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CASE STUDIES

Urban Farming: Opportunities and Challenges of Developing Greenhouse Business in Bangkok Metropolitan Region

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Growing food in a city is quite challenging but possible around the globe. Urban farming practices require specific knowledge depending on the location and the limitation of the land or space availability in a city. Under tropical climate conditions, even though the growing season is extensive, there are investment and business models on greenhouse urban farming within a city boundary. This paper highlights the greenhouse urban farm location and focuses on the commercial perspective of producing crops in Bangkok Metro Region (BMR). The paper focuses on reviewing and analysing greenhouse urban farm opportunities and challenges. There are two objectives of the study to understand landscape patterns and analyse the challenges and opportunities of greenhouse farming within BMR: 1) understand the landscape pattern of greenhouse farming with BMR and 2) analyse the challenges and opportunities of urban farming in BMR. The results are discussed with respect to specific topics including greenhouse urban farming location and operation, greenhouse design, and marketing analysis. There are 54 greenhouse urban farms located within the BMR boundary; 20 of these farms share their business opportunities and constraints of farming in the city. This finding shows that the location of the farms is no longer a constraint of urban farming, as all the greenhouse urban farmers can use social media to promote their farms and products. The most important advantage is that not only are the urban farm greenhouses involved with an extensive farming season, but the local city farms can also set the selling price of their produces higher than the standard price. This study could be used as a database for researchers, urban farmers, and locals who want to invest in the greenhouse urban farming business.

Keywords: urban farming; greenhouse; landscape pattern; tropical climate; green material

Introduction

Urban agriculture has become a common topic on growing and producing food in a big city. Because of the limitations of the techniques for growing plants or raising animals in the city, it might not be the same methodology as the traditional ways of agricultural practice. Midmore & Jansen (2003) forecasted the challenges and risks for a vegetable farming practice in the peri-urban area of South, Southeast, and East Asia on the basis of the limitations of and the competition for land and labour as resources. Urban agriculture can partly replace the demand for both imports from rural agriculture and the overseas food supply to cities (Mougeot, 2000). City farmers create an environment that can fit their specific needs for urban agricultural activities. The typical typologies of urban farming techniques range from growing plants in soil to soil-less systems in greenhouses or plant factories to outdoor raised bed farming. To create a growing environment in a city where air can be polluted, soil can be contaminated with heavy metal, and water might not be used for agricultural practice, greenhouses provide the opportunity for growing plants under the separated growing conditions. Greenhouses can be used not only to extend the growing season but also to protect plants from diseases and insects. These plastic-covered and netted structures can also control temperatures and allow farmers to design separate irrigation systems for selected plants. However, growing plants under this controlled condition requires both capital for investments and specific knowledge (Bon et al., 2015). Only 67% of the glass/poly greenhouse farms in the USA reported as profitable businesses, while 33% remained unprofitable (Agrilyst, 2017).

Smit and Nasr (1992) emphasised that the geographic location of urban farming still lacks the potential information to develop an urban agriculture database. The critical geography of urban agriculture needs to be analysed before claiming sustainability and health benefits (Tornaghi, 2013). Urban farming should be linked to urban resources through urban planning and industrial ecology. The urban resources

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can be opportunities for utilising food wastes, wastewater, and waste heat/CO_2 recovery (Mohareb et al., 2017). There are three purposes of urban farming categorised by economic feasibility as follows: 1) public urban farms, 2) nonprofit urban farms, and 3) commercial urban farms (Phillips, 2013). In the Asian context, particularly in Tokyo, Shanghai, and Singapore, there is interest and demand in greenhouse farming and controlled environment agriculture (Benke & Tomkins, 2017). In Bangkok, according to a Thai city farm map, there are 19 locations of urban farms and learning centres within the inner ring road (Kanchanapisek Highway) on the website (accessed 19 October 2020). There are 11 locations of urban farms including rooftop farming, school yards, therapeutic urban farms, household farming, community gardens, and institutional farming. The other type of urban farming also provides a learning facility and training programs for specific groups of learners. There are eight locations of learning centres, including learning centres for children, vertical farming, rooftop farming, sustainable household, and on-ground urban farming. On the basis of the survey of Urankul and Jiraprasertkun (2016) combined with the data from Bangkok Metropolitan Administration surveying on increasing the green space, 15 locations of green roof agriculture on the rooftop of government agency buildings were reported. Suteethorn (2011) defined Bangkok's urban farm patterns as three characteristics as follows: 1) existing vegetable gardens in the city, 2) urban fringe productive landscape, and 3) urban farm rooftop vegetable gardens. Boossabong (2018) focused on specific case studies on the collective community based urban farming. The urban farmers of the west side of Bangkok used learning centres as a platform to share the urban agricultural network and knowledge as well as the way to negotiate with the local government. Urban farmers work as not only producers but also sellers at the same time (Montrivade, 2014). Furthermore, the typology of urban farming could be divided by farming purpose, scale driven, locations, and farming techniques.

