

Singapore's role within the growing urban food ecosystem: Turning old limitations into new strengths



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Part 1:

Food systems and sustainable, resilient cities

Introduction

It is widely recognised that urban growth, escalating food prices, the fragility of global supply chains, changing consumption habits and accessibility to healthcare and nutrition are increasing attention on how cities feed their inhabitants. Food systems account for 70% of the water extracted from nature and 60% of biodiversity loss. They also generate up to a third of greenhouse gas emissions from human activities.¹ Sustainable food systems, particularly in urban areas, need to deliver on food security and nutrition without compromising on economic, social and environmental bases, to produce food for future generations.²

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Following the Food and Agriculture Organization's (FAO's) Urban Food Agenda initiative³ in 2019, cities such as São Paulo, Seoul, Tokyo and Singapore have been innovating policies and technology to create new food supplies and transform their urban food systems. The inherent limitation of food production in urban areas creates a dependence on imports that, in turn, threatens urban food resilience. To improve food security, Singapore and other cities have taken

preemptive measures and continue to innovate to become more food resilient. Resilient cities should be able to adapt and grow no matter what kind of chronic stresses and acute shocks they may experience. Singapore is unique in that it is essentially building an agriculture industry from the ground up, as a city-state that has historically relied on imports to feed its population. It will become a latent food bank to build a layer of resiliency for the state and actualise 30% of the city-state's food needs by 2030.⁴

Singapore is emerging as a north star for this nascent urban agri-food production sector. This paper addresses the growing importance of the urban food economy globally and in Singapore by highlighting the key drivers of adoption, technology and evolving consumer preferences. It explores how the nation has sought to optimise regulations at the policy level to encourage innovation and facilitate business growth, and how Singapore's expertise and innovation ecosystem offer avenues to elevate the urban food economy in the wider region.



1. United Nations Environmental Programme, "[Food systems hold key to ending world hunger](#)," last accessed September 20.

2. United Nations, "[Sustainable Food Systems](#)," accessed September 10, 2021.

3. Food and Agriculture Organization of the United Nations, "[Urban Food Agenda](#)," accessed September 27, 2021.

4. Tomorrow's Build, "[Singapore's Bold Plan to Build the Farms of the Future](#)," video, July 13, 2021.



Global technology trends in agri foodtech systems

Around the world, new ideas and techniques related to urban food production are beginning to gain traction and generate interest. Examples in the field of biotechnology that have enabled urban cities to overcome limitations of arable land and climate include microbiome editing, soil biologicals, cultured meat and alternative proteins.

Modern farming and agritech operations also differ from traditional farming in the technology that they use. For instance, the use of robots, temperature and moisture sensors, aerial images and GPS technology have become much more common (see sidebar). These technologies enable urban agriculture to grow at scale in a way that is energy efficient, without being constrained by traditional issues such as land and water availability.

Enabling agrifood technologies:

Core technologies that allow food systems to overcome traditional limitations such as climate, land and water. The similarities and differences highlight the nuances amongst the technologies.

Systems



Hydroponics:

The most common soilless cultivation technique. It is the process of growing plants in a soilless substrate, suspended in nutrient-rich water.



Aeroponics:

The process of growing plants in a soilless substrate and nested in a grow net, with the roots dangling in an enclosed light-sealed tank. Instead of filling the tank with a nutrient-rich solution for the roots to absorb, it is administered via a specially engineered spray system.



Aquaponics:

An integration of fish farming and hydroponics. Farmers raise fish in tanks and use a multi-step process to remove fish waste solids from the water. The water is processed with the help of bacteria and microbes that transform the fish waste into nutrient-rich food suitable for plants.

Similarity: Precise control over growing plants

Difference: Aeroponics removes the need for a water reservoir

Novel foods



Lab-grown or cultured meat:

Meat produced via in vitro cell culture of animal cells. By taking samples of cells from a few animals, technicians can produce vast quantities of meat in culture vats.



Mycoprotein:

A protein made by fermenting the spores of the naturally occurring fungus *Fusarium venenatum*, with glucose and other nutrients.⁵ The fermentation process is similar to that used to brew beer. It produces a doughy mixture with a meat-like texture that is high in protein and fibre.



Plant proteins:

Made from plants but mimic the taste, quality and texture of meat. Proteins from plants such as pulses, seaweed and algae undergo a "high moisture extrusion" process involving thermal and mechanical stressors.

Similarity: Cruelty-free

Difference: Origin of protein source

Technological applications in food production



The Internet of Things (IoT):

Networks of sensors that evaluate environmental variables on farms and can be linked to software systems that provide growers with real-time advice about remedial actions. The growers can receive notifications via applications (apps) on smartphones and other devices.



Robotics:

Produce can be grown inside warehouses with the help of software-controlled robotic systems that control every aspect of the growing process also known as controlled environment production. An automated watering system is an example of robotics.



Artificial intelligence (AI):

Platforms using artificial intelligence can 'learn' the peak growing conditions for certain plants – such as soil nutrients, optimum temperature and humidity – and replicate them in an enclosed environment.

