



Novel Technologies for Food Production

# Producing More with Less

Cities around the world are incubating innovative modes and types of food production, promising sustainable new ways to supply the nutritional needs of our societies.

Historically, cities have often sprung from agricultural settlements. However, many farms in cities have relocated or diminished over time due to urban development, zoning changes or stricter environmental standards. Today, only between 5–10% of food is grown in cities.

Yet farms in urban centres offer many important and unique benefits. They contribute to local nutrition and food security in cities, and promote social integration and economic diversification. They also contribute to environmental sustainability by saving energy, mitigating heat island effects, and supporting ecosystem services such as pollination or capturing surface runoff.

Recently, there has been a resurgence of interest in urban farming around the world. Demand for high quality fresh vegetables, herbs and fruits has risen in cities. At the same time, increasingly cheap and available technology has enabled the development of novel foods and efficient new farming methods better suited to urban centres.

### Finding New Spaces for Farming

However, the lack of affordable land continues to constrain farming in cities. Today's urban farms have adapted to this challenge by using technology to overcome physical limitations, maximise available space and create suitable conditions for food production.



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# What if a city could produce all of its own food?

Farm skyscrapers

Greenwall, incl. Vertical farms

Insect Farm

Rooftop Greenhouse and intensive farms

Lab Grown Meat

Automated cleaning, processing and packaging plants

Floating Farm

Farming in marginal spaces

Recirculating Aquaculture Systems (indoor farming)

Underground farming

Edible Landscaping

Herb Garden

Fruit Trees



**Global vertical farming market that is projected to grow to US\$3.88 billion (S\$5.3 billion) by 2020.**

On the land-scarce island of Singapore, local firm Sky Greens has developed 9-m towers with rotatable racks, each of which can grow up to 2500 plants. The new method produces 10 times the farm yield for the same area of land used, without requiring arable land. Each rack also consumes only 40WH of electricity (equivalent to a small light bulb), and uses up to 95% less water than conventional land-based farming. This is just one of many forms of vertical farming to emerge in recent years, fuelling a global vertical farming market that is projected to grow to US\$3.88 billion (S\$5.3 billion) by 2020.



Many urban farms are installed within enclosed, non-landed spaces, thanks to technologies that replicate the natural conditions needed for growth, indoors. This has several advantages.

First, it means that dead or underutilised spaces in the city can be put to better use. While industrial buildings are popular for commercial indoor farming, other enclosed spaces have also been equipped for food production. Alesca Life, a Beijing-based start-up, refits shipping containers with hydroponic systems, lighting and integrated software

to maximise productivity while minimising energy and water use. Such containers can be set up in small underutilised spaces, and also stacked up to expand the farm.

Farming indoors is viable even in climates that do not allow for year-round growing. Warehouses can be converted into growing spaces with LED lights, atmospheric control, substrate mimicry, hydroponic systems and sensors, allowing crops like tomatoes, leafy greens and microgreens to be produced 365 days a year.

01 Aerofarms deploys aeroponics as a means of farming vegetables indoors efficiently.

02 The container farm in Dubai run by Alesca Life provides fresh, pesticide-free produce to nearby restaurants and hotels.

In addition, yields are generally higher in indoor farms. This is due to stacking, as well as better control of seeds, pests, water and carbon dioxide levels. Indoor crops are also less exposed to weather elements or pest invasions. Japan's Mirai Co enjoys 50–100 times more production efficiency, and uses no pesticides or genetically modified organisms (GMO). Within a year of operation, they were supplying 10,000 heads of lettuce annually from a small footprint of approximately 2,300 m<sup>2</sup>. In the US, large indoor farms can produce up to 26.6 kg per m<sup>2</sup> of greens annually, compared to only 3.4 kg per m<sup>2</sup> from conventional farms.

Finally, being able to farm indoors means that more than just vegetables can be grown. In Netherlands, Seafarm BV uses a Recirculating Aquaculture System (RAS) to farm fish indoors in multi-storey layers. The process—from feeding, harvesting to packing—is fully automated and requires only one operator; thus reducing labour requirements. Apollo, a fully-automated aquaculture farm in Singapore, uses RAS technology to grow 12 popular food fish in an 8-tier system. Once at full capacity, the farm is expected to yield 2000 tonnes each year. In Rotterdam, the world's first floating dairy farm is being built: it is expected to produce approximately 800 L of milk a day.