Based on the literature reviews, there is still a gap on understanding the landscape patterns of such complexity systems of urban farming, particularly toward the business opportunity and greenhouse farming in the urban area of Bangkok and its surroundings. From questioning the linkage between local food and the behaviour of multiple actors on food production and consumption in the Bangkok Metropolitan Region, we need to understand the ecosystem of peri-urban food based on the geographical approach (Tsuchiya et al., 2015).

This paper highlights the missing layers of urban farm locations and is focused on the commercial perspective of producing crops in the city of Bangkok and its surrounding provinces. As there is no database on urban agriculture locations in Bangkok Metro Region (BMR), the current data do not cover the existing urban agriculture. This paper focuses on reviewing and analysing greenhouse urban farm opportunities and challenges.

Literature review

Because of the limited resources and pollution in the cities, urban farming faces challenges related to resource scarcity, including water, land, labour, accessibility, and environmental contamination. Bon et al. (2015) mentioned that usually, urban horticulture practitioners are obliged to rent from the land owners or to farm on public land as there is high land pressure on the urban property and such property is expensive.

Greenhouse urban farms can be defined as ground-based-conditioned, and a traditional greenhouse attached on the rooftop could be considered to an integrated-condition building (Goldstein et al., 2016). Growing plants in a greenhouse tends to have a very low net water consumption but very high energy input per kilogram of crop production (O'Sullivan et al., 2019). The research on the energy conservation of greenhouses refers to guidelines including either energy saving with electric motors or with electric motor control systems and energy management in closed-system greenhouses (Namhormchan & Mueangchan, 2020). The study on green material explores the potential for the manufacturing process to develop natural fibre-based materials for urban farming. These biocomposite materials can be used for supporting climbing plants by using hydrophobic green materials (Baharudin et al., 2018). Heavy metal and air pollution can be a concerning limitation for urban farming that can lead to crop toxicity. Bon et al. (2015) stated that some species such as pea, bean, pepper, tomato, and melon have the ability to slowly uptake heavy metals.

In 2018, Thailand had a total of 1,498 rais (239.68 ha) of melon farming land, which produced 4,837 tons of fresh melon. The average productivity was 4,421 kg/rai or 2.8 kg/m2. The top growing area was in Supan Buri, Sara Buri, Ayutthaya, Kanchana Buri, and Buriram (Department of Agriculture Extension, 2019). Bangkok and the surrounding areas were not listed as melon farms in this case. It seems that Bangkok and the surrounding metropolitan areas which have a local registered population of 16 million people (National Statistical Office of Thailand, 2017) cannot produce this type of fruit, which can be bought in almost every supermarket. This could be the argument for this research to look closer into the local urban farm networks which aim to produce and serve fresh fruit and vegetables to the local community within the Bangkok Metropolitan Region, by studying the location of greenhouse urban farming and understanding this farming activity from the perspectives of the opportunities and constraints of city farming.

Objective and methodology

There are two objectives of this study to understand landscape patterns and analyse the challenges and opportunities of greenhouse urban farming within BMR:

1. Understand the landscape pattern of greenhouse farming within BMR.
2. Analyse the challenges and opportunities of greenhouse urban farming in BMR.

The study included surveys on the greenhouse locations and focused on in-depth interviews with the farm owners who were willing to provide the information and discuss the challenges and opportunities of doing agribusiness in the city and on its periphery. The study areas included

Bangkok and the five surrounding provinces of Bangkok, namely Samut Sakorn, Nakorn Pathom, Nonthaburi, Pathum Thani, and Samut Prakan, which are called Bangkok Metropolitan Region (BMR).

The advantage of the in-depth interview method was the ability to capture insightful lessons learned from the greenhouse urban farming practices, particularly from farmers who wanted to share their expertise. Moreover, this method allowed the research team to observe the greenhouse urban farming activity and management systems in detail. The disadvantage of choosing this method was that it was limited when we excluded the greenhouse locations that chose not to share their points of view on farming in the city.

Results and discussion

The survey on greenhouse farming within BMR was conducted from August to October 2020. The results illustrated the greenhouse urban farming locations, operations, management, and marketing tools within BMR.