Similarity: Enabling systems that control indoor environments so that food can be grown independent of arable land

Difference: Varied enabling technologies

5. Monica Reinagel, "What Is Mycoprotein," *Scientific American*, last edited November 16, 2017

One of the most disruptive and useful technologies in urban farming is the artificial LED lighting used to help grow vertically stacked vegetables in climate-controlled indoor spaces that provide optimal conditions for plant growth (in terms of air quality, light, temperature and humidity). This shortens time to harvest by almost a third. There are 450 such farms across China, Singapore, Korea and Japan.⁶ The value proposition of such food production systems is that vegetables can be grown all year round, and they can produce more vegetables per unit area and with less water. These farms can act as a buffer to ensure market supply should climate change affect more traditional production methods.

In addition, the use of Artificial Intelligence (AI) and the Internet of Things (IoT) makes it possible to aggregate data from several farms to establish benchmarks and give farmers insights on their performance, to reduce food spoilage and wastage. Predictive analytics technology can also enhance supply chain efficiency and reduce food spoilage through improved logistics planning.



Shifting consumer preferences and indicative trends

A number of consumer trends will impact how food is grown and consumed in the future. Two are especially worth noting. First, as consumers become increasingly health conscious, they are demonstrating more of an interest in food quality, safety and sustainability. They are seeking more information on where their food is sourced and how it is grown, for example, along with any related nutritional values. This is evidenced in part by a rising interest in organic, locally grown and fair-trade produce.

Second, more people globally are adopting alternative proteins. There are a few major factors contributing to this trend. For one, the global beef industry is seeing prices rise in key markets like China, the UK and the US, due to stronger demand in China, disruptive weather patterns, or labour shortages across the globe. As beef prices rise, consumers seem more willing to try alternative proteins, which are simultaneously becoming cheaper and more accessible. Estimates for the compound annual growth rate of the global alternative meats market range from 11.5% to 27.7% by 2040, leading to a market worth between US\$90 billion and US\$450 billion.⁷

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In addition to the more commonly known alternative meat proteins, plant-based alternative seafoods are also receiving increasing attention, given that 90% of fish stocks are overwhelmed or depleted.⁸ Again, health and sustainability are at the forefront of consumers' minds. Concerns include mercury levels in fish such as tuna, and the presence of microplastics.⁹ Since the start of the COVID-19 pandemic, the number of reviews of alternative seafood products has risen by 9.4 times,¹⁰ with 78% of consumers surveyed disclosing that they would be willing to try alternative seafoods.¹¹



6. Paul S. Teng, "Is Urban Agriculture the Future of Farming?" *Pinduoduo*, January 6, 2020.

7. Grand View Research, Architectural Services Market Size, Share & Trends Analysis Report By Service (Construction & Project Management Services, Engineering Services, Urban Planning Services), By End User, By Region, And Segment Forecasts, 2021 - 2028, May, 2021.

8. Todd Woody, "The sea is running out of fish, despite Nation's pledge to stop it," *National Geographic*, October 8, 2019.

9. Woody, "The sea is running out of fish."

10. Emily Doth and Ravi Gopalan, "Alternative Seafood: An Ocean of Opportunity," last modified July 19, 2021.

11. Megan Poinski, "Alternative seafood has vast growth potential, report says," *Food Dive*, September 15, 2021.

Singapore's aspirations for urban food resilience

The Singapore Government's Green Plan 2030 is an initiative to advance the country's sustainable development agenda. The five core pillars of Green Plan 2030 are:

- 1 City in Nature
- 2 Energy Reset
- 3 Sustainable Living
- 4 Green Economy
- 5 Resilient Future¹²

Singapore relies on global food supplies because its population of almost 6 million is 100% urbanised, and traditional farmland makes up just 1% of the city's land mass.¹³ Singapore's Green Plan 2030 was unveiled on 10 February 2021 as the COVID-19 pandemic exposed the vulnerability of global food supply chains. The pandemic has reinforced Singapore's ambition to strengthen its food security, and the resulting Green Plan is anchored by a three-pronged strategy:

- 1 diversifying the nation's food sources
- 2 supporting companies with foreign production
- 3 increasing domestic production

The pandemic has reinforced Singapore's ambition to strengthen its food security.

Singapore's food security goals fall under the focus area of Resilient Future. One of the key metrics of success is the "30 by 30" target for producing enough food in Singapore to fulfil 30% of the nation's nutritional needs by 2030. This plan helps lay the foundations for a more resilient food future.



12. Singapore Government, "Singapore Green Plan 2030," last modified 22 September, 2021.

13. Sandy Ong, "Singapore cultivates 'Silicon Valley of food' in a hungry Asia," *Nikkie Asia*, last modified July 6, 2021.

Part 2:

Singapore's agri foodtech ecosystem

Harnessing technologies and scaling solutions

Singapore lacks land, labour and water for traditional agriculture, so it has developed and focused on technology solutions that require less of these inputs. Notable technologies include vertical farming, to reduce land usage; aeroponics, to be resource efficient; and hydroponics, to reduce water usage.

