



ESSAY

Safeguarding Food Security with Urban Agriculture

Cities: The Solution to World Hunger?

Global food output will have to double by 2050 in order to meet the demand of a growing world population. **Max Opray** of Netherlands-based sustainable innovation agency Metabolic explains how cities could embrace and revolutionise agriculture, ensuring food security in the face of resource pressures.

Imagine a new kind of skyscraper rising up to join the apartment blocks, commercial towers and hotels that crowd the skyline of modern cities. Instead of homes or office cubicles, these buildings house row upon row of fruits and vegetables. In the dimly-lit basement and lower levels, mushrooms and bean sprouts thrive in dark conditions. The carbon dioxide the mushrooms emit as they sprout is pumped into artificially lit greenhouses in the floors above to help grow produce like bok choy and tomatoes, all efficiently nourished by circulating water systems. The greenhouses on the rooftop do not need artificial light, as they can bask in the sun. At these heights, robots safely harvest the produce to order for nearby supermarkets and grocery stores in the surrounding neighbourhood.

“A cityscape lined with greenhouse towers ... could be what is needed to feed a booming world population.”

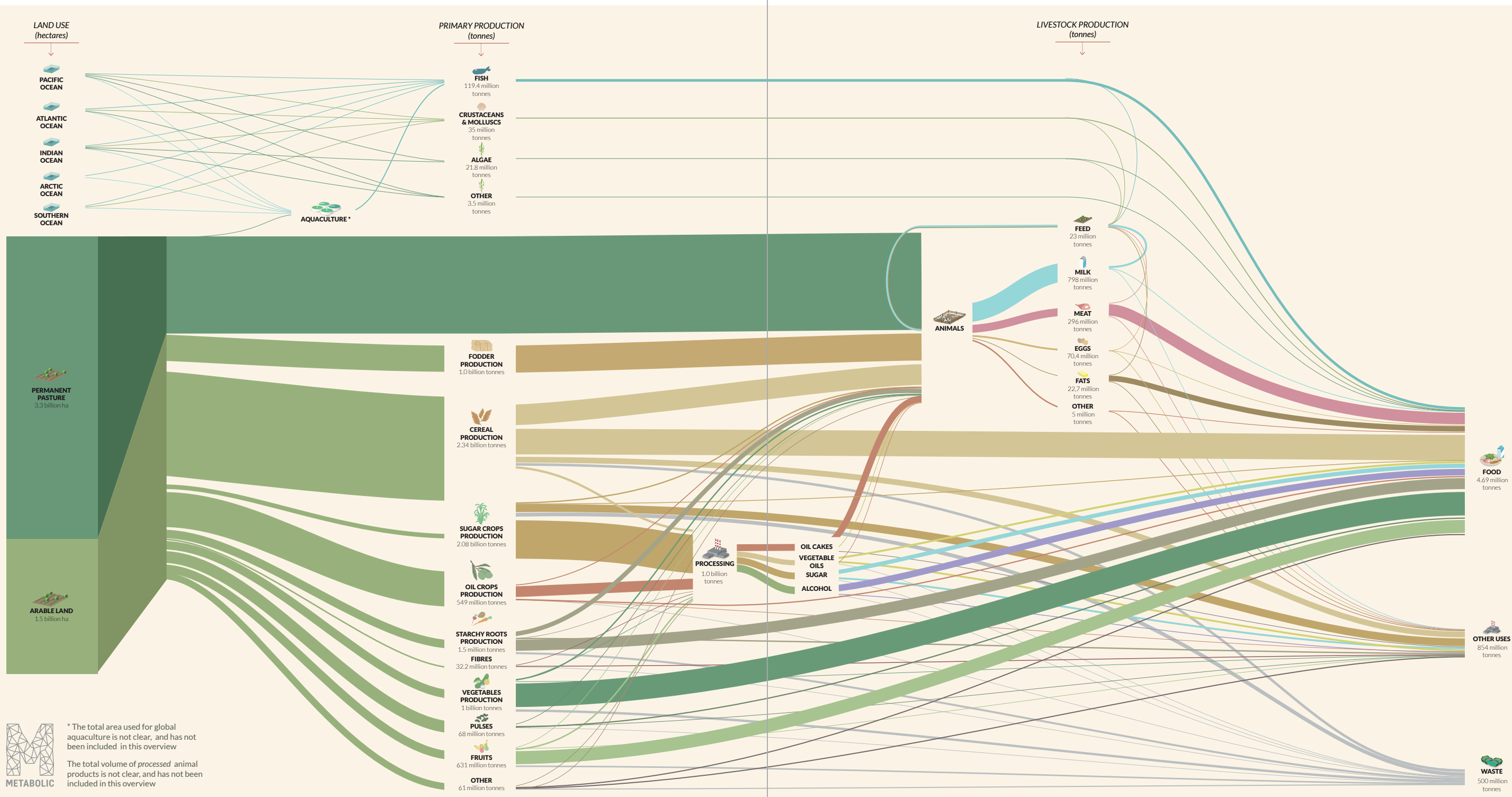
This might sound like science fiction, but for high-density cities with the technical and financial capacity to take the lead, this vision is within reach. Indeed, a cityscape lined with greenhouse towers such as these could be what is needed to feed a booming world population.



