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URBAN FARMING PRACTICE CONCERNING LIFE CYCLE COST COMPONENTS

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Abstract

Urban farming (UF) has become popular, and several cities are trying to enhance sustainability by improving urban greenery and urban farming. In addition to supporting food security within the area, it benefits the people's health and well-being and the surrounding environment. This results in a shifting of time consumption from spending time outside, like travelling and shopping, to commuting to activities within home boundaries. Therefore, UF is becoming an activity for residential communities besides working and studying. Therefore, this paper aims to identify the significant Life Cycle Cost (LCC) components concerning the UF practices. The objective of the research is to establish the attributes of UF practice throughout the LC phase. Hence, the findings of the paper indicate the conceptual framework for LCC components concerning the UF practices which are beneficial to practitioners. To achieve this aim, previous studies on types, techniques, and components of UF technology and practices throughout the LC phase, have been explored in both local and international contexts. Thirteen (13) papers from journal and conference papers were reviewed to determine the LCC components of UF according to life cycle (LC) phases. The attribute placed in the respective phase is based on thematic techniques. The paper's findings indicate that the LCC components occur during Planning, Installation, Management, Maintenance, and Harvesting/ Disposal.

Keywords: Aeroponics, Aquaponics, Conceptual Framework, Hydroponics, Life Cycle Cost Component

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INTRODUCTION

The population has moved and concentrated in urban areas due to urbanisation. According to estimates, 9.7 billion people will inhabit the planet by 2050, with a third of them living in cities (Al-Kodmany, 2018; Hussain et al., 2019; Li et al., 2020; Nafisi et al., 2020). Hussain et al. (2019), Li et al. (2020) and Nafisi et al. (2020) stressed that food security and climate change are the primary impacts of urbanisation. Ahmad et al. (2023) added that Malaysia's rapid urbanisation is endangering the country's green space, particularly its protected areas. Urban green areas in Malaysian cities are still being converted for housing, industry, and transportation infrastructure, even if the amount of green space per capita is decreasing. This trend contributes to environmental problems associated with climate change, such as landslides, floods, air pollution, and rising temperatures. However, areas of green cover must be identified, maintained, and protected since they are essential for supplying ecosystem services, improving the quality of life for urban populations, and balancing the continued expansion of built-up areas. Ivascu et al. (2021), and Marzuki and Jais (2021) confirmed that UF is a new, gradually emerging trend that has the potential to solve the growing food insecurity crisis. Instead of food security, incorporating urban farming into urban planning and design can contribute to the overall liveability of cities. It not only provides environmental benefits by promoting sustainability but also enhances the visual and social aspects of urban spaces (Ahmad et al., 2023). Nevertheless, due to higher initial costs, urban farming must produce adequate high-quality yields, be profitable, protect the environment, and be socially responsible long-term (Keyvenvar et al., 2020). Therefore, this paper aims to establish the conceptual framework that is significant to life cycle cost (LCC) components concerning the UF practices.

LITERATURE REVIEW

Scenario of Urban Farming in Malaysia

UF can be defined as increasing the global food supply without relying on further land clearing as it utilizes the urban area to grow crops. It commands a significant commerce level, making it more than homesteading or subsistence farming. Integrating food production with buildings offers an avenue that does not impinge on the city's many uses for available land. Urban agriculture changes the entire cultivation system to suit the urban environment. More technologically advanced tools are needed to aid farming activity because cities have a different environment than conventional farming areas. In the past decade, investments in agriculture technology have increased dramatically, with $6.7 billion invested in the last five years and $1.9 billion in 2018. Modern agriculture practices suit the Urban Agriculture concept and can be used to increase food production within the city area. Moreover, UF has economic, social, and environmental benefits.