Singapore is at the forefront of developing technologies for scalable solutions that “move the needle” within urban food systems. An example is Sky Urban Solutions, an innovative vegetable-farming facility that uses hydraulic power to rotate and irrigate crops in modular vertical frames. The patented rotating vertical racking system is being exported to China, Canada and other countries to enable them to overcome the limitations around non-arable land and unconducive climate conditions. The company has also created a micro-farm solution using refurbished freight containers that can house fisheries and cold storage rooms. With the help of these technologies, a micro farm the size of a basketball court could produce up to 100 kilograms of leafy vegetables a day.

These technologies have the capacity to revolutionise the way food is grown, distributed and consumed. They would entail a more participatory model of crop growing, with individual cities opening opportunities for residents to get involved. Urban farming would enable cities to become more independent and resilient in providing a buffer for supply stocks. Citizen Farm, an offshoot of the Edible Garden City company, is an urban farm located in a repurposed prison facility. Using a circular model, the farm drastically decreases waste and is almost carbon neutral.¹⁴ Citizen farm engages with the community by providing employment opportunities for individuals from marginalised groups such as former prison inmates, people with autism and those with mental disabilities. The farm's produce is sold to local restaurants, hotels and supermarkets, and subscription boxes are available for individuals.

From creating an ecosystem of innovation to putting in place infrastructure for ambitious entrepreneurs, Singapore has taken an ‘all hands on deck’ approach to expanding its urban food systems.

From creating an ecosystem of innovation to putting in place infrastructure for ambitious entrepreneurs, Singapore has taken an ‘all hands on deck’ approach to expanding its urban food systems. Several government agencies have been collaborating with those in the urban food industry to transform it into one that is not just productive but also employs climate-resilient, resource-efficient and sustainable technologies. Singapore's national commitment to research and development (R&D) is illustrated by the Singapore Food Story R&D Programme that was initiated to support the “30 by 30” food resilience goal. Its core tenets include R&D in sustainable, urban food production, advanced biotech-based protein production, and food safety and innovation.



14. Daniel L, “Singapore's Citizen Farm,” *Hive Life*, July 18, 2018.

Enabling regulatory architecture

Singapore has positioned itself as a global agrifood hub for business by evolving its regulations from being protective and efficient to becoming proficient and enabling.

The approval of cellular meat production exemplifies Singapore's pragmatic and forward-thinking regulatory framework.

Notably, the Singapore Food Agency approved the sale of cultured chicken meat produced by US-based scale-up Eat Just. The cell-based chicken meat has been cleared for use in Singapore as an ingredient in the production of snack foods. The regulatory clearance process involved the completion of more than 20 production runs in 1,200-litre bioreactors, to demonstrate that Eat Just had a consistent manufacturing process for its cell-based chicken meat.¹⁵ The company was able to illustrate that its product met existing poultry industry standards, with extremely low and significantly cleaner microbiological content than conventional, animal-derived meat. The approval of cellular meat production exemplifies Singapore's pragmatic and forward-thinking regulatory framework.



Startup:

A company that is in the nascent stage of developing its product, exploring customer demand, and working towards commercialisation.



Scale-up:

A startup that has reached the stage of scaling production, or a high-growth company that has succeeded in commercialising its offering and therefore has proven product viability.

In this article, the term "scale-up" is used to emphasise the commercial capacity of companies mentioned.

Furthermore, the formation of the Future Ready Food Safety Hub (FRESH) at Nanyang Technical University on April 27, 2021¹⁶ will enable a neutral platform to foster collaboration between regulators, public research performers and industry on the food ecosystem. The overarching goal is to enable the regulatory processes through the early exposure of novel foods and production methodologies, thereby accelerating time to market.



Maintaining the top position in Asia for IP protection

Singapore continues to be internationally recognised as a regional entry point for expansion into the pan-Asian market. Much of the progress can be attributed to the country's business-friendly environment, political stability and strong intellectual property (IP) protection. The Bloomberg Innovation Index 2021—which scores economies on factors including research and development spending, manufacturing capability and concentration of high-tech public companies—ranked Singapore second in the world. The World Economic Forum's Global Competitiveness Report 2019 ranked Singapore second in the world and first in Asia for IP protection, and first in the most competitive country category.¹⁷

15. Jack Ellis, "Singapore grants world's first regulatory approval for 'lab-grown' meat," *AgFunderNews*, December 2, 2020.

16. Navene Elangovan, "NTU, A*Star and SFA set up new outfit to research safety of novel food," *Today*, last modified April 27, 2021.

17. Intellectual Property Office of Singapore, "Singapore's Global Innovation Ranking," last modified September 21, 2021.

Funding Singapore's agri foodtech economy

Singapore has the highest level of capital funding in Southeast Asia, and its burgeoning urban food economy is no exception. The city-state's sovereign fund, Temasek, has invested close to US\$3 billion into the urban food economy,¹⁸ backing corporates and scale-ups in areas such as biotech, alternative proteins and vertical farming.

To support the agri foodtech industry, the Singapore government has also launched a US\$45 million fund to boost the urban food economy.¹⁹ The Agri-Food Cluster Transformation Fund will be used to support the transformation of the high-tech farming sector to make it highly productive, climate-resilient and resource-efficient. The new fund comprises three co-funding components for local food-producing companies to build and expand their production capacities and capabilities.