Figure 1 shows the greenhouse farming locations (green pins) and the focus-group greenhouse farming locations (dark green pins with circles). The results showed that there were 57 urban greenhouse farms located within Bangkok, Samut Sakorn, Nakhon Pathom, Nonthaburi, Pathum Thani, and Samut Prakan. By simply asking all of the urban greenhouse farms to provide an inside interview, I found that 20 farmers wanted to share their backgrounds and knowledge on greenhouse urban farming techniques as well as their views on the opportunities and challenges of investing in greenhouse businesses based on their models and locations. With respect to the locations, I found that 11 urban greenhouse farms were located within the ring road and were mixed with the built-up area. While the other nine greenhouse urban farms were situated outside the ring road, where the adjacent land might still open up as the agricultural landscape.

Table 1 shows the background information, programming, and locations of the focus-group greenhouse urban farms. For the example of 20 greenhouse urban farms, this

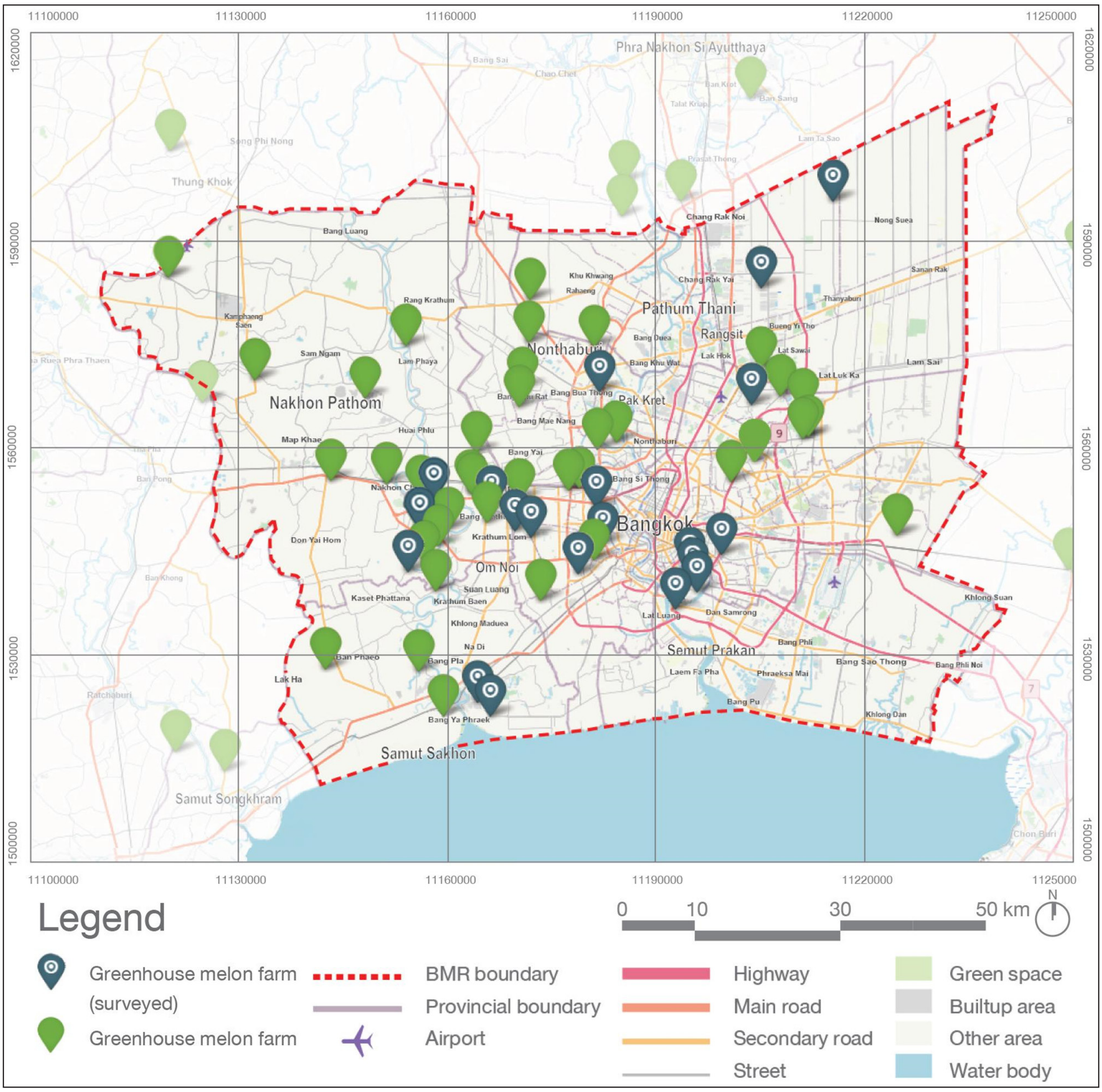

Figure 1: Mapping greenhouse locations within BMR. Photo: Fa Likitswat.

