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Harvesting High-Rises: A Comprehensive Review of Urban Farming Practice and Impacts in Malaysian Buildings

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Abstract: *Malaysia has started to implement urban agriculture in cities as urban farming is more than just growing food in the city. It also integrated into the city's economic, social, ecological, and physical infrastructure systems. Despite its numerous advantages, it also has drawbacks that may affect the building conditions and the occupants because of inefficient management practice. This implies that building managers and urban planners must take into account the implications of urban agriculture when undertaking such projects, and adapt them to suit existing building conditions. Thus, this paper aims to study the current practise and the impact of urban farming towards the occupants and the building conditions. Therefore, a literature review was carried out to reach the study's aim. The study's findings indicate that the negative impact of urban farming on buildings and occupants can be reduced with effective maintenance practices. These results may help guide future research, which should focus on developing a more nuanced understanding of the relationship between urban agriculture and building management efficiency, allowing for the development of effective strategies for implementing urban farming that can mitigate the impacts of climate change in urban areas.*

Keywords: urban farming, building manager, maintenance

1. Introduction

Urban agriculture has been widely implemented in a worldwide as a significant strategy to improve food security. Malaysia, like many other countries, is also taking part in urban farming initiatives. Urban farming is more than just growing food in the city; it is integrated into the city's economic, social, ecological, and physical infrastructure systems (Veenhuizen et al., 2006). Aside from providing healthy food and strengthening community relationships, urban farming has contributed into the city's economy by generating income for households, assisting in lowering food costs, and creating job opportunities (Ackerman et al., 2014). In certain instances, urban agriculture is the sole reported source of income for households, underscoring its significance in mitigating poverty and promoting economic resilience (Graefe et al., 2008; Van Averbeke, 2007). By reducing the financial strain on households, urban agriculture can enable them to allocate their resources toward other essential items (Van Averbeke, 2007). As for the city's social perspective, urban agriculture is frequently touted as a tool for promoting community empowerment and providing urban residents in underserved areas with greater opportunities to participate in food production and procurement, particularly in light of growing concerns around social justice issues (Mees & Stone, 2012). In addition to their agricultural activities, bigger urban farms actively engage in community enrichment initiatives, such as job

training and development of skills, and educational programs, which are designed to benefit underserved populations and promote social equity. The inclusion of urban agriculture can be a key factor in promoting environmental sustainability within a city, serving as a form of green infrastructure. By establishing urban farms and community gardens, cities can address issues such as the urban heat island effect, reduce the impact of urban stormwater, and decrease the energy expended on food transportation (Ackerman et al., 2014). By practising urban farming, cities can experience an array of positive effects such as improved microclimate, conserved soils, reduced waste, better nutrient recycling, enhanced water management, increased biodiversity, and heightened environmental awareness among city dwellers (Deelstra & Girardet, 2000).

Urban farming's advantages have been highlighted in a variety of articles. However, there are relatively few studies that have explicitly highlighted the drawbacks of urban farming, which can potentially impact building conditions and occupants (Jha Ritesh Kumar et al., 2019). The current study will contribute to the literature by discussing urban farming's drawback impacting buildings and the occupants. The objective of this study is to present: 1) the current practice of urban farming and 2) the impact of urban farming towards the occupants and the building conditions.

2. Literature Review

2.1 Current practice of urban farming in Malaysia

Malaysia, being in a tropical region, faces a hot and humid climate all year round with consistent high temperature and humidity levels. Buildings in such regions are exposed to this typical climate with little seasonal variation and a constant annual average (Mirrahimi et al., 2016). This is also supported by Azhari et al. (2008) stating that solar radiation in Malaysia falls between 4.96 to 5.56 kWh/m2, and according to the Malaysian Meteorological Department, Malaysia receives average four to nine hours of sunshine every day throughout the year. With abundant sunlight in Malaysia opens up opportunities for urban farming, such as vertical farming, that can be comprehensively merged into buildings. Retrofitting existing buildings with vertical farming is a widespread practice that commonly involves integrating vertical farming onto commercial, office, or high-rise residential buildings. Vertical farming is regarded as a type of building-integrated agriculture that enables cultivation to take place in a multi-story building, on a building's rooftop, or in open spaces such as interiors, balconies, or façades. This method allows natural sunlight to enter through glasshouses or greenhouses to support plant growth. (Sengodan, 2022).