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Additionally, SEEDS Capital, the investment arm of Enterprise Singapore, had earlier announced plans to invest US\$65 million to develop Singapore-based agri foodtech scale-ups.²⁰ Some appointed partners include AgFunder, Hatch, ID Capital and The Yield Lab, which will meld strengths and expertise in commercialisation, networks and local market knowledge to enable industry growth.



18. Binyamin Ali, "Temasek MD interview: Singapore alone is not going to feed Asia," *Agri Investor*, last modified March 31, 2020.

19. Sing Yee Ong, "Higher Co-funded quantum and expanded scope in new S\$60 million agri-food fund," *Business Times*, March 4, 2021.

20. Enterprise Singapore, "SEEDS Capital appoints seven partners to co-invest in agrifood tech startups," last modified July 26, 2019.

Part 3:

Singapore as Asia's agri foodtech hub

Fertile ground for corporate innovation and venture ecosystems

Singapore is well positioned as an innovation hub for corporate partnerships and venture ecosystems to develop and distribute urban food systems for the wider pan-Asian region, due to its strategic location, strong R&D environment and well-coordinated government infrastructure. Scale can be reached by launching production capacities around Asia, but Singapore has a pivotal role to play. The city-state presents an ideal environment for scale-ups, venture firms and corporations to launch innovative and disruptive food products.

One such corporate innovation partnership is between German engineering and technology firm Bosch and local IoT technology startup AquaEasy. Bosch established a regional innovation and scaleup incubator network with the aim of launching five new ventures in Singapore by 2023. One venture that has received funding through the platform is AquaEasy, a company using AI-based data analytics capabilities to assist shrimp farmers to implement sustainable aquaculture practices, by increasing yield and predictability. AquaEasy's solutions have already been applied in Indonesia, Vietnam and Singapore, and are aligned with Singapore's food security goals. Bosch lends expertise in technology development and supports AquaEasy's business development and partnerships.

In the alternative protein space, there are plans to establish new R&D centres in the near future. Food manufacturing equipment company Bühler and flavour and fragrance maker Givaudan—both based in Switzerland—have collaborated on a Protein Innovation Centre in Singapore. The centre enables scale-ups and scientists to use Bühler's manufacturing capacity and Givaudan's flavour expertise to develop innovative proteins.

Corporate innovations also extend beyond R&D and funding. The collaboration between Oatly, a Swedish oat drink company, and Yeo Hiap Seng (Yeo's), a Singaporean-headquartered beverage company, is illustrative of a joint venture between an international scale-up and a local enterprise. Together, Oatly and Yeo's have jointly invested US\$22 million in the equipment and facilities necessary to produce vegan milk.²¹ This strategic partnership allows the companies to leverage each other's expertise to tap into surging demand in Asia for plant-based dairy products. It is the first time Oatly will be produced outside Europe and North America.

The city-state presents an ideal environment for scale-ups, venture firms and corporations to launch an innovative and disruptive food product.

Singapore has a world-class funding environment with an ecosystem that provides a strong foundation for venture-building initiatives. From tax-friendly policies to public and private sector support for scale-ups, the city-state has proven itself as a land teeming with opportunity and support for many looking to start their own ventures. Attracting US\$9.9 billion in scale-up investment in 2019 alone, Singapore continues to lead as the top destination for investments in Southeast Asia.²² Given the government's push to meet the "30 by 30" sustainability goal, agri foodtech development in Singapore is a government-driven and private sector supported initiative. Firms can find support from many venture capital initiatives specifically designed for the sector.

21. Economic Development Board, "Yeo's, Oatly in S\$30m tie up to produce oat drink for Asia in Singapore," last modified March 29, 2021.

