

Can vertical farms help feed our cities?

Farmland is becoming more limited as cities expand, climate change is affecting crop yields, and the transportation of food to cities leaves a significant carbon footprint. **Kirsty Tuxford** asks if vertical urban farms could help ensure food security for future city dwellers



An artist's impression of the Plantagon greenhouse building that is planned for Linköping, Sweden. The slanted facade is adapted to temperate climate zones and sun conditions and the backbone of the building contains commercial areas and areas suitable for research

Photo: Plantagon

A mother cycles to the organic farmers' market to buy her daily fresh produce. Although she lives in the heart of a heavily populated city, the market is not far, and it is easy to spot—it is next to a gigantic greenhouse several storeys high. The mother's weekly supply of fruit and vegetables now comes from a market where local farmers sell produce alongside a vertical urban farm. These specially designed buildings provide a controlled environment where produce can be grown to feed the local population without the need for carbon-emitting transport to bring it there.

This futuristic vision of urban food supply is starting to take root as companies begin experimenting with building greenhouses in cities. Swedish firm Plantagon began construction of a vertical farm greenhouse in Linköping, Sweden in February this year; and at the World Cities Summit in July, Singapore's Sky Green Pte Ltd. unveiled what it claims is the world's first low-carbon water-driven vertical farm.

The threats to food security are clear with the growing urban population meaning 60 percent more food will need to be produced by 2050, according to the Food and Agricultural Organization. Cities in some developing countries are already suffering food insecurity, which is exacerbated by climate change and droughts. What is less clear is the role that urban farms might play in mitigating these threats.

The theory is that vertical farms can assist with food production because current arable farming and available water and energy resources will not be able to cope by 2050, when the population will have reached 9 billion and 70 percent of people will live in cities. With urbanisation, farms will be pushed further away from population centres, resulting in longer transport routes, heavier reliance on oil-based fertilizers, and more intensive farming of available land. Currently 80 percent of arable land is already being farmed. Eventually, there won't be any more space left to farm.

Farming vertically means producing more produce without using any



Construction of the vertical farm began with a ground breaking ceremony on 9 February 2012 in Linköping, Sweden: (L-R) Paul Lindvall, Mayor of Linköping; Hans Hassle, CEO of Plantagon; and Anders Jonsson, CEO of Tekniska Verken

additional ground space. According to Dickson Despommie, ecologist and Professor of Public Health in Environmental Health Sciences at Columbia University, and author of *The Vertical Farm: Feeding the World in the 21st Century* the benefits of vertical urban farming include better utilisation of space; the creation of a closed eco-system re-using waste heat and water from the surrounding city; the abolition of pesticides; and a consequent reduction in agricultural waste pollution. Despommie even suggests that rural farmland will no longer be needed and can revert back to forest.

Others are not so convinced. George Monbiot, the UK writer and environmental activist, is scathing of the vertical farm concept criticising farm designs for their energy consumption due to artificial lighting and motorised pumps.

Michael Guerra, a permaculture designer and engineer, says vertical farms would need a shift in eating habits. At the moment urban agriculture is focused on the production of fresh greens, tomatoes, peppers and herbs. Vertical farms cannot provide meat, root crops, grain crops and other common components of the western diet.

"Spices are a particular problem," says Guerra. "Culinary flavourings (apart from garlic, onions and chillies) usually come great distances, and are highly dependent on the oil supply. If urban vertical or intensive horizontal agriculture is to seriously address the feeding of cities then it has to find ways of providing its citizens with a balanced diet."

But perhaps the biggest argument against vertical farms is the cost of maintenance and construction. ▶

“Intensive growing under glass, especially hydroponics, which is nearly all of the vertical and intensive systems, have to be kept extremely clean and there is very little natural pest predation though some organic systems use predatory insects and natural biocides, and as the plants are not grown in soil they can suffer from the quick infection of airborne diseases,” says Guerra. “For that reason these systems are expensive to run and build. Even if the initial investment of the engineered system was amortized over 100 hundred years, the produce would still cost a lot more than vegetables from farms hundreds of miles away, for now at least.”

Vertical farms in action

While the arguments rage, the architects have been busy. There are many prototype designs though not many actual functioning vertical farms. Plantagon’s vertical farm which is being built in Linköping, Sweden will cover 4,000m² and will be part of an International Centre of Excellence for Urban Agriculture.

With its greenhouse, Plantagon has set out to tackle the challenges of disease control and access to light through innovative technology.

“The cultivation process is designed to minimise the risk of fungus,” explains Susanna Hultin from Sweco, the partner organisation behind the farming technology. “And if a crop with fruit or flowers is ever grown, we can bring in colonies of bumblebees and ladybirds to help with pollination or any outburst of aphids.”

No soil will be used. “It would mean transporting soil in and out of the city, which doesn’t make sense,” explains Hans Hassle, CEO of Plantagon. “So we moved to pumice.”

The plants will be watered with nutrient stock solutions. “We are investigating the possibilities of using the waste from biogas production but this will need testing,” adds Hultin.

One challenge to profitability with urban farms is the lack of natural light, which is able to penetrate to the centre of the building, as the consequent need for artificial lighting is both costly and comes with a carbon footprint. Plantagon’s

innovative cone-shaped design will allow optimum light to reach the produce growing inside, resulting, if all goes to plan, in 10 or 11 harvests per year, thanks to technology developed by Plantagon’s partners. With the greenhouse in Sweden, which will cost SEK 200 million (US\$30,480,800) to build, Plantagon expects to produce 500-700 tonnes of produce annually and to turn a profit after about six years. The Plantagon vertical farm is a means of enhancing farming methods already used—contrary to Despommier’s dream, it is not here to replace traditional agriculture.

