming can reduce air pollution and carbon sequestration that protects our environment (Cheah *et al.*, 1997), which mitigates the urban heat island effect as well.

  C1.2. Soil health and water cleaning: Urban farming increases the soil's fertility (Heimann *et al.*, 2015), and nourish the soil by organic materials such as compost (Triantafyllidis *et al.*, 2018). "By increasing soil organic matter where necessary, we can enhance water retention and prevent land degradation" (Dimitri *et al.*, 2012).

  C1.3. Biodiversity: Biodiversity has a direct link to human wellbeing, and provides an important base for ecosystem functioning and ecosystem services (Hooper *et al.*, 2005; Green *et al.*, 2005).

  *C1.4. Habitat and Natural preservation: U*rban farming "includes highly productive and biologically diverse ecosystems that offer crucial nursery habitats for many marine species" (Post & Lundin, 1996).

  C1.5. *Dynamic site design and selection:* Urban farms must design with a proper physical and visual access to the farm, sunlight exposure, slope, water sources, transportation network, stormwater/runoff drainage (Dunnett & Hitchmough, 2004; Shafaghat *et al*., 2016a; Ferwati *et al*., 2019).

  C1.6. Community supportive environment: Urban farms can create community support to enhance the attractive and enjoyable environment while simultaneously improving economic development opportunities (Balsas, 2012; Shafaghat *et al*., 2016b).

- *C2. The socio-cultural function:*

  *C2.1. Recreation Planning: A*griculture is the essence of the farm, which motivates people in diverse age groups for farming activities and recreation (Sharpley & Vass, 2006).

  C2.2. Community Engagement: Engagement provides a community, with a sense of place and belonging and with opportunities for members to extend their local social network, to communally manage a program or activities (Brandenburg & Carroll, 1995; Teig *et al.*, 2009).

  C2.3. Sense of Safety: Safety in urban farms is critical not only for liability issues but also dangerous conditions that may diminish visitors' enjoyment (Moskow, 1999).

C2.4. Identity: The local culture and background need to be enhanced which represents the image of farming history and culture to visitors (Roe *et al.*, 2016). Urban farms create opportunities to socialize and recall the skills we learned in childhood (Roe *et al.*, 2016).

C2.5. Building gathering areas: The gathering area is defined as a place where people can gather and congregate and is connected with other activities (Vallianatos *et al.*, 2004).

C2.6. Learning and education planning: Urban farms can be used for learning and enjoying purposes. Crop production, food processing, and harvesting are some learning activities and educational experiences (Vallianatos *et al.*, 2004; Mamat *et al.*, 2011).

- *C3. The economic function:*

C3.1. Food sovereignty: Sovereignty over food governance is about how food is produced. Given the information discontinued from the demand of the commodity market, several large companies currently control major parts of our food system (Feenstra, 2007; Hendrickson *et al.*, 2008; Altieri *et al.*, 2012).

C3.2. Smart food production and yields: This refers to reduce food waste, meat consumption, and maximizing land use for bioenergy (Beuchelt & Badstue, 2013) in order to improve livelihoods in the most deprived areas (Vallianatos *et al.*, 2004; Chen *et al.*, 2013). In fact, in a better food production system, we can create our ecological system for human food needs (Hendrickson *et al.*, 2008).

C3.3. Mixed-use development: A mixed-use development of retail, office and housing is required to create an outdoor shopping and commercial environment inside or nearby urban farms (Balsas, 2012).

Analytical Hierarchy Process (AHP) method

The research has determined the weights of features (i.e., criteria and sub-criteria) by employing the AHP method. The AHP method applies a series of pairwise comparisons to measure the value impact (i.e., weight) of each feature in co-relationship to other features. The research has conducted the following AHP steps to this purpose;

Step 1: Hierarchy decomposition: The decision-making problem is converted into a hierarchical structure.

Step 2: Pairwise comparison: The features are pair-wisely compared with respect to each other. The research has conducted an expert-input study involving a group of experts to compare and rate the comparisons. According to the AHP method instructions, the experts have compared the pair-features based on nine-point scaling (from equal importance to extreme importance). The experts have performed the comparisons for criteria and sub-criteria separately.