Table 1: Background information and greenhouse farm programming.

Size	No.	Approx. areas (m²)	Land ownerships		Agribusiness programming					Locations	
			Own	Rent	No. of greenhouses	Cafe	Restaurant	Learning Centre	Other Programme	Latitude	Longitude
Small	1	712	o		2					13.775608	100.308158
	2	1,008	o		4	o				13.775454	100.443143
	3	1,200	o		2	o				13.745634	100.33791
	4	1,600	o		7	o		o		13.730599	100.450181
	5	1,600	o		4	o	o			13.648348	100.544683
	6	1,600	o		3	o				13.669652	100.562871
Medium	7	2,068		o	4				o	13.514519	100.30722
	8	3,200	o		5					13.686281	100.566319
	9	4,304		o	2	o	o			13.919706	100.446094
	10	4,400		o	2	o				13.748568	100.213996
	11	4,800	o		8					13.902776	100.641833
	12	6,400	o		10				o	13.532287	100.289751
	13	6,400		o	8	o	o	o		14.048877	100.653633
Large	14	8,000	o		5					13.692931	100.419673
	15	9,600	o		6	o	o			13.784198	100.233085
	16	13,600	o		12	o		o		14.156954	100.745661
	17	14,400	o		21				o	13.699168	100.561687
	18	19,200	o		4				o	13.694765	100.201304
	19	24,000	o		6	o				13.716204	100.603185
	20	32,000	o		18	o	o	o	o	13.738425	100.359407

table illustrates that 60% of the interviewed farms had cafe space to serve the surrounding communities and visitors, 30% of the farms owned restaurants that directly served fresh produce from their farms, 20% of the farms offered short courses and training programmes at their learning centres, and 25% of the farms invested in other agribusiness, such as poultry farms (15%) and orchid farms (10%).

Table 2 illustrates the land, water, and greenhouse operations as well as the opportunities and constraints reflecting on the management techniques. On the basis of the focused group survey, this table captures the resources availability and operation techniques which can lead to the choice and decision making on greenhouse farming management. This part can be divided into four issues: land ownerships, water resources, greenhouse materials, and operation costs.

1) Land ownerships

With respect to land ownership issues, 80% of the urban farmers own the land within BMR, while 20% of the urban farmers still rent the land for investing in urban farming greenhouses and other related programmes. From this huge gap of percentage between ownership and rental of a piece of land for greenhouse urban farming, farmers who own their land can gain benefits from investing in their own land as compared to the urban farmers who still rent the lands. Usually, the right to the lands is inherited from their ancestors; thus, there would be no cost for investing in buying considerably expensive land within the city boundary. Most urban farmers who own their lands within the BMR can invest their capital in and explore a variety of programmes, depending on the size of the land parcels. While the small percentage of urban farms who rent the land parcels can gain benefits from focusing on making a high return business model. This is quite challenging for investing in the right programmes and setting a high market position value on their greenhouse businesses and products. However, this group of urban farms takes this challenge as an opportunity to set up their market position to achieve their goals. This group can still make a high income and have a high profit margin to cover the land rental fee as well as the operation costs.

However, farming in the city context can be challenging, as the changing context toward urbanism can have both positive and negative effects on the farms. On the one hand, the changing context toward urbanisation can bring more customs to the urban farms. On the other hand, urbanisation has a negative effect on the crucial resources for urban farming, such as water quality from urban runoff and air pollution. On this issue, the farmers who own the lands could be suffering from this changing context. The high cost and the relative value of the land can be the other factors that cannot compare with the profit from greenhouse urban farming if compared to the cash obtained upon selling the land. While the risks and constraints of rental land farming are that the rental fee could cost more depending on the landowner and the contract, investment on a permanent structure could be wasted if the urban farmers only have the lease for short-term contracts.

2) Water resources

With respect to the water resource issues, 80% of the greenhouse urban farms rely on tap water, 15% of the urban farms still use the canal water, and only 5% of the greenhouse store water in the ponds on site for irrigation of the cultivated greenhouse plants. When we consider

Table 2: Land, water, and greenhouse operation.

