OPPORTUNITIES FOR HIGH-TECHNOLOGY HORTICULTURE IN URBAN AUSTRALIA

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Hort Innovation

RMCG

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HIGH-TECHNOLGY HORTICULTURE *n.*

Production of plants within a growing structure (generally a building or greenhouse) using technology that optimises the use of resources such as water, energy, space and labour. Typically intended for intensive production to maximise yields.

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BACKGROUND

High-technology horticulture is being implemented in urban areas internationally to serve a variety of purposes including economic development, community engagement and environmental benefits. Systems include vertical farm systems, container farms, glasshouses, and nearly fully automated production. Amongst the global landscape, Australia has been slow to take up high-technology horticulture due to several barriers including high initial capital investment, zoning limitations, lower population densities and lack of experience in the industry. However, there is growing interest in how high technology horticulture in an urban environment could complement existing production systems.

This project has assessed new and emerging technology and its application in the Australian urban landscape to:

- Assess the feasibility of high technology horticulture in urban Australia considering technology opportunities, regulatory and planning factors, farm input and waste management and the supply chain
- Identify key opportunities and challenges relating to environmental and social benefits
- Recommend how the Australian horticulture industry can realise opportunities and build the capacity of this sector.

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APPROACH

Assessing the feasibility of High Technology Urban Horticulture (HTUH) in Australia has included:

- Review of current literature on HTUH in Australia and internationally
- Modelling of potential HTUH systems and their applicability in Australia
- Economic analysis of HTUH systems and assessment of how changes to cost and revenue impact on the profitability of these systems
- Consultation with industry stakeholders to inform the modelling and economic analysis.

These activities informed the development of recommendations on how to support HTUH in Australia.

This document provides a summary of the findings of this study. A copy of the full report can be requested from Hort Innovation.

OPERATING CONTEXT

PLANNING

Urban planning and regulations often overlook urban agriculture. With food production pushed to the periphery of cities and rural areas, urban development and planning often do not consider the potential of urban food production, despite calls to reintegrate farming into urban planning. This is particularly evident in Australia, where residential development in peri-urban areas has resulted in market gardens transitioning to more regional areas.

Within Australia HTUH is not integrated into development projects or integrated into planning provisions (notably standard Local Environmental Plans). This has also been noted in other countries where regulatory barriers to urban agriculture have included:

- Zoning ordinances that exclude urban agriculture or are unclear about agricultural uses
- Lack of access to land and secure tenure (urban agriculture is often perceived as a transient use for vacant lots that will be redeveloped)
- Regulations on built structures (maximum allowable building heights, floor-to-area ratios and structure setbacks, fire and energy codes).

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INSTITUTIONAL SUPPORT

Currently there is minimal institutional support for HTUH in Australia. International examples from Paris, Shanghai, Singapore, and Amsterdam demonstrate how a HTUH industry can be supported and guided.

Lessons learnt from Amsterdam and other international examples include the importance of:

- Establishing policy objectives related to HTUH
- Collaboration between universities, government agencies and private businesses through public-private partnership, to foster the development of a HTUH 'ecosystem' made up of start-ups and businesses able to develop new technologies and services
- Providing grants and financial support to start-ups and existing businesses, which can help overcome the barriers of initial capital investment and enable the upgrade of equipment and systems
- Facilitating access to physical space to farm through competitive calls for proposals.

While Australia does not have the level of institutional support for HTUH that other international cities do, there has been progress made in the integration of green spaces into urban policies and planning. The design framework for New South Wales for example has a focus on green spaces. The framework provides a pathway and potential strategy that could be applied for integrating HTUH into urban planning.

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AMSTERDAM & HTUH

In Amsterdam the demand for healthy and sustainable food and the increasing interest in circular economy have created a conducive environment for HTUH. The development of this type of farming has mostly been led by start-ups and incumbent businesses from Amsterdam. However, this 'bottom-up' development of HTUH has been made possible by the Dutch sectorial policy, which promotes the cooperation of government, universities, and private businesses in HTUH through public-private partnerships. The co-investment of government in projects minimises financial barriers for start-ups and enables the development of new products and services. In addition, financial support is also available in the form of subsidies and incentives, at the European, national, and local level. One company, Philips, played a central role in the development of HTUH by developing lighting technologies that became the standard in farms in Amsterdam. While this has contributed to the development of the sector, it has also prevented other start-ups or companies to play a role in those technologies.[1]

[1] Farhangi et al. 2020

BUSINESS MODELS

To cover the high establishment and operating costs of HTUH business models need to focus on attracting a premium price for product. Operators in Australia and elsewhere have focused on:

- Developing relationship-based markets where supply is direct to customers, food service sector and independent grocers in their immediate area
- Consumer marketing which promotes HTUH produce as local, sustainable, high quality, nutritious, clean and safe
- Supply chain integration to reduce post-harvest costs (establishment of HTUH within agri-food precincts such as the Aerotropolis proposed in Western Sydney will facilitate supply chain integration further)
- Development of pre-packaged 'convenience' food such as ready-made salads.