Table 1: UF Project in Malaysia

Location	**UF System/ Plant**	**Source(s)**
Madrasah Tahfiz Raudhatul Baiduri, Bukit Changgang, Banting (2022) 	**UF System:** Hydroponic System **Plant:** Rock melon	Harian Metro (2022), *Projek Rock Melon Hidroponik TKHM-Agrobank mula keluarkan hasil [METROTV],* https://www.hmetro.com.my/mutakhir/2022/01/799213/projek-rock-melon-hidroponik-tkhm-agrobank-mula-keluarkan-hasil-metrotv Date accessed: January 21, 2023
Kebun Komuniti 1 (Taman Rimba Desa Presint 9), Kebun Komuniti 2 (Presint 8), Kebun Komuniti 3 (Presint 9) and Kebun Komuniti 4 (Presint 14) (2008) 	**UF System:** Hydroponic System Fertigation **Plant:** Vegetables Chili Rock melon **Program Initiator:** Program Pertanian Bandar Putrajaya	Inspirasi Destinasi Menarik Percutian Impian (n.d), *Urban Farming Komuniti Presint 9 Putrajaya,* http://destina.my/urban-farming-komuniti-presint-9-putrajaya/ Date accessed: January 21, 2023
Kebun Komuniti Garden 8, Taman Perwira Gombak (2021) 	**UF System:** Hydroponic System **Plant:** Vegetables Herbal Plant Flower **Program Initiator:** University Community Service (UCS), Universiti Putra Malaysia.	DagangNews.com (2022), *Kebun Komuniti UPM capai kejayaan bersama penduduk Taman Perwira*, https://www.dagangnews.com/kebun-komuniti-upm-capai-kejayaan-bersama-penduduk-taman-perwira-18945 Date accessed: January 21, 2023
Location	**UF System/ Plant**	**Source(s)**
Balai Bomba Dan Penyelamat, Temerloh (2021)	**UF System:** Hydroponic System Fertigation	Sinar Harian (2022), *BBP Temerloh manfaat kawasan terbiar usahakan kebun hidroponik*,

	**Plant:** Vegetables **Program Initiator:** Program Pertanian Bandar Kategori Kebuniti	https://www.sinarharian.com.my/article/202693/edisi/bbp-temerloh-manfaat-kawasan-terbiar-usahakan-kebun-hidroponik Date accessed: January 21, 2023

Since 2008, the "Bumi Hijau" program has existed in Malaysia. Putrajaya Corporation launched the “Kebun Komuniti Programme,” a community gardens project involving the citizens of Putrajaya. The initiative has positive outcomes and enhancement. Interaction through community engagement. The community garden used traditional beds and irrigation for farming at the beginning of the program. Two greenhouses were built at the Community Garden by the end of 2013, an initiative to enhance the Community Garden in Putrajaya.

Urban Farming Project in Malaysia
Table 1 shows the implementation of UF in Malaysia since 2008 to 2022. The UF become popular in Malaysia, as it is available in improve technology, easy to handle and good quality of the product.

Urban Farming (UF) Types and Techniques
Urban farming refers to growing crops and raising livestock in cities and other urban areas. Urban farming is incorporated into the urban ecosystem to feed the surrounding population (Murdad et al., 2022). It has been implemented on grounds, vertical farming, and rooftop farming. Each type includes several UF techniques: hydroponic, aeroponic and aquaponic (Portal Rasmi Jabatan Pertanian, 2023).

Hydroponic
According to Al-Kodmany et al. (2018), and Khan and Vadsaria (2020), the term hydroponics is derived from the Greek words hydro and ponos, which translates to “water” and “labor,” presenting “water doing labor” or “water works.” Hydroponics is a cultivation technique that employs nutritive solutions for plants’ growth with or without inert media or substrates. It involves growing plants with nutrients solution and a soil-less manner. The plant roots are submerged in a nutrient solution that is frequently monitored and circulated to maintain the proper chemical composition (Birkby, 2016; Al-Kodmany, 2018). The primary objective of hydroponics is to supply the ideal nutritional environment for

optimum plant performance in any climate (Khan, 2020). The method has successfully produced vegetables, such as onions, lettuce, and radishes.

Aquaponic

Aquaponics is an intensive fish-vegetable production system that combines aquaculture with plant production in a hydroponic system. Aquaponics can be set up in different ways, but the basic principle is that fish are raised in tanks, and part or all of the wastewater containing excreted nutrients is then circulated to the hydroponic plant production system. The plants absorb the water and nutrients, clean it, and return it to the fish tanks (Birkby, 2016).