Resources	Operation	Opportunities	Constraints
Land	80% ownership	+ Low cost on land deposit + Can explore a variety of programmes depending on the size of the land parcels	– Changing context toward urbanism can have both positive and negative effects on the farm – Land price could be very expensive as compared to the profit from urban farming
	20% rental	+ Fast cash business model + Need to consider the right programmes and high market position value	– The rental fee could cost more depending on the landowner and the contract – Investment on a permanent structure could be wasted for a short-term contract
Water	80% tap water	+ Clean and does not clog the irrigation system + Available in all seasons	– Needs stabilisation process if the chemical level (chlorine) is too high for watering plants – High cost and not matching quality of water for irrigation
	15% canal water	+ Free of charge water + Suitable quality of water for irrigation with some nutrients	– Difficult to control the quality in all seasons – Might have to switch to portable water if dealing with a drought or highly salinised water – Need to pump or transport to the site depending on the location – The use of a canal in the urban context as an urban catchment for runoff could lead to contaminated and poor water quality
	5% pond	+ Can be recyclable if planning for the right system + Can control water quality on site	– Requires large space for both retention and settlement ponds – Might not be suitable for contaminated land and porous ground for retaining freshwater
Greenhouse	95% steel structure, net wall, and flexible plastic sheet roof	+ Affordable cost + Flexible for part-by-part maintenance + Plastic can be reused for the other purposes in the farm after being taken out from the greenhouse	– Structure could be destroyed by strong winds or storms as it is light-weight – Net and flexible plastic sheet needs to be replaced within 2–5 years
	5% steel structure, net wall, and polycarbonate sheet roof	+ Polycarbonate roof can be used for a long term + Structure can be permanent	– Polycarbonate roof can trap more dust and thus needs to be cleaned often to keep the transparency quality for photosynthesis inside the greenhouse – This greenhouse will cost more than a regular greenhouse – There will be least waste from the greenhouse, as the material is durable for more than 10 years

this to be a trend, it seems that most urban farmers pay for very good and high water quality as compared to using it for agricultural irrigation. As tap water is clean and does not clog the irrigation system and is available in all seasons, most of the farmers rely on tap water as a water resource for irrigation and use on their farms. Only a few percentage of urban farms that use canal and retention ponds take the advantages of free water resources. As the quality of water can change during different seasons, this group of farmers needs to flow the water either from the canal or the retention pond to the sediment pond before using the water for irrigation.

Most of the greenhouse urban farms rely on tap water for irrigation, which shows the increasing demand for fresh water consumption in the city between residential sectors and urban farms. It can be interpreted that the changing context and water quality outside the farms from the irrigation canal and the adjacent ponds can be the driving forces for urban farmers to stop using the urban water and change to connecting the system with tap water more in the future.

3) Greenhouse materials

Further, 95% of the surveyed greenhouses combined net and flexible plastic sheets on the steel structures. Usually, the thickness of a translucent plastic sheet is 150 or 200 microns when used as the roof material cover. Greenhouse farmers need to replace this plastic sheet within 2–5 years depending on the quality and the condition of the sheet. However, only 5% of the surveyed greenhouses invested in upgraded roof material. The structure combined a steel structure, net wall, and a polycarbonate sheet roof. When the roof material is upgraded, this could last long, for at least 10 years. However, this polycarbonate sheet can trap dust easily, and thus, urban farmers need to clean the roof structure often to maintain the transparency of the polycarbonate sheet, as a clear roof provides the transparency quality and allows natural light for photosynthesis for plant growth and quality.

The construction costs vary from around 900 to 5,000 Baht (around $25 to $140) per square metre. The average cost of greenhouse urban farm structures cost around 1,500 Baht (around $40) per square metre.

4) Operation costs

Operation cost, including electricity for irrigation system and water pumping, greenhouse structure, planting material, and labour cost, can be slightly different depending on various factors. However land ownership is the most sensitive factor that results in the investment model differences. In the focus group surveyed, 80% of the urban farmers who owned the land could benefit from the land ownership rights. While we found that the 20% of the urban farmers who rented the land tended to rent medium-sized farm plots near the city centre. Moreover, we found that the rental land farm owner usually provided and combined other agribusiness activities, such as a cafe, restaurant, and/or a learning centre. These agribusiness activities can support the farming business as the other sources of income with a high profit margin.

Greenhouse designs and systems

Figure 2 shows the greenhouse typology on designs and systems including greenhouse structures, type of growing technique in greenhouses, water management, and plant selection.