Step 3: Supermatrix development: The pair-wise comparisons are transferred to the AHP computation equations, which produce a series of supermatrices. The core of AHP decision-making hierarchy can be represented by the decision-making supermatrix. The supermatrix is analyzed through Equation 1, where C_{ij} (i=1, and N=1, 2, 3,..., N) designates the impact value of ith criterion (i.e. C_i) in association to jth criterion (i.e. C_j). The W_j is the weight of criterion (C_j).

$$A^{i}_{AHP}=\sum_{j=1}^{N} a_{ij} W_j \quad (1)$$

Step 4: Normalization: This step normalizes the supermatrices using Equation 2. The normalization sums up the entries (C_{jn}) in each column. Each entry in the column is then divided by the corresponding column's sum to yield its normalized score. Next, the normalization makes the sum of entries of each row equal to 1, and then, the sum of entries on each column equal to 1.

$$\overline{C_{jn}} = \frac{C_{jn}}{\sum_{i=1}^{m} C_{in}} \quad (2)$$

The criterion weight vector 'w' will be computed by averaging the entries on the row of normalization matrix applying Equation 3; where V_i is ith element of v, C_{ij} is the entry in ith row and jth column of the normalized matrix.

$$W_j = \frac{\sum_{l=1}^{m} \overline{C}_{jl}}{m} \quad (3)$$

Step 5: Consistency analysis: The consistency analysis ensure the researcher that the original comparison ratings were consistent. In AHP, the judgments are considered as adequately consistent if the consistency ratio (CR) is equal to or less than 10 percent (Saaty, 1996). The CR coefficient is calculated by dividing CI to RI using Equation 4 (see Table 1), where λ is the maximum eigenvalue, n is the rating value (from 1 to 9). The "CR is a normalized value since it is divided by an arithmetic mean of random matrix consistency indexes (RI)" (Saaty, 1996).

$$CR = \frac{CI}{RI} = \frac{(\lambda_{max} - n)/(n-1)}{RI} \quad (4)$$

Weighted Sum Method (WSM)

The research has conducted the model validation using the Weighted Sum Method (WSM) method. Kim (2009) asserts that WSM is a simple way to convert multi-objective optimization to a single-objective. Stejskal *et al.* (2013) stated that WSM works well by multiplying each objective with a user-given weight. In this research, the same group of experts has been invited to participate in the validation process. According to WSM's instructions, the experts have to rate the criteria and sub-criteria through 5-point Likert scaling (one refers to weak to five refers to excellent). The WSM conducts the weighting calculation using Equation 5;

$$WSM(a_i) = (\sum_{j=1}^{n} w_j)a_i \quad (5)$$

where,

a_i, *is sub-criterion with the given ordering number of* 'i'.

w_j, *is the assigned rate by the expert number 'j' for the* sub-criterion *'i'.*

Equation 6 indicates the weighting consensus. The consensus is approved either equal to or more than 70 percent.

$$WSM(a_i) \,/\, WSM(a)_{max} = \text{Consensus} \quad (6)$$

where,

a_i, *is sub-criterion with the given ordering number of* 'i'.

$WSM(a)_{max}$, *it is the maximum possible weight the sub-criterion can earn.*

Analysis and Findings

This section presents the procedure for developing the SUFIA model. To develop the SUFIA model, the research has conducted the AHP steps described in the previous section. The following presents the analysis and the findings of AHP steps and procedure.

Firstly, AHP has developed the hierarchical structure of urban farming assessment features towards food productivity (see Figure 1). Referring to the AHP hierarchy, the top layer is the goal of the decision-making problem; the middle layer involves the decision-making criteria, and the bottom layer includes the decision-making sub-criteria.

AHP had to evaluate the weight of each feature by inviting K respondent experts for n sub-criteria. The output from each expert in direct relation of an $n \times n$ matrix was designated as X_{ijk}, where ij is the influence level of sub-criterion i on sub-criterion j. The research has

Table 1: Random Inconsistency (RI) indices for n nodes (Alonso & Lamata, 2006)

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.48	1.51	1.53	1.55	1.56	1.58