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FEASIBILITY ASSESSMENT

MODELLING

Greenhouses used to dominate the 'indoor farming industry', however over the past fifteen years, adoption of new systems has increased, to include:

- Vertical farming which can be defined as a 'fully enclosed and opaque room with a vertical hydroponic, aeroponic, and/or aquaponic system' (approximately 38% of Controlled Environment Atmosphere (CEA))
- Container farms, which are a 'standardized, self-contained growing unit that employs vertical farming systems and artificial lighting' (approximately 6% of CEA).

Greenhouses still constitute approximately 40% of CEA worldwide[2].

The six systems or types of HTUH modelled under Australian conditions as part of this study are outlined in Table 1 on the following page. These include vertical farms (also known as a Plant Factory with Artificial Lighting (PFAL)), container farms and glasshouses on rooftops and floating platforms.

[2] Autogrow & Agritecture Consulting 2019, Agrilyst (2016)

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In this study the following assumptions were built into the feasibility modeling:

- Commercial production (community benefit is not the primary purpose)
- Base the systems in urban Sydney
- Use butter lettuce as the comparative product line with year-round continuous production.

The input use of the six systems is shown in Table 2 (next page). Pairwise comparison of this data showed that the best performing system for Australian conditions (considering social, financial and environmental performance) was the Building Facade, followed by the Rooftop Glasshouse (Vertical).

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TABLE 1 HTUH SYSTEMS MODELLED UNDER AUSTRALIAN CONDITIONS

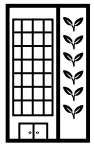
	LOCATION	BUILDING INTEGRATION AND SYNERGIES	SPACE UTILISATION	NAME
	Rooftop	Integrated with building (synergies)	Vertical	Rooftop glasshouse (Vertical)
	Rooftop	Integrated with building (no synergies)	Horizontal	Rooftop glasshouse (Horizontal)
	Container	Not integrated with building	Vertical	Container Farm
	Inside building	Integrated with building (no synergies)	Vertical	PFAL
	Floating	Not integrated with building	Horizontal	Floating Glasshouse
	Building façade	Integrated with building (no synergies)	Vertical	Building Façade

TABLE 2 INDICATIVE MEASURE OF ENVIRONMENTAL, SOCIAL AND FINANCIAL PERFORMANCE OF SIX HTUH SYSTEMS ANALYSED UNDER AUSTRALIAN CONDITIONS

		ENVIRONMENTAL			SOCIAL			FINANCIAL		
	MEASURE	Water Use	Energy Use	Space Use Efficiency	Job Opportunity	Visual Amenity	Improved food security for remote communities	Operational Expenditure	Capital Expenditure	Revenue
	UNIT	Litres/m²/ year	kWh/m²/ year	Yield/m²/ year	Total labour hours	1, 2, 3	kg/$AUD/year	$AUD/m²/ year	$AUD/m²	$AUD/m²/ year
	**Rooftop glasshouse (Vertical)**	161.9	951.7	105.5	14.0	2	0.11	1,399.9	1,509.3	987.2
	**Rooftop glasshouse (Horizontal)**	587.4	41.4	63.2	12.6	2	0.05	1,245.2	772.0	591.7
	**Container Farm**	232.7	1550	151.6	1.4	3	0.03	5,190.5	3,781.5	1,418.9
	**PFAL**	161.9	951.7	105.5	14.0	1	0.08	1,399.9	1,509.3	987.2
	**Floating Glasshouse**	587.4	41.4	63.2	12.6	3	0.05	1,245.2	772.0	591.7
	**Building Façade**	89.8	509.3	97.7	14.0	2	0.11	893.3	1,992.9	914.1