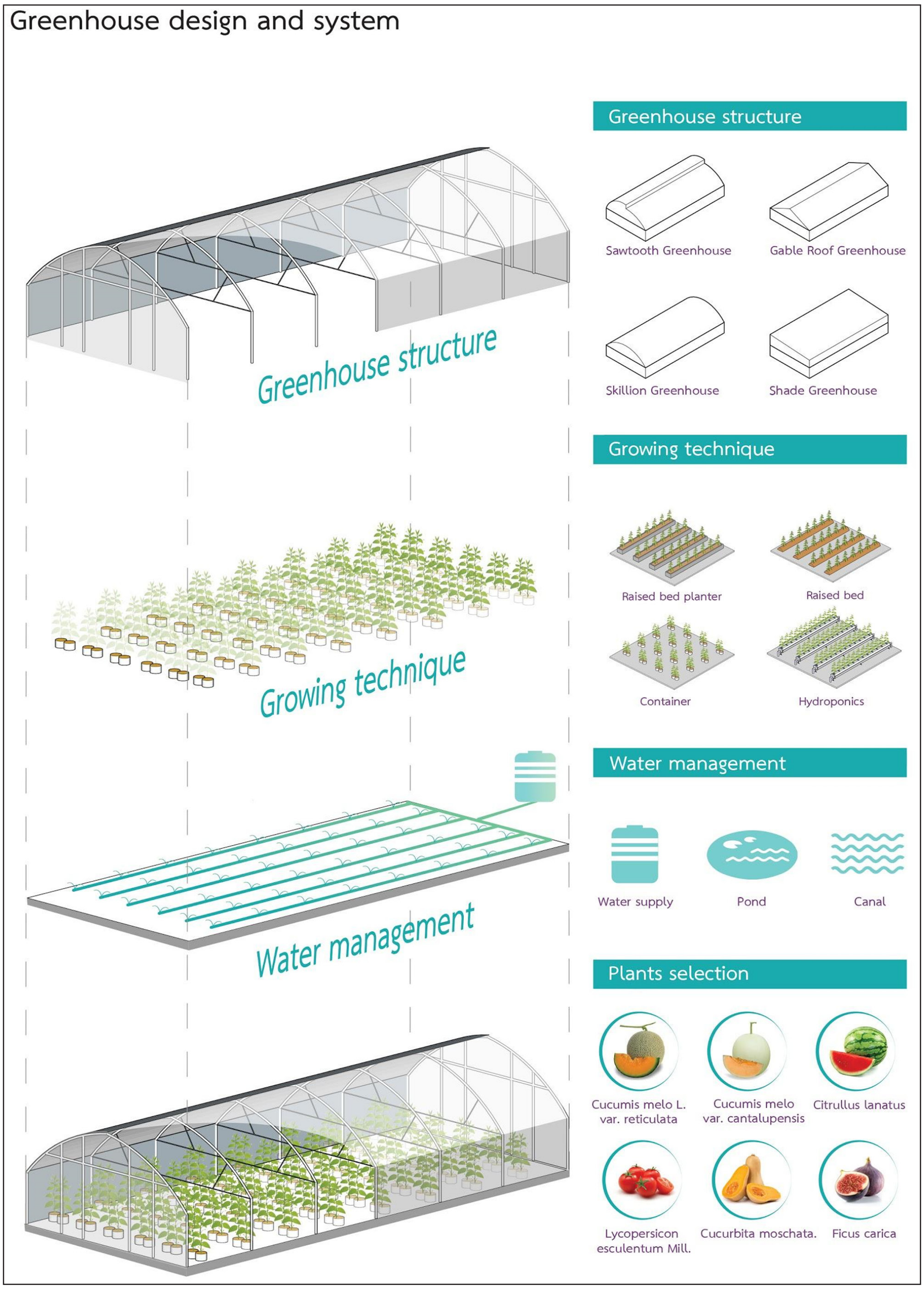

Figure 2: Greenhouse typologies in BMR. Photo: Fa Likitswat.

There are four types of greenhouse designs with respect to the different forms of structures: sawtooth greenhouse, gable roof greenhouse, skillion greenhouse, and shade greenhouse. Most of the urban farmers chose and invested in a greenhouse with an arched roof called a skillion greenhouse. This might be the simplest form to build and the cheapest one as compared to the other forms of greenhouse structures. However, the temperature inside this roof structure is quite warm as compared to that in the sawtooth greenhouse, which was also found from this survey. As sawtooth structures allow the air to circulate inside the greenhouse better than the other roof systems, the temperature inside this type of greenhouse is usually similar to the outdoor temperature. A gable roof and shade greenhouse was also found but was not as popular as the other two types of roof designs.

