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## The Integration of Urban Agriculture and the Socio-Economic Landscape of Future Cities

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**Abstract:** Cities rely upon the provision of imported foods in order to feed their large populations. As a result, the ecological footprint of cities is far greater than their geographical areas. Through the integration of facade and roof-based food systems, agriculture within urban environments has the ability to grow vast amounts of food upon some of the most underused and undervalued areas of the built environment. Such large-scale agricultural systems would not only reduce a city's ecological footprint by reducing the need for imported foods, but they would also engage with the city at an economic and social level. The following paper aims to understand the additional positive impacts of urban agriculture - such as reduce air pollution, decrease depression, promote healthy lifestyles and create jobs - and postulates how such impacts might affect the physical health, mental well-being and financial security of urban populations. Urban agriculture is a viable driver of environmental change, but it is also a catalyst for social and economic reform.

**Keywords:** Urban Agriculture, Ecosystem Services, Social, Economic, Architecture

### Introduction

Urban agriculture is capable of producing large volumes of crops upon the surface area of cities through the integration of horizontal and vertical based food systems (Jenkins, et al., 2015). In doing so, a multitude of supporting services are created such as air filtration, psychological restoration, and the creation of jobs. The following paper aims to understand the role these supporting services play in the physical, psychological and financial well-being of urban populations, and forms an overview of the different ways in which urban agriculture can benefit cities. The research, in most cases, does not aim to quantify these impacts but instead discusses the linkages between prevalent issues within cities and the additional services provided by urban agriculture. Although the research discusses the economics of urban agriculture, it is not the role of this paper to develop robust economic models. Instead, the paper aims to use simple methods of analysis to calculate the impact on local economies and the number of jobs created.

### Global Food Demand

At some point during 2010 and 2011, the world's population surpassed 7 billion people for the first time in human history (ESA, 2015). As a result, a single hectare of agricultural land will need to supply enough food for 6.7 people per annum by 2050, whereas the same area of land in 1970 had only to produce enough food for 2.6 people (FAO, 2012).

The relationship between agricultural land share and food production is not always a direct one however. Due to increased economic prosperity and changing dietary habits, it is

estimated that food production will need to increase by 70 per cent in developed countries and 100 per cent in developing countries by 2050, when referring to production values of 2005 through to 2007 (Bruinsma, 2009). If these estimations are correct, the increase in production will have to be met regardless of changing climates and concerns over energy security, without the cultivation of additional land and without further damage to essential ecosystem services (The Royal Society, 2009).

### **Ecosystem Services**

Ecosystem services are described as the benefits that people obtain from ecosystems (Millennium Ecosystem Assessment, 2005). These include, but are not limited to, food, natural fibres, purification of water, air filtration, regulation of pests, pollination, microclimate regulation, medicinal substances, noise reduction, carbon sequestration, nutrient cycling, open space, and protection from natural hazards such as floods.

Since the inception of the first cities, the dependence on ecosystem services has not changed. The city of Uruk, founded by the Sumerians in 3500BC, was dependent on the flooding of the River Tigris and River Euphrates to enhance the fertility of their soils. However, this flooding was unpredictable and so led to unpredictable harvests. To combat this, the city constructed the first artificial landscapes; building large levees to contain the river and constructed sophisticated irrigation systems to distribute the water evenly to outlying farms (Steel, 2013). By moulding the natural world to suit their needs the Sumerians could predict their harvests more accurately, enabling them to hold a larger static population and in doing so, establish the basic ground rules of urban civilisation.

In 3500BC, city and nature combined to form the ‘city-state’, exemplifying the connection between prosperity and ecosystem services. Since the invention of global trade, however, these ecosystem services have been displaced well beyond the civic boundaries of today's cities. This disconnection not only shields urban populations from the vital role nature plays in their lives, but it also separates the very processes that are needed to keep people alive, happy and healthy from where they are most needed; cities.