Plantagon has worked hard on their business model to make the idea of investing appealing. “A vertical farm cannot produce 29 different types of lettuce to match the choice in the supermarket,” says Hassle. “And no one is even going to walk an extra 300 metres to buy one item from a vertical farm—people want to buy everything in one place.”

Hassle therefore envisages inviting local farmers to sell their produce next to the vertical farm. “Everyone is just talking about the technology as if there’s a market for vertical farms—but there is no market, you have to create one,” says Hassle.

Another challenge to many vertical farm designs in terms of profitability is the cost of urban land. Land in city centres is sold at premium rates and crop production—even at high yields—is not usually sufficient to generate a substantial profit, especially compared to the revenue that could be generated by an office building of the same size.

So for Shanghai, Plantagon is examining a different model. It is looking too expensive to build a large-scale greenhouse in the centre of the city and so a vertical farm could be located outside the city limits. This would mean that food would travel along the usual production trail. The cost of constructing a vertical greenhouse combined with the added cost of transport means the food produced will be more expensive than regular food. “The food produced in such a greenhouse in Shanghai will only be of interest to the middle class because it will always be more expensive, about 20 percent more than food of the same quality,” says Hassle. Vertical farm

greenhouses at this stage of development can only save money by being located at the centre of demand and cutting out the middlemen who transport the produce. “On the other hand, delivering directly to the consumer will mean better food at a lower price as 60 percent of the cost is the middlemen,” says Hassle.

Vertical farms for developing cities?

Some of the less ostentatious and smaller models—such as rooftop greenhouses—could be a small-scale solution for developing cities where budgets don’t stretch to producing steel and glass towers.

According to Michael Guerra, the wealthy north needs glass to keep in the heat and to extend the growing season but in the developing world it is possible to grow produce all year round.

“It can be easier to develop urban agriculture in places where concrete, steel and glass is not the preferred construction material,” maintains Guerra. “Look at Mexico City—it’s spread out, with a huge unplanned shanty population. There are very few skyscrapers, and a good deal of the food grown for the city comes from just outside. The city was built on a lake that over the centuries was converted to canals with market gardens between them. This still has huge potential to feed a city.”

Another Asian city, Singapore, is looking at vertical farms as it already produces less than 10 percent of its food needs locally and has limited space available for farming. In collaboration with the Singapore government, Sky Green Pte Ltd. has been working on the world’s first low-carbon hydraulic water-driven, tropical vegetable urban vertical farm.

Rotating A-frame vertical structures (called ‘A-Go-Gro’), stand 6 metres tall with 22 racks of plants. They use so little energy that each tower only costs US\$3 to run per month. In relation to its production output, each A-frame consumes 75 percent less land, water, pesticides, fertilizer and manpower than traditional farming. The cost per frame is SGD10,000 (US\$8,200). Rainwater is collected to power the pulley system and then it is re-used continuously. The result is five times the produce output in comparison to the land area used for traditional farming—helping Singapore reach its goal of locally producing 10

percent of the leafy vegetables it consumes. Estimates are that the farm can produce 10 tonnes of leafy vegetables each day. Singaporeans consume 330 tonnes per day—but it's a start. Cost-wise this model could be easily adapted for developing cities—however, the key to making the whole thing work is the collection of rainwater, thus limiting its use.

Alternative solutions

With so many potential functional issues with vertical farms (disease, light, and energy use) and their steep construction costs, different solutions are coming to light. BrightFarms design, finance, build and operate hydroponic greenhouse farms at, or near, supermarkets, eliminating time, distance and cost from the food supply chain.

There are no steel and glass skyscrapers and BrightFarm's greenhouses operate with minimal artificial lighting on commercial building roofs often with the customer (i.e. the supermarket) directly underneath. There is no cost to the retailer to build the BrightFarm greenhouse but only an obligation to purchase the output on a fixed-price 10-year contract.

Plantagon too, have other innovative ideas in addition to their stand-alone greenhouses. Solutions for cities with limited space include buildings that function as office and/or living space internally with a farm built into the façade. They can also retrofit existing buildings with a greenhouse façade—a more interesting solution for cities with limited space to construct vertical farms from scratch and with limited funds.

Following a similar integrated building theme, the US architectural firm, Mithun, designed a Centre for Urban Agriculture in response to the 2007 Living Building Challenge competition and won 'Best in show'. The conceptual idea proposed a 'living' building that generates all its own energy, provides a diverse habitat, uses only the water it can gather and produces food for local distribution.

Richard Franko, Principal at Mithun, believes the expense of centrally located vertical farms will stall their development. "Edge city development

With so many potential functional issues with vertical farms (disease, light, and energy use) and their steep construction costs, different solutions are coming to light



Plantagon's innovative cone-shaped design will allow optimum light to reach the produce growing inside, resulting in 10 harvests per year

of these high yield food systems seems much more likely for reasons of easy distribution and lower operational costs," says Franko. "Rooftop retrofits will be another opportunity within the existing urban fabric. The community building benefits of in-city farms and gardens, where people can meet their neighbourhoods and grow fresh food, is a different animal to vertical farms and an important, healthy cultural shift."

As with many of the solutions to the challenges posed by diminishing resources, rapid urbanisation and climate change, there is no quick and easy answer

to ensuring food security. The notion of locally grown organic food has strong appeal for cities but creating such a supply has both heavy financial costs and technical challenges. The future may well see a combination of food production methods with vertical farms on the outskirts of cities; rural land being used more sustainably to deliver higher yields to city distributors; hydroponic greenhouses making use of supermarket and office roofs; and good old-fashioned allotments and home-grown vegetables becoming more popular. All of course within cycling distance for the eco-mum. ■