Despite being in the early phase of urban farming green roof implementation, Malaysia has already established a successful pilot project called the rooftop paddy field, which involves cultivating rice, a staple food in Malaysia. The initiative, known as the "Rice Garden," was established in the late 1990s and is located in Langkawi (Zahir et al., 2014). With this kick start, Malaysia has started building several buildings with these green roofing features, as shown in Table 1 below

Table 1: List of Malaysian green roof buildings (Source: Sengodan, 2022; Zahir et al., 2014)

Building	Type of Building	Year
Rice Garden Museum (Laman Padi), Langkawi.	Educational	1998
Ministry of Finance, Putrajaya.	Office	2002
Putrajaya International Convention Centre (PICC).	Convention Building	2003
Malaysian Design Technology Centre (MDTC), LKW, Cyberjaya.	Office	2004

Serdang Hospital.	Hospital	2005
Faculty of Social Sciences and Humanities, UKM.	Institutional	2007
Sime Darby Oasis, Damansara.	Office	2009
KL Sentral Park @ Platinum.	Office	2009
Newcastle University Medicine Malaysia, Nusajaya.	Institutional	2011
Laman PKNS, Shah Alam.	Office	2013
The ARC, Bandar Rimbayu	Community Centre	2015
Heriot-Watt University, Putrajaya.	Institutional	2015
Acapella Hotel Suite	Hotel	2015
Tun Razak Exchange (TRX), Kuala Lumpur	Office	2019

The inclusion of green roofs and facades have become increasingly prevalent in the design of modern high-rise buildings in urban areas, with the government playing a role in promoting sustainable development. While high-rise urban farming is a promising approach, it presents certain difficulties when it comes to growing edibles. The proximity of high-rise buildings means that some façades or levels of the building may not get enough sunlight to support vegetable cultivation, leading to lower photosynthesis rates and crop yields (Song et al., 2018).

2.2 Impact of urban farming towards building and occupants

Various researchers have looked at the benefits of urban agriculture in different contexts, including environmental, economic, and social factors. For example, planting indoors can provide health benefits to household residents in addition to improving environmental conditions (Zaid et al., 2018). According to Smith & Pitt (2011), plants can enhance interior air quality by simultaneously raising air humidity by the production of water vapour from small pores on the leaves called stomata and releasing oxygen via light-dependent photosynthesis, while continually eliminating carbon dioxide. Vegetation used in a Vertical Greening System (VGS) contributes to the air quality by producing oxygen through photosynthesis. Additionally, these plants provide natural insulation and help to regulate temperature while their sound-absorbing properties can help to mitigate noise pollution (Bakar et al., 2013; Wang et al., 2016). In addition, the choice of plants used to reduce air pollution in a building should be taken into account. It not only depends on their air-cleaning capabilities, but also on their growth characteristics, ease of maintenance, and lighting needs (Smith & Pitt, 2011). The mental well-being and serenity of building occupants are believed to be significantly influenced by the presence of plants. Research has also demonstrated that plants can have tangible positive effects on occupants of living and working spaces (Mahyuddin et al., 2022). Earlier research has demonstrated that indoor plants can boost the productivity of office workers in spaces without windows (Lohr et al., 1996). Additionally, other studies have revealed that incorporating indoor plants in classrooms can result in higher final grades for students, psychological relaxation, create a positive impression of the course, and induce physiological (Benfield et al., 2015; Igarashi et al., 2015).