ECONOMIC ANALYSIS

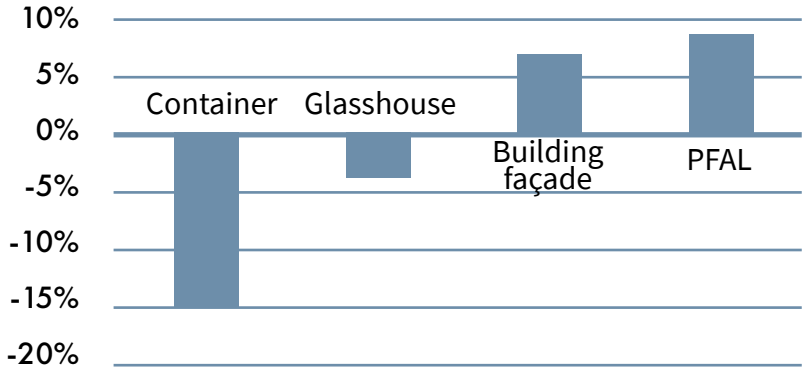
Analysis of the modelled data using a Discounted Cash Flow (DCF) and Net Present Value (NPV) evaluation returned mixed results, with the Container Farm (CF) and Glasshouse (GH) returning a negative NPV, while the Building Façade (BF) and PFAL (PFAL) systems were both positive (see Table 3 below). The negative results for the CF and GH systems were largely driven by a relatively high operational and capex cost to output/income ratio. After consultation with stakeholders, it was agreed that these systems would be more profitable if a higher value crop was used, and systems refined to drive further productivity.

The BF and PFAL systems returned both a positive NPV and Modified Internal Rate of Return (MIRR) as indicated in Figure 1 (right). Our model shows these systems are worth further consideration and are likely to perform well in the Australian economic context. There are, however, likely 'normal' market fluctuations that will impact productivity and profitably that have not been accounted for in our research. Further, a MIRR below 10% invites substantial downside risk and as these systems are relatively untested within the Australian context these results should be treated with caution.

TABLE 3 ECONOMIC SUMMARY

DESCRIPTION	CONTAINER FARM	GLASS HOUSE	BUILDING FAÇADE	PFAL
Capex	$136,451	$1,111,665	$2,152,298	$1,992,314
Opex	$20,239	$652,624	$363,138	$299,944
Labour	$64,000	$338,481	$322,123	$362,123
Income	$56,755	$946,749	$1,096,867	$1,096,867
NPV	$(337,131)	$(2,103,870)	$245,606	$791,788
MIRR	–15%	–4%	7%	9%
Capex $/m²	$1,997	$842	$1,630	$1,509

FIGURE 1 MODIFIED INTERNAL RATE OF RETURN FOR ALL MODELLED SYSTEMS



Internationally there is limited evidence as to the profitability of HTUH and the ability of these systems to generate revenue are dependent on management and markets. In 2017, 51% of controlled environment farms in the United States were not financially profitable. This is partially attributable to the fact that urban farms are capital intensive, and most of them are likely still paying back their initial investment[3].

HTUH has some advantages over field-based production in that climate can be controlled and production is not constrained to certain seasons. There is also the potential to produce higher yields per unit of area. However, factors that increase the cost (and hence reduce the profitability of HTUH) include high land prices (due to production in city centres where land is expensive) and high establishment costs particularly for glasshouses built inside or on top of buildings.

The success of individual enterprises will also depend heavily on the product line chosen, the business model used and the skill and aptitude of the farm manager. HTUH, like any other agricultural enterprise, is a business that requires careful planning and good management.

[3] O'Sullivan et al 2019

"These new systems certainly are the modern face of horticulture that should complement the current supply chain in a key range of nutritious and delicious produce."

Graeme Smith, Protected Cropping Specialist

Photo: Aisyaqilumaranas/shutterstock.com

SOCIAL CONSIDERATIONS

The social acceptability of commercially focused HTUH can be negatively impacted by perceptions that:

- It is not 'real agriculture' due to its localisation in urban settings and the nature of the farming operations
- Its produce is unnatural and unhealthy
- It is highly resource intensive and unsustainable
- There may be health risks due to air pollution and water contamination
- Only wealthier members of society will be able to buy HTUH produce, and it will contribute to the gentrification of the neighbourhood in which it is implemented reducing the equity of HTUH produce.

Support for HTUH needs to come from urban communities who have a desire for 'locally grown food' and seek to engage in food growing projects and spaces. The path forward for this in Australia has been demonstrated by the increasing integration of green spaces into urban policies and planning in NSW. Increased government support is required to drive this for fresh food production, and developers incentivised to include this in new urban developments.

ENVIRONMENT

Research to quantify the environmental benefits of HTUH continues internationally. In general, HTUH is perceived as being more water efficient than field-based production however often the energy requirements are much higher. It is also dangerous to compare HTUH with field-based production as management practices can be highly variable and the environmental impact varies accordingly. Australia is a climatically vulnerable and water scarce country. HTUH offers benefits as it is highly water efficient and resilient to extreme weather events. Rather than viewing HTUH as a competitor to field-based production, it may be more relevant to assess how it can complement land-based agriculture, which will be increasingly affected by extreme weather events and water scarcity.