With respect to the growing techniques, there were four types of practices used inside the surveyed greenhouses. The first typology was raised bed planters. The material used for the curve was concrete or bricks. There was no wastage of the containing material in greenhouse growing plants with this technique. The second type of growing pattern inside of the greenhouse was container or pot plants. The common material used in this case was PE bags or plastic pots. The farmers needed to replace the PE bags after using them three times. The upgraded material of the PE bags was plastic pots, which could be used for a longer period of time. Ridge and furrow farming were also used in the greenhouses, particularly on the outer edge of the city where the development was not dense. This was the growing technique closest to the traditional method of farming. The additional part of the traditional technique was the PE sheet used to cover the soil. In this new technique, this growing system also produced some agricultural waste, such as the plastic sheet.

As mentioned already about the water resources which could have different sources, the farmers also controlled the irrigation system differently according to the needs of the plants and the plant species. For example, in the melon cultivation techniques, they relied on two types of watering systems, namely drip and fog irrigation.

With respect to the plant selection, the common plants grown in the greenhouses in BMR were Cucumis melo L. var. reticulata, Cucumis melo var. Cantalupensis, Citrullus lanatus, Lycopersicon esculentum Mill., Cucurbita moschata, and Ficus carica. Most of the urban farms promoted a variety of melon cultivars as the main products growing in greenhouses. Usually, the cycle of the planting to the harvesting of melons is approximately 120 days; this allows urban farmers to grow 3–4 crops per year within a controlled environment.

Table 3 shows the greenhouse management and the plant selection from the focus-group survey.

According to the observations, the greenhouses in BMR mostly produce exotic plants and herbs, including melon, butternut squash, tomato, and hops. The common species that this study found are the melon planted inside the greenhouses. However, there is an argument on the method of planting melons in an open field without a greenhouse structure in the city. From the author's perspective, urban farmers can manage to carry out this agricultural practice as long as they have sufficient space for the planting experiments. In the case that the land is quite small or limited, most of the farmers choose to grow melon in greenhouse structures for maximising space, extending the growing season, and protecting the plants from disease.

Marketing analysis

Online social media brings an opportunity to the urban farmers to promote their fresh urban produce, products, atmosphere, and farming activities. By doing so, urban farms can connect and reach out to the customers who are interested in Facebook pages and can reach a wider range of customers. Moreover, supporting programmes such as cafe, restaurant, and/or learning centre can be an attraction to bring more people to the farms.

Furthermore, urban farms can gain benefits from the low cost of promotion on social media; they can use the traditional media such as newspaper and television channels for writing and filming their urban farm stories. For doing so, most urban farmers have multiple channels and ways to promote their urban farming and greenhouse businesses at a low cost. Most of the farms interviewed were in the early stage of farming in the city, not more than 10 years, and social media had a positive impact on promoting these urban farm businesses directly. Urban farmers can also set up their own price, which is higher

Table 3: Greenhouse management, material cycles, and plant selections.

Greenhouse input	Input material	Material cycles/maintenance techniques
Soil and bed	65% PE Plastic bags	3 crops/bag
	20% Plastic pots	Lasts long if not exposed to sunlight
	10% Plastic sheet raised beds	1–2 years
	10% Concrete raised beds	Lasts long
	5% Bamboo basket	Depends on quality of bamboo and humidity
Climbing rope	100% Cotton rope	Up to 2 years/can be boiled to clean-up organic matter
Plant selection	Cucumis melo L. var reticulata	75–90 days (summer), 90–100 days (winter), 3–4 crops/year
	Cucumis melo var. Cantalupensis	80–90 days (summer), 90–100 days (winter), 3–4 crops/year
	Citrullus lanatus	1 crop/year
	Lycopersicon esculentum Mill.	65–80 days, 4 crops/year
	Cucurbita moschata.	80–90 days (summer), 100–110 days (winter), 3–4 crops/year
	Ficus carica	Lasts long

than the standard market price. I found that the most expensive fresh melon produce can be higher than the market price by seven times. Usually, most of the urban farms sell the fresh melon from their farms for three times higher than the market price. Selling without the involvement of the market middlemen can be one of the incentives for producing urban fruits and vegetables.

The other activities on urban farms such as cafes and restaurants also act as a magnet to draw the local neighbours and customers from the city to the urban farms. More than 50% of the surveyed farms provided these facilities as tourist attractions. These could be one of the tools for developing the business branding and image. I found that a few urban farm places reserved the freshly produced fruit only for serving as food and beverage in their own cafes and restaurants. This is one way in which urban farmers can earn more than selling the whole fresh fruits. Promoting these urban farms through social media can lead to attracting the online media and traditional television channels to the urban farm locations for urban lifestyle pieces.