From an economic standpoint, urban farming can provide a source of income for building tenants who sell their produce, create employment opportunities (Diehl et al., 2020; Smith, 2013) and reduce the cost of produce transportation (Benis & Ferrão, 2017). Implementing sustainable agriculture practices can also reduce operating costs, save energy, and improve building efficiency (Diehl et al., 2020; Sam & Hui, 2011). According to Sengodan (2022), urban consumers have a higher demand for food quality, leading to increased food imports, which negatively affect trade balance and consumer prices, resulting in higher prices of fruits and vegetables. To address this, various urban farming techniques have been developed, such as genetically modified seeds, soilless cultivation, and biofortification (Benke & Tomkins,

2017; SharathKumar et al., 2020; Zeidler & Schubert, 2017), to increase indoor farming production in line with urban population growth (Sengodan, 2022). These green features can also have financial benefits, as green infrastructure can increase property values and marketability of nearby real estate (Jha Ritesh Kumar et al., 2019; Sam & Hui, 2011).

Through the use of VGS, the environmental advantages of urban agriculture provide protection for building facades against damage from high temperatures and precipitation. (Bakar et al., 2013). This can lead to a longer lifespan for building facades and reduced maintenance costs (Wong & Baldwin, 2016). Other than that, by incorporating agricultural practices in urban areas, there is an opportunity to indirectly enhance urban water management. The inclusion of green spaces with permeable land surfaces can facilitate the absorption of rainwater and runoff through the soil. This is particularly valuable because of the expansion of hard-surfaced areas in cities, such as parkings, roofs, and streets, which exacerbate the amount of runoff during storms and increase the risk of flooding and landslides. The need for costly storm water sewers and drainage systems can be reduced by having enough green space provided. As a result, funding urban agriculture is equally as important as building a system of channels and drains. (Deelstra & Girardet, 2000).

Besides having the benefits of urban farming, there are also some impacts of this activity that should be considered. Proper planning is essential when installing vertical farming on existing rooftops, similar to ground-level greenhouse construction. This includes assessing the building's roof capacity to ensure that it capable of sustaining the load of the equipment, personnel, and farm (Whittinghill & Starry, 2016). When installing vertical farming on commercial rooftops, HVAC units and other building utilities can take up a portion of the space, restricting the available area for vertical farming. Additionally, the use of greenhouse structures can place extra load on the rooftop. Hence, it is necessary to perform a building safety and integrity check that must be approved by the city council before any vertical farming can be established (Astee & Kishnani, 2010; Sam & Hui, 2011). To support these statements, Jha Ritesh Kumar et al. (2019) conducted a survey to identify reasons for low levels of participation in rooftop farming activities. It turns out, 31.66% of respondents are hesitant to use soil as a growing medium on their roofs due to concerns about the added weight, which could lead to seepages in the roof. Homeowners are also apprehensive about the possibility of ceiling and roof dampness. Researcher Udawattha et al. (2018) supported that leaky roofs can lead to interior mould growth. Additionally, many studies have shown that green roofs have had failures in the past due to various reasons. These include the complexity and difficulty of maintenance, fear of unknown risks, susceptibility to fire, limited awareness of green roof technology, limited local expertise on green roofs, limited local scientific research, lack of design standards and guidelines for contractors and developers, high construction and maintenance costs, lack of incentives from the government, and high material supply costs (Mahdzir et al., 2020; Braithwaite, 2012; Ezema et al., 2016; Ismail et al., 2012; Williams et al., 2010; Zahir et al., 2014; Zhang et al., 2012)

Meanwhile, Deelstra & Girardet (2000) advise against planting crops within ten metres of busy roadways, especially in nations where leaded fuel is still used, as there is rising concern about the viability of contaminated urban land for food production. Special measures must be taken while working on land that has been contaminated with heavy metals like cadmium and lead. There are also concerns about the effects of urban agriculture on water resources, with the potential for increased levels of pesticides in groundwater being a particular issue. The use of certain pesticides or fertilisers in the urban farm could also have an impact on indoor air quality. There also have been studies that have investigated the impact of urban farming on building

conditions. Some studies have looked at the effect of indoor agriculture on indoor air quality. For example, unlike vertical greenery, which is usually placed on a solid wall, vertical planting is located in the porous part of the building (for example, on the balcony), which is very important for the natural ventilation of the building. It has been shown that the planting can worsen the natural ventilation due to the additional resistance to the air flow (Yuan et al., 2019). Besides, there have also been reports of negative impacts associated with indoor agriculture, including moisture damage and mould growth. Arizzi et al. (2015) reported that mould growth in indoor agriculture facilities can have serious consequences on indoor air quality and building-related health issues. The most dangerous mould species, which can be found in indoor agriculture settings, can release small particles that can cause a range of health problems. The particle size of mould spores can be a significant factor in the severity of health effects.