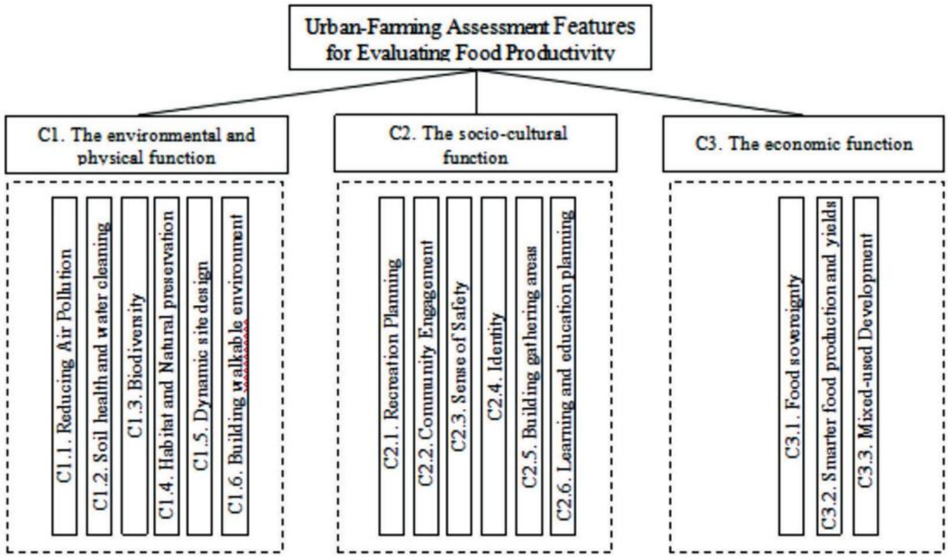

Figure 1: AHP hierarchical structure of the SUFIA model

conducted an expert input study for collecting the experts' rating to each feature through a series of pairwise comparisons. AHP data input process has been conducted by involving five experts who had approximately ten years of experience in urban landscaping, urban farming, and sustainable urban development. The experts have rated each feature based on AHP's 9-point rating scale.

AHP computed the supermatrices based on the experts' inputs. The research has computed the supermatrices with the aid of an outsourced software (developed by Business Performance Management Singapore (BPMSG) Co.). It is an AHP online software for constructing AHP decision models. The software is accessible via; https://bpmsg.com/. By opening the software website, it asks for opening an account, and then a brief description of the decision-making project. The software starts with defining the hierarchical structure of the decision-making (DM) problem. The hierarchy is a text field that uses a simple syntax; where, the DM hierarchy is defined by its node (i.e., criteria), and the node's leaves (i.e., sub-criteria). The nodes are separated with a colon ';', and the node's leaves are divided by a comma ','. By submitting the 'new hierarchy', the hierarchy table is shown, then, the software shows the PWC Input (i.e., pair-wise comparison input) in the Project Administration menu. The new page shows the project's session code (i.e., the session for each expert), and the expert's Input Menu (which each expert should klick to start the pair-wise comparisons). Next, the software shows different forms to the experts. A form for criteria pair-wise comparisons with respect to the project goal asks for importance of each criterion in respect to other criteria in the scale of 1 to 9. After completing this form, the researcher can click 'Check Consistency'. If the consistency is acceptable, the expert(s) can open the other forms with similar procedures for sub-criteria pair-wise comparisons. The software can also provide the excel files of these forms for experts' judgement, which were used in the current research. In this research, the group of experts could complete all required forms at the same time. By completing all required forms, the researcher can save and store the data, and proceed with the data analysis steps. The researcher has to click on the 'AHP Analysis' button to start data analysis. The software releases the final weights of criteria in a table called Normalized Supermatrix (see Table 2), and similarly for sub-criteria (see Table 3), then, sub-criteria correlated to the corresponding criterion (Table 4). These tables can be downloaded in the csv. excel format.

Table 2 shows the normalized weight of each criterion measured during the decision-making process. According to Table 2, the socio-cultural function has received the highest normalized weight ($W_{C.2}$=1.1035), while the economic function has gained the lowest weight ($W_{C.3}$=0.8521).

Table 3 shows the normalized weights of sub-criteria. The results reveals that Reducing Air Pollution is the most important sub-criterion ($W_{C1.1.}$=27.8412), followed by the sub-criteria Soil health and water cleaning ($W_{C1.2.}$ =27.7681), and Food sovereignty ($W_{C3.1.}$=25.6442). In contrast, the sub-criteria Dynamic site design and selection, and Community supportive environment have received the least weights among sub-criteria, $W_{C1.5.}$=23.2590 and $W_{C1.6.}$=21.1572, respectively.

Table 4 presents the integrated normalized weight of sub-criteria in respect to the corresponding criteria. In this regard, the output of Table 2 and Table 3 have been used. The integrated weight multiplies the weight of the sub-criterion to the weight of its respected criteria. According to Table 4, reducing air pollution and soil health and water cleaning are the most important sub-criteria for food productivity, $W_{C1.1.}$=29.3224 and $W_{C1.2.}$=29.2454, respectively. It was followed by the community engagement ($W_{C2.2.}$=28.1135). Contrary, the least important sub-criteria are smarter food production and yields ($W_{C3.2.}$=21.0929), and mixed-use development ($W_{C3.3}$=19.9885). The integrated normalized weights have developed the SUFIA index which is presented in the next section.