Aeroponics

Aeroponics is the science of plant cultivation without incorporating soil or a substrate culture. Where the plant grows in the air with artificial support, and no soil or substrate is required to support the plant. In the air-water culture cultivation system, the plant roots are hung inside a sealed container under darkness and openly exposed in the air to receive water nutrient-rich spray via atomizers. The plant leaves' upper portion and crown extend above the wet zone. The artificially provided structure separates the root and canopy of the plant. The system uses nutrient-enriched spray in the air using pressure nozzles or foggers to sustain hypergrowth under controlled conditions (Lakhiar et al., 2018).

Life Cycle Cost Component for Urban Farming (UF)

Life cycle cost components refer to the various cost categories involved in the entire lifespan of a product, system, or project. The LCC phase for UF needs to be identified to come out with the LCC component (Opawole et al., 2020). Figure 1 displays the mapping of the UF Phase to the LCC Stage.

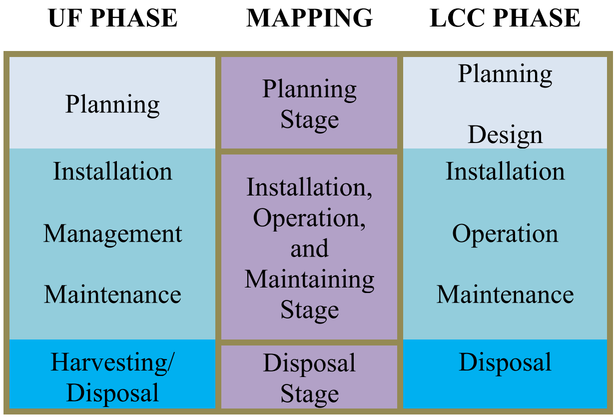

Figure 1: UF Phase Concerning LCC Phase
Source: UF Phases: Hamidon et al. (2020) and Medina-Salgado, García-Muiña, Cucchi & Settembre-Blundo (2021); Source: LCC Phase: Miah, Koh & Stone (2017)

RESEARCH METHODOLOGY

Academic journals and conference papers in online databases use to produce the conceptual framework. There are four phases involve. Phase 1 is the **identification**. This phase was where a rigorous search of topics related to urban faming. There were 443 articles discovered using the search string and these were limited to English language articles from the year 2017 to 2022 that covered the subject of urban farming. Second phase is **screening**. In this phase, the identified literature was screened according to the suitability of the topic (Sidrotul et al., 2022) remarks that the screening includes exploring the topic and abstract of the papers. At this phase, 60 manuscripts were reviewed, and only 16 were found to be eligible for this paper's review. In the next phase **eligibility**, only 13 papers were selected for the analysis after being thoroughly analyzed in the eligibility phase. The final phase is Phase 4: **Data Abstraction**, Table 2 shows the thematic analysis result that was tabulated in the data abstraction phase based on the data from the 13 selected literatures by identifying relevant or intriguing trends in the data.

ANALYSIS AND DISCUSSION

Table 2 displays the LCC Component in relation to UF Practices based on the reviewed paper. There are five main phases in UF: the Planning Stage, Installation, Management, Maintaining Stage, and harvesting stage.