Max Opray is a content specialist with Metabolic, a consulting and venture-building company that uses systems thinking to tackle global sustainability challenges.



Illustration of a highrise building mixed with office and greenhouse space in Linköping, Sweden.



M * The total area used for global aquaculture is not clear, and has not been included in this overview

The total volume of processed animal products is not clear, and has not been included in this overview

METABOLIC

01 Metabolic's sankey diagram shows how land and ocean resources produce different food products, including waste, in 2011.

Doing More with Less

The case for urban agriculture is clear. Between now and 2050, the world's food output will have to at least double in order to support a global population that, according to 2017 UN estimates, is not only growing in number by an estimated 83 million people every year, but also demanding increasingly more resource-intensive diets.

According to our WWF-commissioned 2017 study *The Global Food System: An Analysis*, this massive new demand has to be met by a system already straining at the limits of what our planet can support. Humans use 38% of the world's land surface for agriculture, including nearly half of the land capable of supporting plant life. Most of the remaining space is not suitable for food production. Land degradation is also on the increase, thanks to intensive agricultural practices responsible for rising salinity and declining soil health. Current food production is water intensive, using 69% of the world's extracted fresh water. On top of all this, the enormous shift of human populations from rural areas to cities means that urban centres are expanding and paving over some of the world's best farmland. With all these extra mouths to feed, cities are particularly vulnerable to global shocks, and will need to devise innovative solutions in order to safeguard their food security.

Closing the Loop

In the current food system, cities are primarily consumers: one of the endpoints in a linear process. At every stage of this process, there are huge losses of finite resources: be it fertiliser ingredients mined from the ground, land used up and degraded by exploitative agricultural practices, fossil fuels consumed in the process of transporting food, which also generates carbon emissions, or nutrient loss through food wastage and disposal.

Urban agriculture could serve as a panacea for many of these concerns. Clearly, food miles would be reduced by growing the food where it is consumed. The benefits could go further however: urban farming operations can potentially close resource cycles locally, reusing phosphorus and nitrogen in nearby production systems rather than let them go to waste.

Deciding what to Farm

While urban farming can help reduce food miles, spoilage, packaging demand and land use, it also poses challenges. In order to make the business case work, there needs to be extremely high output per m², since land in cities is typically much more expensive than in rural areas. Cereal crops are generally not viable, although Japan once had an underground rice paddy in what was previously a bank vault. The problem is that cereal crops require too much space, and do not enjoy the profit margins needed to justify its use of urban space. Likewise, meat, milk, and other produce sourced from animals are usually too space-intensive to work in cities.



01

The Netherlands features extremely high population densities, yet the country is not a net food importer—in fact, the Dutch are the second largest food exporters by value in the world.

The key here is “value”. The Dutch grow produce—such as tomatoes, capsicums, eggplants, and zucchinis—that can be cultivated within confined spaces in short growth cycles and at a lucrative premium. This approach is now being applied all over the world, including in Singapore, where the pioneering Sky Greens project grows a variety of vegetables in 120 slender four-storey towers.

Looking Up: Vertical Farming

To integrate agriculture into a high-density urban environment, one solution is to look to the skies. Vertical farms could work in layers like a forest ecosystem, harnessing synergies between produce that grows in darkness and crops with fast growth cycles that thrive off natural or artificial light. As a closed system, water and nutrients can be cycled over and over with less external inputs than a conventional farming system. Waste biomass could be used for other purposes, such as chemical production or biofuel.

There are trade-offs, however. Although hydroponic growing operations use up to 90% less water, they require increased energy for artificial lighting, so renewable power sources would be needed to ensure that reduced carbon dioxide emissions from reduced food miles are not outweighed by the carbon emissions from greater electricity consumption. Farm 360 in Indianapolis is an example of how this could work: it grows lettuce in a warehouse using energy-efficient LED lighting and 100% renewable energy.

To deal with the significant logistics of urban agriculture, a hub and spoke collection model could minimise disruption to urban traffic



02

flows. A highly automated system might see robots deployed to harvest produce in response to specific requests by nearby supermarkets and restaurants, based on current needs. By leaving produce on the vine until needed, some fruits and vegetables stay fresh for longer without the need for refrigeration, minimising wastage and energy use.