AHP calculated the Consistency Index (CI) equalled to 0.139. Referring to Table 1, RI is 1.58; hence CR coefficient (CI divided to RI) equalled to 0.087 (< 10%). According to Saaty (1996), the CR is acceptable if it is less than 10% (< 0.10). Therefore, in this research, CR was consistent sufficiently. Referring to the weights resulted in Table 2 and Table 4, the SUFIA index was developed (see Equation 7). This index is a linear formula involving the sub-criteria and their corresponding constant values, which have been transferred from Table 4 last column (i.e., integrated normalized weights).

Sustainable Urban farming Assessment (SUFIA)

$$Index = \Sigma\, Index_{\text{Social and cultural}} + Index_{\text{Environmental}} + Index_{\text{Economic and functional}}$$

$$SUFIA\ Index = [(\textstyle\sum_{i=1}^{6} a_i X) + (\sum_{j=1}^{6} a_j Y) + (\sum_{k=1}^{3} a_k Z)] \quad (7)$$

where,

a; coefficient of urban-farming sub-criterion

i; Social and cultural urban-farming sub-criterion (i:1,2,3, ..., 6)

j; Environmental urban-farming sub-criterion (j:1,2,3, ...,6)

k; Economic and functional urban-farming sub-criterion (k:1,2,3)

X; Weight of the sub-criterion 'i' of the Social and cultural sub-criterion assigned by the experts during case assessment

Y; Weight of the sub-criterion 'j' of the Environmental sub-criterion assigned by the experts during case assessment

Z; Weight of the sub-criterion 'k' of the Economic and functional sub-criterion assigned by the experts during case assessment

Table 2: Normalized supermatrix of urban farming criteria

Criterion	**C1.**	**C2.**	**C3.**	**Weightage vs. Goal**	**Normalized Weightage vs. Goal**
C1.	0.6774	0.5385	0.7143	1.9302	1.0532
C2.	0.0968	0.0769	0.0476	0.2213	1.1035
C3.	0.2258	0.3846	0.2381	0.8485	0.8521

Note: The environmental and physical function (C1), the socio-cultural function (C2) and the economic function (C3).

Table 3: Normalized supermatrix of urban farming sub-criteria

Sub-criterion	C1.1.	C1.2.	C1.3.	C1.4.	C1.5.	C1.6	C2.1.	C2.2.	C2.3.	C2.4.	C2.5.	C2.6.	C3.1.	C3.2.	C3.3.	Weightage vs. criteria	Normalized Weightage vs. goal
C1.1.	0.0485	0.0046	0.0177	0.0275	0.1037	0.0086	0.0279	0.0547	0.0238	0.0082	0.0047	0.0791	0.0062	0.1951	0.1326	0.0495	27.8412
C1.2.	0.0485	0.1838	0.0295	0.0183	0.1037	0.1033	0.0070	0.0137	0.0238	0.1483	0.0944	0.0066	0.1732	0.1672	0.0332	0.0770	27.7681
C1.3.	0.4854	0.0115	0.0884	0.1098	0.1186	0.1205	0.0558	0.1095	0.0476	0.0494	0.1180	0.1319	0.1732	0.0557	0.2652	0.1294	24.6278
C1.4.	0.0485	0.1149	0.0295	0.0549	0.0741	0.1205	0.0558	0.0547	0.1903	0.0989	0.0708	0.1055	0.0495	0.0040	0.0995	0.0781	23.7215
C1.5.	0.0121	0.0230	0.0177	0.0110	0.0296	0.0344	0.1394	0.2189	0.0952	0.0124	0.0708	0.0527	0.0041	0.0056	0.0041	0.0487	21.1572
C1.6.	0.0485	0.0459	0.0295	0.0137	0.1186	0.0172	0.0836	0.0547	0.0190	0.0247	0.0472	0.0044	0.0035	0.0139	0.0055	0.0353	23.2590
C2.1.	0.0485	0.0230	0.0442	0.0275	0.1186	0.1205	0.1115	0.2189	0.0952	0.1236	0.0944	0.0791	0.1980	0.0836	0.1326	0.1013	25.2760
C2.2.	0.0324	0.0115	0.0147	0.0110	0.0148	0.1205	0.0040	0.0137	0.0119	0.0031	0.0039	0.0264	0.0049	0.0836	0.0047	0.0241	25.4767
C2.3.	0.0194	0.1378	0.0221	0.0275	0.0741	0.0861	0.1115	0.0156	0.0119	0.1730	0.1180	0.1055	0.0247	0.0056	0.0047	0.0625	24.1703
C2.4.	0.0162	0.1149	0.0884	0.1647	0.0889	0.0689	0.1394	0.1095	0.1903	0.0742	0.0944	0.1055	0.0990	0.1115	0.0995	0.1043	24.5794
C2.5.	0.0324	0.0077	0.0221	0.0183	0.0889	0.0057	0.1394	0.0219	0.0238	0.0124	0.0236	0.0088	0.0049	0.0139	0.0083	0.0288	23.8764
C2.6.	0.0139	0.0115	0.0221	0.0137	0.0148	0.1033	0.0093	0.0219	0.0317	0.1483	0.0708	0.0264	0.0062	0.0093	0.1326	0.0424	24.3297
C3.1.	0.0243	0.0115	0.0221	0.0078	0.0021	0.0172	0.0558	0.0156	0.0136	0.0247	0.0708	0.0044	0.0049	0.1115	0.0055	0.0261	25.6442
C3.2.	0.0243	0.1149	0.0221	0.3844	0.0049	0.0043	0.0040	0.0547	0.0317	0.0494	0.0472	0.0791	0.1237	0.0279	0.0055	0.0652	24.7540
C3.3.	0.0971	0.1838	0.5302	0.1098	0.0445	0.0689	0.0558	0.0219	0.1903	0.0494	0.0708	0.1846	0.1237	0.1115	0.0663	0.1272	23.4579