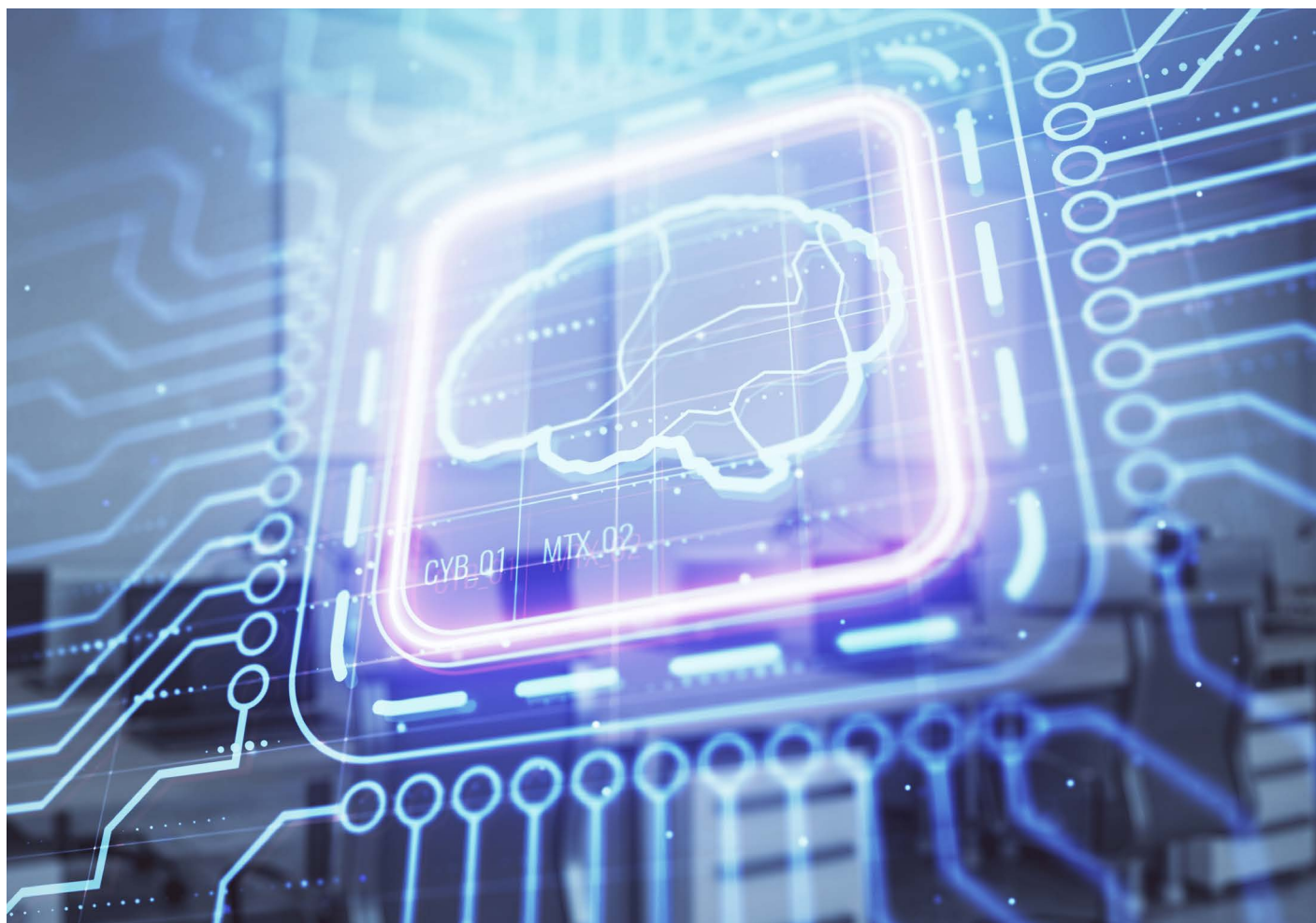
22. Enterprise Singapore, "Venture investments in Singapore rise, with emerging interest in deep tech sectors," media release, October 17, 2019.

The New Ventures arm of Singapore's Economic Development Board (EDB) oversees a programme assisting Singapore-based multinational corporations (MNCs) and large local enterprises (LLEs) to expand their core business and accelerate their venture-building process. The programme gives participants access to well-established venture studios. From the initial ideation stage to the launch of the new business, New Ventures aims to finish the whole cycle within six months, enabling rapid commercialisation.

There are plenty of other venture-building support mechanisms in the country. Temasek recently set up a vehicle targeted at accelerating agriculture and food investments, in response to products that have been identified as consumer-friendly but which require additional investment to scale up. Temasek's new platform aims to help its portfolio of agri-food firms build operational and manufacturing capabilities to launch products on a large scale.

In addition to governmental funding, agri foodtech scale-ups can also obtain venture-building assistance from other international corporations. Thai Union, one of the world's leading seafood producers, has been investing in the agri foodtech space in Singapore. Its investments include Alchemy Foodtech, a Singapore-based scale-up aiming to help curb diabetes through plant-based fibre, and VisVires New Protein, a Singapore foodtech investment fund.

Global venture capital firms such as Big Idea Ventures are focused on innovative scale-ups within the agri foodtech space. Big Idea Ventures has an accelerator programme for alternative proteins, a USD\$50 million New Protein Fund, and a US\$250 million Generation Food Fund that targets cutting-edge companies developing alternative proteins and sustainable food supply chains respectively.²³



23. Big Idea Ventures, "[Solving the World's Biggest Challenges by Supporting the World's Best Entrepreneurs](#)," accessed September 10, 2021.

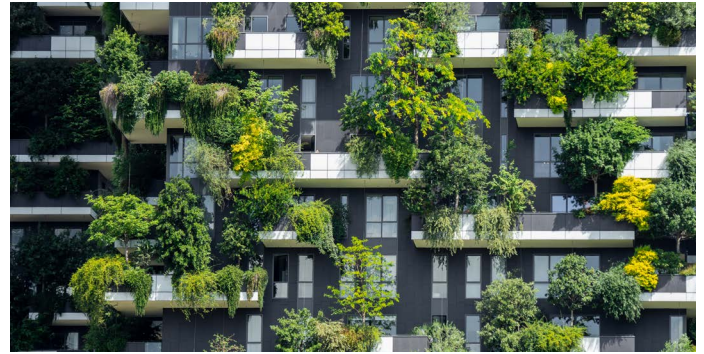
Singapore's strengths position it as a pan-Asian hub

Singapore's ready-built infrastructure helps scale-ups tap into emerging opportunities, further stimulating innovation in agri foodtech. The country has established a specialised district for agri foodtech development, platforms focused on facilitating agritech partnerships, and regional urban food conferences.