There are technical challenges, of course, particularly in terms of automation. Developing robots that can grip produce without crushing it is one difficulty. However, some highly automated systems are already at work, including a Dutch mushroom production tower that automatically harvests, slices, cleans and packages mushrooms for sale.

- 01 A rice paddy in what used to be an underground bank vault.
02 Vertical farms enable us to farm upwards instead of outwards.



01

New buildings designed specifically for urban farming are the ideal option, but it is possible to retrofit existing buildings or even integrate food production into residential towers, with dedicated shafts for horticulture. One challenge of this approach is how to build greenhouses on rooftops not designed to carry such heavy weight. A more practical solution might be peri-urban farming just outside the city core, in warehouses two to four storeys tall.

Look to the Seas

Building up is not the only option available to cities: there are also the rivers, lakes and seas near which most cities are built. Our research has found wild fisheries under increasing strain, with 90% either collapsed, overexploited or at capacity. Fish or seafood supplies 15% of total protein demand globally, and this demand is set to rise.

Aquaculture could help meet humanity's growing appetite for seafood, and contribute to the cultivation of alternative food sources such as algae. Although wild capture fisheries still dominate the seafood market, aquaculture has more than doubled since the start of the millennium: it is positioned to become the primary contributor to seafood production in the near future.

The principles of vertical farming can be applied to aquatic farming as well, by building down rather than up, using layers of nets. However, precautions would have to be observed to avoid the risk of disease from overcrowded conditions and genetic problems from inbreeding. Another challenge is in sourcing feed for the fish. Much feed for aquaculture operations is sourced from the wild fish stocks currently under so much strain. More sustainable options include farming black fly larvae, which can be fed food waste and then processed into capsules to feed aquaculture operations. By thinking outside the box, human populations may continue enjoying the fruits of the sea for centuries to come.

Wasted Opportunity

One of the easiest ways to improve food security is to reduce wastage. Globally, about a third of food is currently wasted: some 1.3 billion tonnes a year. Reducing this would represent a quick win in the race to feed the world's growing population.

“Aquaculture... is positioned to become the primary contributor to seafood production in the near future.”

In urban environments, food waste has another consequence: it takes up precious space. As the population and economy continue to grow, further increases in food waste could pose a challenge in terms of competition for limited land.

A range of things can be done to reduce food waste: from apps like Spoiler Alert that help food businesses manage their unsold inventory more effectively, to education programmes that teach people how to better use their food, as well as new regulations. France recently became the first country in the world to ban supermarkets from throwing away unsold food; it must now be donated to charities. US-based project DC Central Kitchen recovers food that might otherwise go to waste, turning it into meals which are provided to other non-profit organisations to feed their clients.

Between 20-40% of produce never makes it off the farm, because it does not meet the aesthetic requirements of supermarkets and other retailers. In the United Kingdom, retailers are forced by law to sell these “ugly” foods, with others in other countries voluntarily choosing to sell these.

“...the greater the share of the world that lives within cities, the more cities become a useful leverage point for change.”



01

“Globally, about a third of food is currently wasted: some 1.3 billion tonnes a year.”

What Comes Next

In our case study analysis of the European food system, we argue that reforming the EU's Central Agricultural Policy (CAP) could be a powerful lever to encourage the growth of urban farming. A range of CAP subsidies incentivise large-scale farming more suited to rural areas. By shifting the focus of these subsidies away from larger farmers towards small-scale operations and urban agriculture innovations, systemic change could be realised.

The EU is the top layer of a sprawling, complex set of governments that administer 28 countries across Europe, each with several layers of bureaucracy. Municipal governments, however, are directly connected to their urban populations. The rapid urbanisation of the global population means that the greater the share of the world that lives within cities, the more cities become a useful leverage point for change. In cities with centralised authority, small policy changes can have a potentially massive impact on how large urban populations relate to the food system. For instance, urban authorities could encourage the identification of underused

02



warehouses and other suitable space for farming. They could also foster relevant connections between stakeholders responsible for water, energy use, and food production.

An extensive urban food system could not only help cities shore up their own food security—it could also serve as an example for others. By making better use of limited space, reducing food miles, and cutting back wastage, cities could show the world how to feed growing populations in a sustainable way while generating new industries and intellectual property. Approached the right way, urban land constraints could shift from a challenge to a strategic advantage. ◉

01 DC Central Kitchen has turned 827,247 pounds of otherwise wasted food into meals.

02 Recognising that ugly food may not necessarily be bad food, grocers are starting to sell “ugly” produce at discounted prices to minimise food waste.