Note: C1.1. Reducing Air Pollution, C1.2. Soil health and water cleaning, C1.3. Biodiversity, C1.4. Habitat and Natural preservation, C1.5. Dynamic site design, C1.6. Building walkable environment, C2.1. Recreation Planning, C2.2. Community Engagement, C2.3. Sense of Safety, C2.4. Identity, C2.5. Building gathering areas, C2.6. Learning and education planning, C3.1. Food sovereignty, C3.2. Smarter food production and yields, C3.3. Mixed-use development

Table 4: Integrated normalized supermatrix of urban farming sub-criteria

Criterion	**Criteria Normalized Weightage**	**Sub-Criterion**	**Sub-criteria Normalized Weightage**	**Sub-criteria integrated Normalized Weightage vs. Criterion**
C1.	1.0532	C1.1.	27.8412	29.3224
		C1.2.	27.7681	29.2454
		C1.3.	24.6278	25.9380
		C1.4.	23.7215	24.9835
		C1.5.	21.1572	22.2828
		C1.6.	23.2590	24.4964
C2.	1.1035	C2.1.	25.2760	27.8921
		C2.2.	25.4767	28.1135
		C2.3.	24.1703	26.6719
		C2.4.	24.5794	27.1234
		C2.5.	23.8764	26.3476
		C2.6.	24.3297	26.8478
C3.	0.8521	C3.1.	25.6442	21.8514
		C3.2.	24.7540	21.0929
		C3.3.	23.4579	19.9885

Results

The research has conducted a comprehensive and in-depth model validation process. Although the SUFIA model is such a universal tool and can be applied to any urban farms around the world, in this research, the SUFIA model has been implemented to Zenxin Organic Farm in Kluang in Malaysia (see Figure 2). Agriculture is one of the critical sectors playing leading roles as the success story for economies in Malaysia over the last few decades. The Zenxin Agri-Organic Farm is the largest fresh organic producer in Malaysia (Tong, 2015). The Zenxin Agri-Organic Farm fields provide both organic vegetables and fruits that spread across the islands of Peninsular Malaysia. It does not use pesticides or chemicals at any stage of agricultural production. The Zenxin Agri-Organic Farm has been awarded a grand prize on the scale of its vegetables in the recent Malaysia Agriculture, Horticulture and Agrotourism Show (MAHA). The Zenxin Organic Farm has been developed based on the following objectives; to achieve a high level of customer satisfaction with organic foods, to produce organic products of the highest quality without the use of chemical fertilizers and pesticides, to promote food products free of pesticides, chemical fertilizers, artificial preservatives and additives, to allow land and humans to lead a greener and healthier life, to set up an organic food company with quality products for consumers, and to provide better environmental work for the members of the company and create a sustainable organic business for investors.