Table 2: Life Cycle Cost Component in Relation to UF Practices

LIFE CYCLE COST COMPONENT IN RELATION TO URBAN FARMING	Dorr et al., (2017)	Li et al. (2020)	Sanjuan-Delmás et al. (2018)	Vinci & Rapa (2019)	Farhana & Salim (2020)	Keyvanfar et al. (2020)	Hamidon et al. (2020)	Yusoff et al. (2017)	Zainal & Hamzah (2018)	Ramaloo et al. (2018)	Mah et al. (2018b)	Zheng et al. (2019)	Gou et al. (2013)	TOTAL FREQUENCY (f)
	Malaysia	Malaysia	Malaysia	Malaysia	Malaysia	Malaysia	Malaysia	Malaysia	Malaysia	Malaysia	Shanghai	New York	Shanghai	
PLANNING														
Training and workshop							●	●	●	●				4
Technology and techniques		●			●		●	●	●	●			●	7
Transportation										●				1
Capital					●		●	●	●	●			●	6
Planting area		●			●					●		●		4
Available resources or facilities		●			●	●	●	●	●	●	●		●	9
Type of Crop		●			●	●	●	●	●	●	●		●	9
INSTALLATION														
Auxiliary equipment	●		●			●			●			●	●	6
MANAGEMENT														
Seeding		●			●	●	●		●		●	●		7
Water consumption	●		●	●		●	●			●	●	●	●	8
Electrical consumption			●				●				●			3
Fertilizer	●	●	●			●	●				●	●	●	8
Pesticide		●			●	●	●				●	●		6
MAINTENANCE														
Monitoring and inspection	●					●	●		●		●	●		6
Sensor calibration	●										●	●		3
Irrigation system maintenance					●	●	●				●	●		5
Pest and disease management					●		●							2
Nutrient management							●				●	●		3
HARVESTING														
Auxiliary equipment disposal	●													1
Output		●	●	●		●	●						●	6
Substrate production	●			●		●	●		●		●	●		7

Planning

Table 2 lists the most prominent LCC component. During the initial stage, the attributes with the highest scores are the availability of resources or facilities and types of crops, each with a score of f = 9. They are closely followed by selecting suitable technology, techniques, and capital, with scores of f = 7 and f = 6. Meanwhile, training, workshop, and land area all have scores of f = 4. The lowest frequency of UF practice attributes is transportation, with a score of f = 1. As a result of the analysis, the practitioner seeks to collect the database to predict the project's feasibility during the planning stage. The data collection stage is essential before starting any UF project (Li et al., 2020).

Moreover, suitable site design and selection are crucial during the beginning stage. The data will assist in deciding the suitable technology or system to be used, suitable areas to place the UF system, and types of crops that benefit them. Ramaloo et al. (2018) urged the responsible authorities, such as Municipal and City Councils and the Department of Agriculture, to train the farmers on the appropriate technology and technique and estimate spending expenses for UF activity. Detailed planning and initial input are required to assist the decision-making due to cost implications. This is in line with Keyvanfar et al. (2020); Li et al. (2020) and Vinci et al. (2019), who agreed that the UF technique requires high initial capital investments and proper data collection must occur before selecting the technique and technology.

Installation

Table 2 presents the activity that usually occurs during installation. The frequency for installing the UF-selected technologies is f = 7. It is the only attribute during installation. During installation, the practitioner must be familiar with the equipment required for the selected techniques, such as substrates, pots, and all necessary equipment, such as netting, wood Pine sawn wood, and geotextile polypropylene (Dorr et al., 2017). UF consists of various techniques; each technique has specific equipment to fit with the function of the techniques. The supplier must install the equipment to ensure all the parts are properly connected and according to the manual. The testing must be conducted to ensure the equipment can function accordingly after completion. The life cycle of the equipment can be maximized if the practitioner handles it with care.

Management

Table 2 displays the important LCC components during the management phase. The highest-ranked attributes are water consumption and fertilizer, with scores of f = 8. They are closely followed by seeding and substrate production, with scores of f = 7. Meanwhile, pesticide scores f = 6, while the lowest frequency of UF practice attributes is electric consumption during the management phase, with a score of f = 3.

Management are the crucial and longest phase compared to the other LC phases. The phase begins with the seeding process. The seeding must be conducted according to the types of crops. During the plant's growth period, which lasts between three weeks and three months, it must be periodically watered, fertilized, and treated with pesticide to ensure it receives sufficient nutrients and is protected from pests and insects. Watering equipment, such as irrigation pipes and tap water, should be considered (Dorr et al., 2017; Hamidon et al., 2019). Instead, Hamidon et al. (2019) added that the plant's temperature, electricity, and water pH should be monitored to ensure the plant's even growth. Vinci et al., (2019) highlight the benefit of applying technology-based UF due to the proper monitoring. For example, hydroponic techniques allow a high control of energy, nutrients, and pesticides. Ideally, it can guarantee even plant growth and reduce waste and resources by automatizing the system.