In an effort to further catalyse innovation within the urban food economy, the Singapore Government has plans to establish the Agri-Food Innovation Park (AFIP) in the near future. The AFIP will host firms focused on various segments of the supply chain, from research to processing and distribution. The park is intended to be a space for industry players to tap into a network of like-minded people to form new partnerships and strengthen existing ones. Firms focused on urban farming and other associated R&D activities will be concentrated in the AFIP, increasing robustness and collaboration within the growing industry.

With a plethora of ready-built infrastructure and a rapidly growing agri foodtech ecosystem, Singapore proves to be an advantageous place to set up operations and R&D.

Furthermore, Singapore is home to platforms that specialise in helping build a robust network to foster partnerships. Rabobank, a multinational food and agribusiness bank headquartered in the Netherlands, is a leader in facilitating strategic partnerships in the agri foodtech space. The bank piloted the FoodBytes! platform to connect corporations, investors and scale-ups. FoodBytes! provides stakeholders with incentives to promote partnerships and the information needed to bridge asymmetries. Scale-ups get access to funding from investors and guidance from industry experts. Corporations can use the platform to source scale-ups they may want to collaborate with and obtain valuable insights into trends. Investors get access to a pool of vetted and robust scale-ups.



With a plethora of ready-built infrastructure and a rapidly growing agri foodtech ecosystem, Singapore proves to be an advantageous place to set up operations and R&D. Singapore provides many resources to help scale-ups easily connect to the rest of Asia.

Nurturing the agri foodtech talent pool will be critical for success

The advent of agri foodtech has prompted a growing demand for expertise in digital transformation that is not met by the current talent pool. Unlike labour-intensive traditional farms, agritech farms need more than just people who are knowledgeable about agriculture and plant biology. There is an observed unmet demand in agritech firms for those skilled in engineering, data science and design, alongside the more traditional skills such as food science. In response to the growing global shortage of talent within the urban food economy, Singapore has actively taken steps to foster talent in relevant areas. While there is still room for improvement, the city has taken the first step in pushing for educational programmes focused on urban farming technology.

One example is the establishment in June 2018 of the Wil@NUS Corporate Laboratory, a collaboration between leading Asian agribusiness Wilmar and the National University of Singapore (NUS). The US\$80 million lab focuses on researching nutrition, ingredients and the production of eco-friendly industrial biochemicals.²⁴ This partnership combines the strong biomedical science background of NUS with the rich industry experience of Wilmar.

Additionally, Singapore's Nanyang Technological University (NTU) launched Asia Pacific's first university course on alternative proteins.²⁵ "Future Foods: An Introduction to

24. National University of Singapore, "New Wilmar-NUS Joint Lab to drive innovation in food-tech and sustainable biochemicals," press release, June 20, 2018.

25. Ryan Huling, "APAC's first Alternative Protein University Course Coming to Singapore," Good Food Institute APAC, June 21, 2021.

Advanced Meat Alternatives” is a being offered through the university's science and engineering faculty, starting in the 2021–22 academic year. This course was developed after the university observed a possible bottleneck given the surge in demand for food scientists and technologists globally to cultivate new talent.

The industry's proactive initiatives in cultivating expertise in the agri foodtech sector demonstrates encouraging signs for the future.

US-headquartered scale-up in the alternative dairy space, Perfect Day, is harnessing the ecosystem in Singapore and is committed to nurturing talent. It has partnered with government statutory board, A*STAR, to open an R&D centre in Singapore to find ways to refine its fermentation technology and protein ingredients. Perfect Day announced plans to help nurture local talent in agri foodtech by training local scientists, researchers and engineers. In fact, it aims to house 10% of its workforce in the new centre.²⁶

The industry's proactive initiatives in cultivating expertise in the agri foodtech sector demonstrates encouraging signs for the future.



What will success look like?

The foundation for global urban food ecosystems has been laid. Singapore's efforts in further evolving these systems are accelerating the industry and setting new benchmarks. The path forward will need to be built on initial successes while overcoming some of the identified hurdles. New technologies coupled with innovative products and business models and supportive government policies can create more resilient food systems in the coming decade.

In that time, there must be a collaborative and entrepreneurial spirit across borders to help overcome hurdles. While several countries have set food goals in line with the United Nations' 2030 Agenda for Sustainable Development, attention is now beginning to shift towards implementation, monitoring and evaluation. A proposal of universal indicators needs to be developed to measure progress. Measurement must acknowledge the implicit urban focus of sustainable development goals and their targets, and the fact that increasing growth in city populations mean metropolitan areas are where experimentation and actions can reap the greatest impacts. Effective indicators must be measurable, relevant and reliable at a global and national level.

Comprehensive enabling levers such as regulation are needed to maintain momentum. Having a more connected industry can increase knowledge sharing and help push for a cohesive regulatory framework globally. To support innovation and the adoption of new technology, policy makers, academia, urban farmers and operators need a holistic, collaborative approach. Adoption of new technologies will potentially alleviate farmer's carbon footprints and land usage, and the public's ethical concerns about the rearing of animals for meat.