Figure 2: ZenXin Organic Farm in Kluang, Johor, Malaysia (Source: Tong, 2015)

The research conducted the Weighted Sum Method (WSM) steps to validate the model. The same group of experts has been invited, and they have rated the criteria and sub-criteria for the case of Zenxin Organic Farm. They have rated the criteria and sub-criteria using WSM's 5-point rating scale (see the columns of Expert Inputs in Table 5). The WSM calculated the which is the maximum value can be assigned to each criterion/sub-criterion. was obtained by giving maximum rate (i.e., 5) to all five experts for all criteria and sub-criteria. Applying Equation 5 equalled to 25. Referring to Equation 6, the consensus is achieved by dividing the sum of rates (i.e., which the experts given to each criterion/sub-criterion) to the Final Consensus calculated by multiplying the consensus value of the sub-criterion to the consensus value of its corresponding criterion. The results of Final Consensus values are presented in the last right column of Table 5. Referring to Table 5, the following presents an example for the sub-criterion C1.1. Soil health and water cleaning;

Example:

Consensus value of C1. (Social and Cultural Revitalization) = 0.92

Consensus value of C1.1. (Soil health and water cleaning) = 0.64

Final Consensus value of C1.1.= Consensus value of C1.× Consensus value of C1.1.= 0.92×0.64=0.588

As shown below, all final consensus values have been trnasferred from Table 5 to the SUFIA model (Equation 7); as result, the Zenxin Organic Farm has received 241 scores.

$$SUFIA\ Index_{implementation} = \Sigma\ Index_{Social\ \text{and cultural}} + Index_{Environmental} + Index_{Economic\ and\ functional}$$

$$SUFIA\ Index_{implementation\ of\ Social\ \text{and cultural}} =$$

$$(29.3224*0.588)+(29.2454*0.846)+(25.9380*0.846)+(24.9835*0.883)+(22.2828*0.604)+(24.4964*0.652)=14.6588+20.8962+24.806+16.2065+17.5552=93.3617$$

$$SUFIA\ Index_{implementation\ of\ Environmental} =$$

$$(27.8921*0.691)+(28.1135*0.846)+(26.6719*0.729)+(27.1234*0.809)+(26.3476*0.883)+(26.8478*0.729)=19.2441+19.798+19.2024+22.25+21.572+19.329=99.1463$$

$$SUFIA\ Index_{implementation\ of\ Economic\ and\ functional} =$$

$$(21.8514*0.739)+(21.0929*0.772)+(19.9885*0.772)=15.477+15.228+18.266=48.9712$$

$$SUFIA\ Index_{implementation} = 93.3617 + 99.1463 + 48.9712 = 241.4792 \cong 241$$

Table 5: WSM results of the SUFIA implementation in ZenXin Organic Farm

Sustainability Criterion	Expert Panels					$WSM(a)_{max}$ of Sustainability Criterion	Cons.	Sub-criterion	Expert Panel					$WSM(a)_{max}$ of Sub-Criterion	Cons.	WSM final Cons. of Sub-Criterion
	Ex_1	Ex_2	Ex_3	Ex_4	Ex_5				Ex_1	Ex_2	Ex_3	Ex_4	Ex_5			
C1. Social and Cultural Revitalization	5	4	4	5	4	25	0.92	C1.1. Soil health and water cleaning	3	4	3	2	4	25	0.64	0.588
								C1.2. Reducing Air Pollution	5	5	4	4	5	25	0.92	0.846
								C1.3. Biodiversity	4	5	4	5	5	25	0.92	0.846
								C1.4. Habitat and Natural preservation	5	5	5	4	5	25	0.96	0.883
								C1.5. Dynamic site design	3	4	4	4	3	25	0.72	0.604
								C1.6. Building walkable environment	5	4	2	2	4	25	0.68	0.652
C2. Physical and Environment Revitalization	4	5	4	5	5	25	0.96	C2.1. Recreation Planning	3	4	3	4	4	25	0.72	0.691
								C2.2. Community Engagement	3	3	5	4	4	25	0.76	0.846
								C2.3. Sense of Safety	4	4	5	4	2	25	0.76	0.729
								C2.4. Identity	5	5	3	4	5	25	0.88	0.809
								C2.5. Building gathering areas	5	4	5	4	5	25	0.92	0.883
								C2.6. Learning and education planning	4	3	5	4	3	25	0.76	0.729
C3. Economic and Functional Revitalization	5	5	4	4	3	25	0.84	C3.1. Food sovereignty	5	4	5	5	3	25	0.88	0.739
								C3.2. Smarter food production and yields	4	5	4	3	5	25	0.92	0.772
								C3.3. Mixed-use development	5	4	4	3	5	25	0.84	0.772

Note. EX: Expert; Consensus; It is calculated based on Equation (6).