Maintenance

Table 2 displays the important LCC components during the maintenance phase. The highest-ranked attributes are monitoring and inspection, with scores of f = 6. They are closely followed by irrigation system maintenance, with scores of f = 5. Meanwhile, sensor calibration and equipment maintenance scores f = 3 respectively, while the lowest frequency of UF practice attributes is pest and disease management, with a score of f = 2.

Maintenance plays a crucial role in ensuring the success and longevity of smart urban farming systems. Dorr et al. (2017), Hamidon et al. (2020), Keyvanfar et al. (2020), Mah et al. (2018a), Mah et al. (2018b), Zainal and Hamzah (2018), Zheng and Lyu (2019) agreed that UF required regular monitoring and inspection. Therefore, implement a schedule for regular monitoring and inspection of the smart farming infrastructure, including sensors, automation systems, irrigation systems, and environmental controls. Follow maintenance schedules, clean or replace filters, and ensure proper functioning of equipment. Timely maintenance reduces the risk of equipment failures and maximizes operational efficiency. This allows for early detection of any issues or malfunctions and enables prompt corrective action.

In addition, maintain and clean irrigation systems to ensure proper water delivery to crops. Regularly check for clogs, leaks, or malfunctioning components. Adjust irrigation schedules based on crop requirements and seasonal changes. Proper maintenance of irrigation systems promotes optimal plant health and water efficiency (Farhana & Salim, 2020; Hamidon et al., 2020; Keyvanfar et al., 2020; Mah et al., 2018b; Zheng et al., 2019). According to Dorr et al. (2017), Mah et al. (2018b) Zheng et al. (2019) calibrate sensors regularly to ensure accurate data collection and monitoring. Check sensor performance, replace batteries if necessary, and clean sensors to prevent interference or inaccurate readings. Proper maintenance of sensors is vital for reliable data-driven decision-making. Moreover, Mah et al. (2018b) and Zheng et al. (2019) added that management of nutrients is also crucial. If using hydroponic or nutrient delivery systems, monitor and maintain nutrient levels according to crop requirements. Regularly check nutrient solution pH and conductivity, and adjust as needed. Keep nutrient tanks clean and well-maintained to prevent contamination or nutrient imbalances.

On the other hand, integrated pest management strategies need to be implemented to prevent and manage pest and disease issues. Regularly inspect plants for signs of pests or diseases and take appropriate action, such as using organic pest control methods or biological agents. Prompt identification and treatment can prevent major infestations and crop losses (Farhana & Salim, 2020) and (Hamidon et al., 2020). In short, proper management and maintenance practices are crucial for maximizing yield, minimizing losses, and ensuring the overall success and sustainability of an urban farming project. Through careful monitoring, adjustment of environmental conditions, and the use of appropriate technologies, farmers can optimize plant growth, resource utilization, and productivity.

Harvesting/ Disposal

Table 2 represents the auxiliary equipment disposal and output scores of f = 6 and f = 1, respectively. According to Hamidon et al. (2019), the seed can be harvested between three weeks and three months. After harvesting, the waste, such as the plant's root, should be disposed of. The output of the product will be calculated. Dorr (2017) added that waste, such as plastic irrigation pipes, netting, drip tape, and geotextile membranes, would be reused at the other site, while the non-recycle waste must be dumped in a legal landfill. The practitioners must be aware of the practices involved throughout the LC Phase, as each practice is the LCC component for the UF works. There are 21 significant LCC components listed according to the theme/ LC phase for UF.

FINDINGS

Figure 2 displays the connection of LCC components relating to UF practice throughout the LC phases. The framework contributes to the practitioner to understand the whole process involved, from the planning stage to the harvesting and disposal of the UF technology. Integrating life cycle cost analysis into the planning aspect of the built environment helps ensure that projects are financially sustainable, cost-effective, and aligned with long-term goals. By considering both initial and ongoing costs, practitioner can make informed decisions that lead to more resilient, efficient built environments and cost effective. According to Keyvanfar et al. (2020), Li et al. (2020) and Vinci et al. (2019), the UF technique requires high initial capital investments, and proper data collection should be conducted before selecting the technique and technology to ensure the feasible and successful of the project. Although the initial capital is high, Hamidon (2019) mentions that the UF can provide greater production and return yield. Hence, the attributes have the potential to be integrated with the LC cost for each practice.