In accordance with earlier findings, Tables 2 and 3 summarize the compiled data. Table 2 lists 9 benefits and impacts of urban agriculture along with brief descriptions. These factors are considered important and should be taken into account when managing urban farming applications.

Table 2: Abbreviation and description of the urban farming impacts

Abbreviation	Positive Impact
IAQ	Improve air quality
HP	Improve human psychology
NP	Mitigate noise pollution
EO	Create employment opportunities
RC	Reduce cost
NT	Develop new technique of farming
PV	Increase property values
BF	Protect building facades
WM	Enhance urban water management
Abbreviation	**Negative Impact**
BR	Effect building's roof capacity
LR	Leaky roof/seepage
MG	Mould growth
DM	Difficulty of maintenance
UR	Fear of unknown risks
SF	Susceptibility to fire
MC	High construction and maintenance costs
CL	Contaminated urban land
IV	Impact ventilation

Table 3 offers a summary of past studies that have examined the positive and negative impacts of urban agriculture, using the abbreviations and descriptions provided in the prior section.

Table 3: Impacts of Urban Farming

Source	Positive Impact									Negative Impact								
	IAQ	HP	NP	EO	RC	NT	PV	BF	WM	BR	LR	MG	DM	UR	SF	MC	CL	IV
Zaid et al., 2018	/																	
Smith & Pitt 2011	/																	

Bakar et al., 2013		/					/										
Wang et al., 2016		/															
Mahyuddin et al., 2022	/																
Lohr et al., 1996	/																
Benfield et al., 2015	/																
Igarashi et al., 2015	/																
Diehl et al., 2020			/	/													
Smith, 2013			/														
Benis & Ferrão, 2017				/													
Sam & Hui, 2011				/		/			/								
Sengodan, 2022																	
Benke & Tomkins, 2017					/												
SharathKumar et al., 2020					/												
Zeidler & Schubert 2017					/												
Jha Ritesh Kumar et al., 2019						/			/	/							
Wong & Baldwin, 2016							/										
Deelstra & Girardet, 2000								/								/	
Whittinghill & Starry, 2016									/								
Astee & Kishnani, 2010									/								
Udawattha et al., 2018										/	/						
Mahdzir et al., 2020												/	/	/	/		
Braithwaite, 2012												/	/	/	/		
Ezema et al., 2016												/	/	/	/		
Ismail et al., 2012												/	/	/	/		
Williams et al., 2010												/	/	/	/		
Zahir et al., 2014												/	/	/	/		
Zhang et al., 2012												/	/	/	/		
Yuan et al., 2019																	/

Arizzi et al., 2015	/

The compilation of findings on urban farming highlights several benefits, including improvements in air quality and human well-being, noise pollution mitigation, job creation, cost savings, the development of new farming techniques, increased property values, and enhanced urban water management. However, it also summarizes some of the potential impacts of urban farming, such as the effect on building roof capacity, leaky roofs and seepage, mold growth, maintenance difficulties, fear of unknown risks, susceptibility to fire, high construction and maintenance costs, contaminated urban land, and impact on ventilation.

3. Methodology

This paper conducted a literature review to identify journal articles that discussed the impact of urban farming on buildings and tenants. The paper presents a review of the literature from the year 2000 to the year 2022. Literature relating to urban farming implementation and its impact was obtained from Scopus, ProQuest, Web of Science, Research Gate, Science Direct, Google Scholar and other websites. The researchers began the process of reviewing the literature by conducting a search on Google Scholar's multi-database, cross-disciplinary online citation services using the following key words: "urban farming," "urban agriculture," "impact of urban farming on buildings," "types of urban farming," and "green roof." The selection of keywords was guided by the researchers' knowledge of urban farming and its impact on buildings. The researchers also carried out literature reviews based on citation tracking, also known as "snowballing." This involved taking into account publications that were cited by other researchers and conducting citation analysis using resources such as Scopus, ProQuest, Web of Science, Research Gate, Science Direct, or Google Scholar.