The SUFIA model has five grading labels; A, B, C, D, and E (see Table 6). Label A has the highest grade and has the maximum value, while label E has the lowest grade and minimum value. The following presents the calculation of the maximum and minimum score of the SUFAI model. The maximum score A is calculated by assuming rating value one (1) to all sub-criteria (*X*, *Y*, and *Z*) in Equation 7. The minimum score is 0.2 of the maximum score. The range between maximum and minimum has defined the five grades A to E.

$$SUFIA\ Index_{Max} \cong 160+154+65=380$$

$$SUFIA\ Index_{Min} = SUFIA\ Index_{Max} = 380 \times 0.2 = 76$$

According to the SUFIA model's grading interpretations, Zenxin Organic Farm has earned Grade C (Fair). It means that Zenxin Organic Farm is a usable urban farm. However, some features need major improvements and corrections, included soil health and water cleaning (0.64), Dynamic site design and selection (0.72), Community supportive environment (0.68), and Recreation Planning (0.72).

Discussion

In recent decades, the intensive operation has led to the reduction of biological habitat in the traditional agricultural landscape, which has caused the fragmentation of natural landscape diversity (Makhzoumi, 2000; Magagula, 2003). These changes in land use have severely damaged the ecology of the agricultural landscape (Bunce *et al*., 1993). Baudry *et al*. (1997) stated that farming's function is not only the production of food. Urban designers and planners are attempting to develop rich and abundant agricultural resources, farming benefits, and food productivity and security in urban areas. Thus, urban farming has become an effective solution for securing ecological landscapes and food production for many nations in the world (Li, 2001; Todd *et al*., 2003; Lovell & Johnston., 2009). Indeed, urban farming "encourages the development of multifunctional landscapes that provide sustainable food production, biodiversity conservation, protection of ecosystem services, and poverty alleviation" (McNeely & Scherr, 2003). Ever-increasing emissions and environmental pollution are some main negative consequences of modern urbanism. This research found out that air pollution reduction, soil health, and water cleaning by urban farms can extensively contribute to food productivity. Accordingly, Simon (2008) states that promoting green spaces or vegetated surfaces in the form of urban farming can reduce these negative changes.

According to Sterk *et al*. (2009), "issues such as cross-sectoral policy making (agriculture, forestry), land-use planning and integrated ecosystem service management (water management, nature protection, tourism) make it necessary to involve multiple stakeholders." As for involving multiple stakeholders, the SUFIA model bridges the gap for policy-

Table 6: SUFIA model grades and interpretations

Grades	Scoring	Description
Grade A: Superior	301-380	A well-designed urban farm where is performing excellently in food production.
Grade B: Good	251-300	A well-designed urban farm where is performing good in food production and needs minor improvements.
Grade C: Fair	201-250	A usable urban farm where is performing fair in food production, and needs major improvements.
Grade D: Poor	101-200	An urban farm where is performing poorly in food production and needs very major improvements and corrections.
Grade E: Very Poor	76-100	A non-usable urban farm.

makers, scientists, and practitioners. The results of this tool can be taken up by all stakeholders, including local authorities, municipalities, land managers, policy-makers, and farmers. This study has constructed a firm foundation based on these constraints. This study has developed the urban-farming assessment index for evaluating food productivity. The development of the SUFIA index model is supported by Hewett *et al.*'s (2016) who state that "technical experts who are removed from potential end-users, such as farmers, land managers, and policy-makers, produce tools that are complex and difficult to use." This research developed the SUFIA model and asserts that it is a reliable and applicable multi-criteria decision support tool that aids urban farm evaluation and assessment. This model functions as a decision support tool that can draw information from multi-criteria analysis on ecological, hydrological, land use, biological, user satisfaction, and other management strategies. To develop the SUFIA model, the research has employed AHP. It was highly advisable to apply the AHP method since AHP has demonstrated its capacity to analyse and synthesize the relative weights and calculate a ranking score of all criteria. Furthermore, this research complements previous studies which defined the linguistic labels for performance grading.

