8 Alternative Production Systems: Moving away from Farming the Land

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Introduction

Following on from Chapter 7, where we raise the issue of the complexity of delivering food security, when faced with both constraints in availability and conflicting demands on resources, specifically in the context of expected increases in global population levels, the jury is out as to how food security may be achieved.

The dominant discourse is that an increase in the number of mouths to feed requires an increase in productivity, but there are well reported pressures on land available for food production that might inhibit 'sustainable intensification' of food production (Garnett *et al*., 2013). This chapter examines some of the recent technological developments for the production of food that are reputed to redress this issue.

Technological developments have been varied, and included the use of digital technology for, for instance, the production for in vitro meat and meat substitute, 3D food printing, precision farming, as well as innovative use of space as in Urban and vertical farming. This chapter follows on from Chapter 7, which suggests that some radical thinking must be undertaken with respect to the food supply chain, and in particular the rethinking of the political economic framework, and the issues of managing supply and food waste. This chapter provides a brief introduction to current initiatives, which based on the productionist neoliberal framework, are being put forward to redress the issue of the delivery of sufficient food for growing populations. It examines the ways in which land resources and technologies are deployed in order to produce more for less. It states that the issue of feeding populations is about the volume and costs of production. The chapter then moves on to consider how the production of sufficient food is not a function of primary production but of food manufacturing, and manufacturing through the vehicle of nanotechnology. We start with the use of land resources and consider the developments of urban and vertical farming.

Urban and vertical farming

As the global population increases, many additional demands are being placed upon food production. An increase in the number of mouths to feed requires an increase in productivity but pressures on land available for food production requires 'sustainable intensification' of food production (Garnett *et al*., 2013), not only in terms of the quantity of crop that can be produced per hectare but in the location of farmed land as well. In addition to population pressures, climate change is affecting the area of cultivable land available by altering not only the growing temperature and seasonal variability, but water availability, soil nutrient and salinity levels and the frequency of damaging weather events, such as flooding, storms and drought (Beddington, 2012).

In addition, urban expansion may also reduce the availability of farmland as more and more is turned over to housing an increasingly urban population. Globally, more people now live in urban areas than in rural areas, with 54%of the world's population residing in urban areas in 2014. In 1950, 30% of the world's population was urban, and by 2050, 66% of the world's population is projected to be urban (UN, 2015). However, urban areas also provide an opportunity to reclaim some of this lost land for food generation, and in doing so help increase global food production, via the adoption of so-called 'urban farming' schemes, whereby food is produced from setups located in urban areas.

Urban farming is not a new means of feeding urban communities. The use of allotments and gardens in urban areas for growing produce is common around the world both in developed (Mok *et al*., 2014) and developing economies (Orsini *et al*., 2013). However, the scope of urban farming projects is changing and it is the adoption of large-scale commercial systems that is currently expanding in popularity and, if suitably popular, could provide a useful means to augment food production by making use of urban spaces to grow crops. An increasing number of companies that produce crops in such environments are emerging and are developing innovative approaches to meet the challenges of urban agriculture in a sustainable manner. These new approaches can provide opportunities for increased efficiency, new technologies, patterns of food supply and beneficial urban spaces (Thomaier *et al*., 2015).

Urban farming systems can range from conventional ground-level plant growth, for example in city parks and other open spaces, to sophisticated growing environments with highly regulated conditions, which can be found in unusual locations wherever space permits. Rooftops are a common site for urban crop production as they provide large flat spaces, which are raised above the shady street level and provide good illumination for growing plants (Figure 8.1) (Orsini *et al*., 2014). Such locations have been described as 'zero-acreage farming', as no additional land is used in their operation (Thomaier *et al*., 2015). Rooftop production can be performed uncovered, particular in warmer countries, although this may lead to concerns about crop contamination from pollution sources such as vehicle exhaust fumes (Tong *et al*., 2016).

Figure 8.1: The Long Island City rooftop farm, part of Brooklyn Grange Rooftop Farms, New York, USA (Image from www.brooklyngrangefarm.com).

Urban farming is often performed in greenhouses, as these provide a series of benefits. Greenhouses allow the growing environment to be heated and allow natural light to the plants. Supplementary artificial lighting can also be used in low light level periods, such as during the winter months to maintain crop production (Bergstrand and Schüssler 2013). Greenhouses also protect plants from external pollution and pests, and allow a degree of control over humidity. Lufa Farms Inc., in Montreal, Canada, claim to have built the world's first commercial rooftop greenhouse in 2011 (Figure 8.2) and currently produce a range of different vegetable crops including herbs, peppers and aubergines (Lufa Farms, 2014). Over 200 metric tons of vegetables are produced from their two greenhouses each year. The produce is distributed to customers along with other locally-grown food items. Similar schemes are also underway providing vegetables in other cities such as New York (Gotham Greens Local Produce, 2016).

Figure 8.2: The world's first commercial rooftop glasshouse, the Ahuntsic glasshouse, located in Montreal, Canada, operated by Lufa Farms Inc. (Image from lufa.com).

Covered, self-contained controlled environment (CE) facilities can also be used to grow plants and allow complete control over growth conditions, independent of prevailing weather conditions. Being completely enclosed, CE facilities do not require natural illumination from sunlight and so can be located anywhere in the urban environment and are not restricted to use on rooftops. Both glasshouse and controlled environment facilities require precise control of internal conditions to optimise production and plant health, and may also benefit from the provision of additional carbon dioxide which may be sourced from waste CO_2 to improve sustainability and recycling (Dannehl *et al*., 2014).

These facilities often use light-emitting diode (LED) lighting systems which provide a high-efficiency light source comprising predominantly red and blue wavelengths that can be tailored to the needs of particular crops, but with minimal heat production, allowing the lights to be located near the plants, maximising efficiency of light use (Yeh and Chung, 2009). As LED lighting technology improves, the light spectra can be optimised for maximum benefits, for example a 10-30% proportion of blue LED lights amongst red LED lights is optimum for lamb's lettuce growth (Wojciechowska *et al*., 2015). The largest LED farm in the world, measuring around 2500 m^2, is based in Japan, and can produce up to 10,000 lettuce heads every day (Dickie, 2014). Even more precise control and higher efficiency could be achieved with the use of quantum dot lighting technologies (Yang *et al*., 2015) where the entire light spectrum emitted by the light source can be specified to provide maximal absorption by the crop.

Vertical farming uses stacked layers of plant beds to maximise the amount of crop that can be produced in a given area (Al-Chalabi, 2015). While vertical farming is not limited to urban areas, the high demand for space and limited dimensions of many urban farming setups have led to vertical farming being used as the method of choice for some companies. Vertical farming setups can