Only research that was relevant to the topic of urban farming and its effects were considered for this study; as a result, a total of 44 papers was found to be relevant to the topic. The following is the structure for this article: The introduction, current practice and our approach in conducting our research are covered in Sections 1 and 2, respectively, in order to supply the reader with the necessary conceptual understanding. The third section focuses on the impact of urban farming development and implementation in Malaysia. This study will be strengthened by the results as well as the recommendations for the direction of future research.

4. Results and Discussion

The study presented here stems from the consideration that, to date, there have been limited studies to discover the maintenance issues of intensive urban farming as a guideline for management practice, especially in the Malaysian context. Most of this research has focused on the benefits associated with urban farming (Al-Kodmany, 2018; Diehl et al., 2020; Ilieva et al., 2022; Murdad et al., 2022). Few studies have explicitly examined the maintenance issues associated with urban farming (Ismail et al., 2010) in order to help building managers and urban planners carry out building maintenance effectively. This research gap reflects the urgency to comply with the government's instruction on the management of the maintenance of government buildings and assets, which was issued through General Circular (No. 1) on February 11, 2003 (Mohd-Noor et al., 2011).

As Malaysians adopt a more widespread and commercially viable sustainable lifestyle, more buildings are incorporating 'greens' into their design. In order to become more sustainable,

regardless of the type of urban farming—green roofs, vertical farming, or others—it is also important to consider and address the maintenance-related obstacles and difficulties. Ismail et al. (2010) argued that the primary challenges with green roofs were technical, such as damage to water-proofing, leaking into the floor structure at green roof level, and obstruction in the drainage system, which increased the likelihood of water ponding and mosquito breeding. This observable fact of inadequate maintenance can lead to roof gardens failing to operate as intended. Thus, maintenance is a critical factor to consider when evaluating the feasibility of implementing green roofs, and it is widely regarded as one of the significant barriers to their installation (Shaharuddin et al., 2019). (Whittinghill & Rowe (2012) further added that several challenges must be addressed to enable wider adoption of this production system. These include cost implications for installation and maintenance, limitations on roof weight capacity, media composition and depth, necessary cultural practices, potential issues regarding the water quality of effluent runoff, and the potential impact of crop production on other well-known benefits associated with green roofs.

Other than that, the maintenance of urban farming in terms of pest control must be taken into account, as pests are easily attracted to the plants. Planting a green roof, for example, will attract a variety of pests and insects, as well as diseases that will afflict the building's occupants. Due to the risk of environmental contamination through runoff or drift, pest management must be carefully evaluated, especially when chemical treatments are used. Monitoring, via frequent inspections, and prevention are the most effective strategies for maintaining healthy plants and are also the most effective pest management measures. Walters & Stoelzle Midden (2018) added that early detection can reduce the severity of pest and disease outbreaks and prevent them from inflicting undue harm. Hence, it is essential to prioritise the maintenance of urban farming and building in a way to accomplish the objectives of implementing these urban farming and reap all of their benefits.

5. Conclusion

Sustainable practices have become a widespread global trend so there is various research highlighting the benefits of urban farming. However, in Malaysia, there is still insufficient attention given to prioritising the maintenance of urban farming, which can have significant implications for the building and its occupants. This study focuses on the current practise of urban farming in Malaysia and its impact on building owners and tenants. Prior to implementing any urban farming initiative, building managers and urban planners must be mindful of the maintenance requirements and the building's capacity to meet those needs. Future research should conduct a comprehensive analysis of the practice and its impact on buildings. This research can serve as a foundation for outlining best practices in maintenance that can be employed to improve the state of urban farming in the country and indirectly mitigate the impacts of climate change in urban areas.

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