HTUH also represents an opportunity for the development of circularity around heat/air, wastewater (water and mineral fertilisers) and organic waste in cities. Several barriers currently exist to the use of these techniques constraining widespread adoption.

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OPPORTUNITIES

Although there are challenges that limit the expansion of HTUH in Australia currently, emerging trends which provide opportunities for HTUH to address include:

- A changing natural resource context where the frequency and intensity of extreme weather events, such as droughts, bushfires and floods will increasingly threaten food production. HTUH is well placed to provide secure and sustainable food production due to its ability to control the production environment.
- Increasing consumer concern for the provenance of produce, its health and environmental performance, as well as social and ethical dimensions. HTUH offers a system of production with low food miles, efficient resource use, traceability and quality control of food.
- An aging agricultural workforce which is struggling to attract new people into the industry. HTUH may attract a younger, more technology oriented generation towards farming, and offer opportunities for technology-based graduates to join the industry.
- An increased focus on the use of technology to enable agriculture. HTUH industries can leverage this interest in technology to reduce operating costs within production systems.

RECOMMENDATIONS

This feasibility study has identified a number of areas where further work is required to enable HTUH in Australia. Challenges limiting the expansion of HTUH in Australia include:

- Low profitability due to high capital and operational costs
- Urban planning not accounting for food production in cities and a lack of incentives to incorporate HTUH into new developments
- Minimal institutional support for the development of HTUH by entrepreneurs
- High energy requirements reducing environmental sustainability
- Uncertainty by communities as to the acceptability and equity of HTUH.

Recommendations for addressing these challenges, focusing on the social, economic, and environmental considerations of HTUH are outlined in Table 4 on the following page.

Photo: Irina Zharkova31/shutterstock.com

TABLE 4 RECOMMENDATIONS TO IMPROVE THE FEASIBILITY OF HTUH IN AUSTRALIA

CONSIDERATION	RECOMMENDATION
ECONOMIC 	The financial viability of HTUH could be improved by: • Reducing capital costs to establish HTUH by developing and locating 'precincts' in peri-urban areas where land prices are lower (such as the proposed Aerotropolis in Western Sydney) • Utilising any current or future unused space in urban environments such as car parks as we transition to a low carbon economy • Utilising business models that focus on selling produce at a premium based on their local provenance, environmental credentials and nutritional value direct to consumers, the food service sector and green grocers. • Incorporating value-adding activities such as educational tours of the farm, workshops and community events on the farm. Investing in innovation that reduces the costs associated with HTUH such as: • Automation, and use of data analytics and sensor networks, to reduce labour costs and facilitate greater economies of scale by enabling farmers to manage several farms at a distance • Genetic improvement to develop plant varieties that are better suited to HTUH production systems with reduced height, shorter development cycles and rapid fruit development • Advancing LED lighting systems that have lower energy consumption, low waste heat generation as well as optimised spectra of plant growth. Building the capacity of HTUH entrepreneurs by increasing their understanding of: • The crops that will perform best in HTUH environments • Refining the production system through manipulation of temperature, lighting periods, and CO_2 levels to achieve the highest number of plant cycles • Consumer marketing, supply chain and business management.
PLANNING AND GOVERNMENT SUPPORT 	• Fostering a more supportive regulatory and institutional environment for HTUH by drawing on the experience of cities internationally, that have successfully developed HTUH, as well as on the Australian experience of integrating green infrastructure into the urban fabric. • Integrating food production, and in particular HTUH, into urban policy and planning and providing incentives for developers to integrate HTUH into new development projects.
ENVIRONMENT 	Assessing how HTUH can complement land-based agriculture, which will be increasingly affected by extreme weather events and water scarcity, to develop a more sustainable food production system for Australia. This includes investigating alternative sources of energy such as geothermal or urban waste heat for heating, and renewable energies, such as solar photovoltaics, for energy can be more easily applied to HTUH systems.
SOCIAL 	• Promoting community engagement in the design and planning of HTUH projects to improve social acceptance and awareness. • Investigating opportunities to improve the food security of remote communities through the development and application of high technology systems such as container farms in regional areas.

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PROJECT COLLABORATORS

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- Institute for Sustainable Futures, University of Technology Sydney (UTS) (for review of literature)
- Agritecture (for the modelling of scenarios)
- Graeme Smith (for technical advice related to HTUH).

A copy of the full feasibility study report can be requested from Hort Innovation (communications@horticulture.com.au).

DISCLAIMER

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