Growth in the industry is also tied to the availability of talent. Several countries have promoted higher education in the agritech food sector to varying extents, but education is still a lagging indicator that needs to be ramped up.

An urban food ecosystem will never feed the world; however, it will vastly improve the resilience of cities by diversifying food sources and contributing to the sustainable management of natural resources. The benefits to our cities are beyond just food security.

26. Sally Ho, "Fermentation dairy Startup Perfect Day To Establish Singapore R&D Centre With A*STAR," Green Queen, January 5, 2021.

Case Studies:

Overcoming limitations with shared experiences: urban food powerhouses in the Netherlands and Israel

The Netherlands and Israel provide are two countries that have developed outsized roles in the global food system despite lacking natural advantages. What can Singapore learn from them?

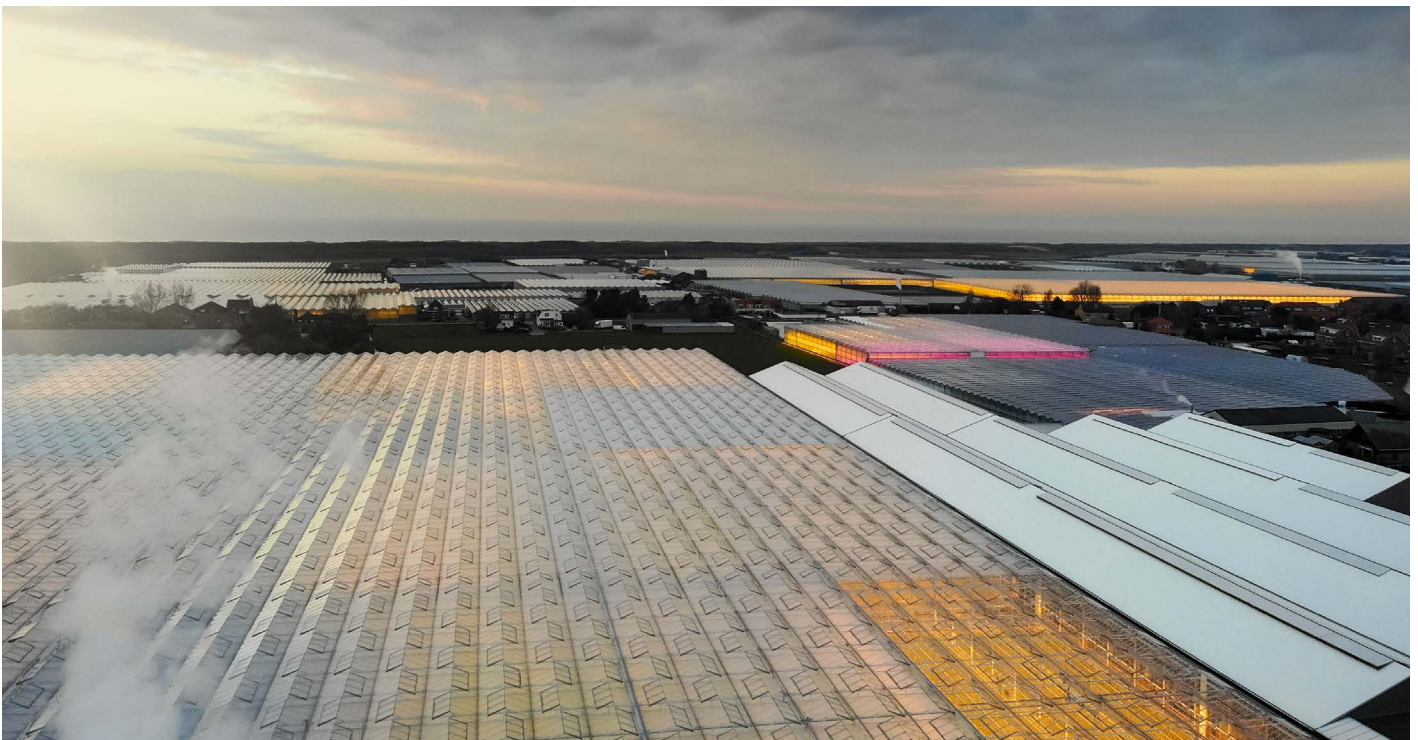
The Netherlands adopted the national motto “Twice the food using half the resources” in 2000.²⁷ Its agriculture sector relies heavily on greenhouses that allow farmers to monitor and adjust growing conditions and use less water, fertiliser and other resources. The greenhouses permit extended growing seasons. The Western Netherlands is one of the most important regions in the world for greenhouse horticulture and has the highest concentration of greenhouses.

The production of agricultural products and technologies require collaboration between food industries, technology providers, government and academia. The Netherlands leads the urban food economy with its open and

collaborative environment, fostering creative collaboration between these groups.

The Netherlands’ vision for 2030 is to become a global leader in circular agriculture, with a focus on both production and reducing environmental impact.²⁸ This ambition entails a shift from production volumes and cost price reductions towards optimising the use of resources and food production. Policies supporting circular agriculture help promote precision agriculture and farm innovations, creating more possibilities for experimentation and rewards for sustainable farming practices.