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### Expanding Our Diets to Alternative Foods

Cities often attract entrepreneurs and talent. The gathering of bright and curious minds have made cities hotbeds for the creation of new, innovative food types. One new food that is gaining traction is insects: some crickets, locusts, ants, and grubs offer high quality protein, amino acids and vitamins, requiring less feed to produce compared to fish, chicken or other meats. Edible insects have been part of the diets of some Asian, African and South American cultures for centuries. As global protein demand grows, fast-growing insects could supplement food supply. More than 300 entomophagy (insects for human food) companies worldwide are now taking this food mainstream, producing protein bars, pasta, cookies, snacks, shakes and more.

Farming insects is more sustainable: it needs less space than typical livestock, emits lower levels of greenhouse gases and produces yield at much faster rates. It is thus suitable to farm even in large cities. Insects are also useful for animal feeds: Enterra Feed farms black soldier flies in a warehouse outside of Vancouver; they

are about to establish three new mega facilities, following tens of millions of dollars' worth of investments to fund expansion.

Algae is also becoming popular as an alternative food: both as macroalgae, such as seaweed, and microalgae, such as spirulina and chlorella. While most large algae farms are located in deserts, some are finding their way into cities. EnerGaia, for example, has set up farms on rooftops in Bangkok to produce high quality, unadulterated spirulina for health bars, restaurants and nutrition stores in the city. Besides having no smell, algae has the benefit of absorbing carbon dioxide from the environment for photosynthesis and producing oxygen when it is grown.

“Lab grown “meats” are another emerging food trend ... being taken seriously by major food industry players.”

- 01 Food like these burgers made from buffalo worms may one day become prevalent.
- 02 When completed, Floating Farm will be three storeys high and fully mechanised.
- 03 EnerGaia harvests algae on building rooftops in Bangkok.
- 04 The “Impossible Burger” is now sold in burger restaurants, including the popular American fastfood chain White Castle.

“Like any industry, the food industry benefits from clear, transparent and supportive municipal policies and regulations.”

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Lab grown “meats” are another emerging food trend. Typically developed in city labs with access to research talent and facilities, these “meats” may be grown from cells (cultured or in-vitro), or are plant-based but synthesised to replicate the look, texture and taste of meat. A number of companies—including *JUST*, *Beyond Meat* and *Memphis Meat*—are producing what they dub “clean meat” grown from cells. They are being taken seriously by major food industry players. *Future Meat Technologies* has partnered with *Tyson*, the world’s largest poultry and pig farming company. *Impossible Foods*, located in the San Francisco area, has created a plant-based beef-like burger patty made out of heme, textured wheat protein and coconut oil, which is now being sold throughout the US.

#### Encouraging Food Production in Cities through Policies and Incentives.

Food companies are increasingly interested in setting up in cities to be closer to markets. Like any industry, the food industry benefits from clear, transparent and supportive municipal policies and regulations. Some cities are adapting their urban policies to make more of opportunities in the growing field of urban food production and encourage its advancement.

For example, the city of Chicago, through its “Growing for Chicago” initiative, has amended zoning plans and introduced economic incentives to encourage the establishment of urban farms all over the city. Its commercial farms, such as *Gotham Greens*, intensively produce food for local markets and double as catalysts for urban regeneration.

The city-state of Singapore produces less than 10% of its food needs, yet its food industry adds S\$4.3 billion to its GDP

and provides 48,000 jobs. To spur their growth, urban farms and food producers benefit from multi-agency public sector support, which includes a range of incentives, facilities and other schemes, to advance their development.

For instance, Singapore’s JTC has facilitated the use of industrial spaces for food clusters, including the *JTC Food Hub @ Senoko*. Within this development, a 1,130 m<sup>2</sup> small batch production facility will help strengthen the food innovation and R&D ecosystem in Singapore. Through a pay-per-use model, companies will gain access to a range of cutting edge equipment, such as a *Pulse Electric Field* and *Microwave Assisted Thermal Steriliser*, to carry out small batch production of their newly developed food products for market validation.

#### Conclusion

While staple foods such as rice, wheat and maize are unlikely to be grown at scale in cities, other food types are clearly moving into urban settings. These can be grown more intensively, producing less waste and with reduced time and distance from farm to table. Novel foods and innovations are more likely to be incubated and to take off in cities, which have better access to talent, resources and markets.

Major cities around the world, including London, New York, Shanghai, Beijing and Tokyo, are looking at incentives and policies to facilitate urban food production, helping ensure that there is a measure of food resilience and innovation in local industries.

Cities are thus natural settings to facilitate producing more food with less, while contributing to national resilience, sustainability and economic diversity. ○

01 Food manufacturers can validate new products and test their commercial viability at JTC Food Hub @ Senoko’s small batch production facility.