This research has conducted a comprehensive study for model validation. The validation has followed the case-study strategy, which focused intensely on one case executing these stages; site selection, field observation, expert input study, and consensus analysis. The SUFIA model was implemented to the Zenxin farm to be validated. The model implementation resulted that the Zenxin farm ranked as Grade C; it means that Zenxin farm is a usable urban farm, but some features did not meet the WSM's saturation level; soil health and water cleaning (0.64), Dynamic site design and selection (0.72), Community supportive environment (0.68), and Recreation Planning (0.72). Therefore, these factors need major improvements and corrections. By Zenxin farm assessment, the group of experts has raised the following recommendations and suggestion to resolve those shortcomings;

Soil health and water cleaning:

- Each soil log should extend to the bottom of the facility, describe the soil series, the textural class of the soil horizon(s) through the depth of the log and note any evidence of high groundwater level, such as mottling.

Dynamic site design and selection:

- It can build an iconic center (such as lake, or pond) to supports a diverse array of non-motorized activities.
- The existing vehicular access and circulation are deficient and unclear; so, clearly marked entries and turning lane provisions within the surrounding roadway system are critical.

Community supportive environment:

- The Zenxin Organic farm needs to improve connectivity and accessibility, particularly for poorly served parts. It is needed to create a strong sense of a unified large-scale landscape with improved access and seamless pedestrian connectivity instead.
- It needs to connect to its surroundings, both visually and physically.
- Generally, having more local urban-farms within walking distance is positively associated with its usage, while the necessity of driving to reach often deterred use.

Recreation Planning:

- It needs to integrate the resources, standardized operation, and more robust agricultural tourism industry.
- It needs to provide open space nodes of sufficient size to fulfill users' recreation needs while not being dominated by one group as well as the growth of layer tress, amenity, planting, and space for community gathering.

Conclusion

Urban farming is an environmentally friendly concept that maintains the harmony between people and the environment and inspires and motivates sustainable living. Urban farming emphasizes the efficient and practical agricultural production and simultaneously fulfils the landscape needs, attraction features, and design for tourism absorption. In light of the urban farming advantages, this study has developed the SUFIA model, which can be used as a decision support tool. This assessment model can be used for evaluating and comparing urban farming capabilities in sustainable food production. The SUFIA model is a universal tool that can be applied in any urban farms around the world, mostly tropical regions. The SUFIA model can benchmark the food productivity of urban farms with best practices. It aids to benchmark operational measures of appraising and performance of food production in urban farms with respect to the identified criteria and sub-criteria. Furthermore, the SUFIA model is an integrated model that can be applied at two main decision-making stages; i) the strategic decision-making stage (which has a long-term effect; examples include urban-farming infrastructure development, urban-farming facilities investment, etc.), and ii) the tactical decision-making stage (which has a medium-term effect; examples include resource management, food-cropping systems, etc.). The SUFIA model facilitates the decision-making processes of local-level policy-makers and local authorities. The model promotes; 1) a systematic group collaborative decision-making towards a common goal, 2) a committed effort of policy-makers and stakeholders to collectively frame development criteria, and 3) an established mechanism to build planning consensus based on policy-makers' preferences. By implementing this model in different cities, not only urban developers can inspire food and crop production, but they can also make a place for people to visit, recreation, sightseeing, leisure, education, and other pursuits. Additionally, the model can bring people closer to nature and allow them, especially the younger generations, to experience farm life. The criteria and sub-criteria of the SUFIA model would be adapted to the target urban and region for the localized environmental, social, cultural, and economic characteristics. Hence, the list of criteria and sub-criteria would be localized, modified, and adjusted.

The research is subject to some limitations. Eighteen features (including three criteria and fifteen sub-criteria) have been compared pair-wisely. Indeed, using more than eighteen features was found to be very complicated and complex for the AHP method application and expert inputs. Also, the SUFIA model is such a universal tool that can be applied in any urban area, while the features would be more adapted to tropical regions (like Malaysia). Therefore, the features can be adjusted to the respective environment, for instance, in terms of urban development policies, climate conditions, culture, etc.

In model development, the research has conducted an exploratory analysis to determine the weight of each feature using the AHP decision-making method. In future works, the AHP method can be coupled with other methods; for instance, GIS, Fuzzy, SEM (structural equation modelling), SNA (social network analysis) and so on. Coupling with different methods can reduce inconsistencies and errors while increasing certainty and accuracy. Although it may never end, this research can be expanded to more advanced scientific and practical decision-making applications. In the future, this model can be upgraded as a computer-based and/or web-based decision support system for processing, recording, and publishing information to decision-makers and policy-makers.

The adoption of this model makes a consolidated involvement of decision-makers and stakeholders towards sustainability and sustainable urban development. The end-users of this model are both professionals and practitioners; urban developers, urban designers and planners, landscape planners, consultants, authorities, contractors, and academicians, who may use the research outputs for their actions.

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