An example of this innovation is a game-changing innovation developed by family-owned company VDL, which uses AI technology to enable robots to pick and harvest fruits and vegetables. The robot is geared towards picking cucumber plant leaves, allowing more sunlight to reach the fruit. This technology has the potential to increase cucumber yields by 30% per square metre. The software used to detect leaves is the same used to digitise a photo of a human face for facial recognition.²⁹



27. Ashley Capps, “It’s Time to Replace Slaughterhouses With Greenhouses,” *Free From Farm*, December 3, 2018.

28. Wageningen University & Research, “Circular agriculture: a new perspective in Dutch agriculture,” accessed September 28, 2021.

29. Lucette Mascini, “VDL’s picking robot should finally conquer the market in 2021,” *Innovation Origins*, December 28, 2020.



The Netherlands and Israel are both relatively small countries that have turned the old limitations of resource scarcity into new strengths.

Israel also faces natural limitations to food production as it only has small amounts of available land and its dry climate often leads to water scarcity. Despite these limitations—or, indeed, because of them—Israel has set benchmarks for sustainable farming and agritech. Israel's Netafim brought a modern irrigation drip system to the world in the 1960s, which has reduced the amount of water needed in rice farming by 70%.³⁰ Harsh land, scarce water, limited labour and a history of conflict in and around the country stimulated resourcefulness in Israel's drive for increased food security, whilst also fuelling its ambition to

have a meaningful position in the global food system. The food-resilient nation has overcome these obstacles through research and innovation, and by placing a high premium on social responsibility.

Another Israeli farming technology that is setting a new standard is Crop X. Crop X is a system of wireless nodes that can be stuck in the soil at strategic points in a field, with each node sending a constant stream of data about moisture and fertiliser levels and pesticide content to a farmer's smartphone. It can automate adjustments to a connected irrigation system, reducing the daily input of farm labour.

The Netherlands and Israel are both relatively small countries that have turned the old limitations of resource scarcity into new strengths. As a similarly small and resource-strapped country, Singapore seeks to follow in their footsteps and establish a similar presence in the nascent industry within the Asian region.

30. Netafim, "Drip Irrigation for Rice is Changing the Rules of the Game," accessed September 10, 2021.

Next Gen Foods: changing the alternative protein space one chicken dish at a time

Next Gen is a Singapore-headquartered scale-up that is making strides in the alternative protein space. Its TiNDLE brand has pioneered plant-based alternative chicken thighs consisting of nine core ingredients, staying true to the “farm to fork” concept. The co-founders launched the scale-up in Singapore due to the availability of talent, access to capital, the engaged investment community and Singapore's ability to act as an accurate test market for the region. Next Gen has been able to develop an innovative product, establish manufacturing and supply chains, and enter six different markets within a short period of time.

Next Gen made the deliberate choice of creating an alternative chicken product, as it is the most consumed

meat in the world and has the greatest capacity for triggering acceptance. Next Gen first identified the taste, texture and culinary versatility of chicken as traits consumers and chefs find most appealing. It used technology to combine simple ingredients in an innovative way—specifically, the use of extrusion technology to precisely mimic the texture of chicken. Lipi, the company's trademarked proprietary ingredient, is the secret in recreating the taste, cooking experience and smell of chicken fat.

The company's business model involves a chef-led approach, through partnering with top restaurants. Its manufacturing facility is located in the Netherlands, another networked urban food hub.



Sustenir Urban Farms: leafy vegetables that you would not expect from the tropics

Sustenir is a Singapore-based, high-tech indoor farming company that produces over 90 tonnes of crops annually. Its business model is to grow on-demand produce that is typically imported, greatly reducing food transit times and staying true to the “farm to fork” concept. The farm specialises in temperate zone leafy vegetables, from kale to ice plant, that would not thrive in the tropics.

Sustenir uses a closed-loop watering system that pumps nutrient-rich water from a tank to growing racks. The controlled environment allows precise management of all inputs, ensuring the high quality of the output. The facility is designed to optimise the use of resources for each crop, with technology systems that help reduce power and water usage. The average time from picking to availability on supermarket shelves is astonishingly less than 24 hours.

Sustenir has operational facilities in Singapore, Hong Kong and Malaysia, and has been so successful that it has plans to expand into North Asia in 2022. While Sustenir is an international brand, it engages in forms of localisation by growing different crops in different countries according to demand. For instance, crops grown in Singapore are slightly different to those grown in Hong Kong.



Aleph Farms: quality steak directly from cells

Aleph Farms, an Israel-based culture meat scale-up, is working with Mitsubishi to bring lab-grown meat to Japan. The company is also looking at launching its scalable BioFarm in Japan and Singapore. Last April, Aleph Farms committed to eliminating emissions associated with its meat production by 2025. It aims to reach the same net-zero emissions across its entire supply chain by 2030.

Singapore is the only place worldwide that has allowed the production of cultured meats, but Japan is open to the sale of cultured meat. Aleph Farms and Mitsubishi belong to the Association for Cellular Agriculture Study Group, a consortium centered around defining and promoting the acceptance of cellular agriculture foods. Mitsubishi Corporation will support the food tech specialist with its expertise in biotechnology processes, branded food manufacturing and local distribution channels in Japan.

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