The main products including melon, salad greens, tomato, and other types of vegetables are either sold in place or processed into food and beverage served in the cafes or restaurants. The survey found that 55% of the local farmers sold both fresh melon and a melon-processed dish or drink, 40% of the farmers sold only fresh fruits, and only 5% of the local farmers sold only the food processed from the melon grown at their farm. For example, fresh melon can be sold at the urban farms at prices ranging from 100 Baht/kg to 350 Baht/kg, which is about two to seven times more than the standard price. Most of the urban farms sell their fresh melon at 150 Baht/kg, which means around three times higher than the standard market price. In one of the deep interviews with a local urban farmer in Klong Sam, Pathum Thani, I found that the owners set the price to sell fresh melon, salad greens, and sunflower sprouts at the same price of 250 Baht/kg. This price is higher than the market price by about five times for melon, two times for salad green, and two and a half times for sunflower sprouts. The owner said that the price could be set higher than that of the products sold in the hyper market or wholesale market, as the customer could learn about the process of growing fruit locally. Moreover, this urban farm location was close to one of the wholesale markets situated on the north of Bangkok, called Talaad Thai.

With respect to the processed-food dishes and drinks, it can be creative and a value-add for attracting the customers to the farms. The most common menus in the local restaurants and farm cafes include melon ice cream, detox drink, melon salad, melon cakes and tarts, freeze-dried melon, and melon curry. The price can be set higher depending on the quality and presentation of the dishes or drinks. The local urban farms plan to sell these products according to the demand of the customers to match with the supply from their farms and networks.

It is clear that while the local farms cannot meet all the demands of the green consumers around Bangkok, the local urban farmers can establish local customer relationships, produce urban food, and set reasonable and sellable prices, which are still higher than the standard market prices. Furthermore, one of the tools that can be used to promote urban farms matches the social media applications which provide the ability to draw customers to the hidden urban farm locations in the city.

Summary and Findings

Greenhouse urban farming creates a closed loop for self-sustaining growing business models, producing fresh fruit and vegetables, and functions as a distributing node for the surrounding communities. This controlled environment of growing plants fits with the concept of urban farming, as it can either require a land-based property or be installed on top of a building. Most of the surveyed greenhouses in BMR are land-based system. Few of urban farms explained their plans to upgrade and extend rooftop greenhouses. Rooftop greenhouses can be based on a technique called 'Zero-Acreage Farming' (ZFarming), which depends on the non-use of land for farming practices (Thomaier et al., 2014). However, both urban farming and new ZFarming practices can be as unsustainable as regular farming if not managed properly (Specht, 2014). This concept can be used for the new learning opportunities for both urban farming practices and customer experiences.

Most of the greenhouse businesses in BMR are run as family businesses. Furthermore, 80% of the survey group owned the land, and 20% still rented the land for the greenhouse and agribusinesses. I found that few of the business models which still rented the land planned to buy the property because of the profits that they could make from the urban agriculture business.

With respect to the typologies of practicing greenhouse farming in urban areas around Bangkok, I found that there are many ways of designing the structures, choosing the types of growing techniques, water management, and plant selection. Thus, greenhouse farming in the city is quite complex with respect to planning a systematic design as well as the management systems. The cost of designing greenhouses could range from $25 to $150 per square metre depending on the material, system, and technology used. The cost of the greenhouse structures can reflect the technological level of the controlled environment structure, which ranges from low to medium to high technology (Ponce et al., 2014). According to the survey, most of the urban farm greenhouse structures within BMR are still considered to be low to medium technology. However, some of the urban farms have started to invest more on the use of high-technology equipment in their existing greenhouses; the cost of smart technology is relatively high. Most of the greenhouse farming requires a set of knowledge and understanding of the tips and techniques as well as a reasonable investment budget, for investing in the development of a control environment which is suitable for growing exotic species. Thus, most of the urban farmers in the interview process shared their common background on engineering and marketing.

This reflected that the management of greenhouse urban farming is quite complex and that urban farmers need to have appropriate knowledge and skill management. The opportunity to share this knowledge is also important in terms of both earning more profit on urban farming and expanding the local networks within the different locations. Urban farms with multiple programs can position their businesses as an agritourism destination in the city fabric. The question remains now is whether in terms of the diversity of urban farming, digital urban farming or large-scale indoor plant factories can replace this wide range of complexities (Carolan, 2020).

This study could be used as a database for researchers, urban farmers, and the locals who want to jump into this business. The future research related to urban farming and greenhouse design should focus on these other areas including: 1) land organisation and development, 2) material and cost management, 3) growing and post-harvesting strategy, 4) marketing and branding, and 5) smart farming and technology management.

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Competing Interests
The author has no competing interests to declare.

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