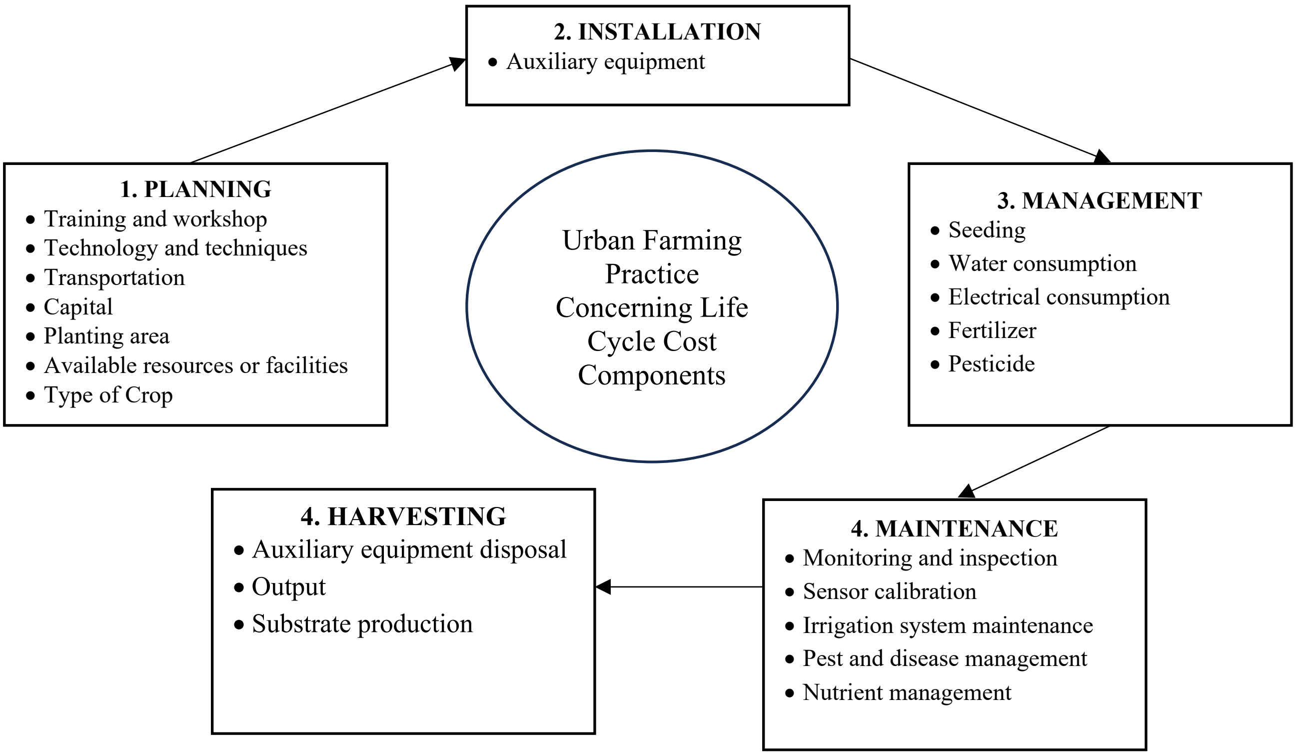

Figure 2: Conceptual Framework for Urban Farming Practice Concerning Life Cycle Cost Components

CONCLUSION

UF is the best practice in the current world's situation and population. As mentioned earlier, resources, such as land and water, become scarce and limited due to the increasing population in cities or urban areas. As a solution, UF technology was introduced to cater to the space, resources, and limited time problem among urban dwellers. However, UF can improve the dweller's well-being, neighbourhood relationships, stress level, and economy and provide healthy food sources. Therefore, this study has listed the attributes of UF practice that occur during Planning, Installation, Managing, Maintenance, and Harvesting/ Disposal. The knowledge of the process and the equipment required are important to guarantee the viability of the UF technology because many activities are involved throughout the LC.

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