### **Urban Health**

Urbanisation is a process closely linked with economic development, but its impact on health and wellbeing can, in some instances, be dramatic. Non-communicable diseases (NCDs) - mainly cardiovascular diseases, chronic respiratory diseases, cancers, and diabetes - are the world's biggest killers. More than 36 million people die annually from NCDs accounting for 63 per cent of global deaths each year (WHO, 2013). The primary causes in most cases of premature death from NCDs are tobacco use, an unhealthy diet, physical inactivity and the excessive consumption of alcohol. Although urban development cannot be held responsible for these risk factors, the urban context is associated with the adoption of lifestyles that favour the development of NCDs (Van de Poel, et al., 2009). This is due in part to increased exposure to outdoor air pollution, overcrowding, crime, stressful work and social isolation, as well as the increased consumption of salt and high sugar foods, reduced physical activity, and increased tobacco use. All of which increase the risk of hypertension and obesity, leading to increases in heart disease, strokes, certain cancers and diabetes (Mendez et al., 2009).

### ***Depression and Anxiety***

Psychiatric disorders, including stress and anxiety amongst other conditions, are one area in which the urban context can dramatically affect the wellbeing of an individual. Peen, et al., (2009) discovered that the presence of psychological conditions, on average, were 38 per cent higher in urban areas than in rural areas. This also included for depression and anxiety, which were 39 per cent 21 per cent higher respectively. Within the UK, the total cost of depression and anxiety in 2007 was £16.4 billion. These psychological disorders, as a result of city living need addressing to help increase the mental well-being of urban populations, reduce the economic strain brought about by these conditions, and to reduce the number of those affected developing more serious physical conditions.

### **Air Pollution**

Another factor affecting physical wellbeing within cities is exposure to air pollution; compromised of particulate matter, ozone, nitrogen dioxide and sulphur dioxide. Urban air pollution can be responsible for such problems as Chronic Obstructive Pulmonary Disease (COPD), which is a collection of lung diseases including chronic bronchitis, emphysema and chronic obstructive airways disease. Within the UK, air pollution is estimated to reduce life expectancy by seven to eight months (Environmental Audit Committee, 2010) and within Europe, over 100,000 deaths are recorded per year as a direct result of exposure to fine particulate matter (WHO, 2003). The total direct cost of COPD to the National Health Service in the UK is over £800 million per annum, with the indirect cost of lost productivity to employers and the economy estimated at £3.8 billion a year (NHS Medical Directorate, 2012). The total cost of health problems related specifically to particulate matter is even higher; estimated to be between £9.1 and 21.4 billion per annum (DEFRA, 2007).

High levels of air pollution can exacerbate symptoms found within asthma sufferers and in some cases, can lead to fatal asthma attacks, which currently accounts for approximately 250,000 annual deaths worldwide. (Bousquet, et al., 2007). It is expected that urban air quality will continue to deteriorate globally with air pollution projected to become the top cause of environmentally related deaths worldwide by 2050 (OECD, 2012).

### **Obesity and Diabetes**

Although not necessarily exacerbated within urban areas, (Peytremann-Bridevaux, et al., 2007; Befort, et al., 2012) obesity is quickly becoming a global problem. Diabetes, on the other hand, is projected to increase globally as a result of urbanisation (Wild et al., 2004). In 2012, an estimated 62 per cent of adults were overweight in England; 24.7 per cent of which were obese, with 2.4 per cent noted as severely obese (Public Health England, 2014a). In 2013, 2.7 million adults were diagnosed with diabetes in England; an increase of 137,000 people from the previous year (Prescribing and Primary Care Team, 2013). Within the UK, 10,000 premature deaths per annum are linked to obesity (Faculty of Public Health, n/d) with type 2 diabetes accounting for 23,300 deaths per annum in England alone (Public Health England, 2014b). Obesity costs the UK £4.2 billion pounds per annum and type 2 diabetes and its related effects on healthcare and the economy account for expenditures of £13 billion per year (Public Health England, 2014b). Only through challenging the risk factors associated with NCDs - specifically physical inactivity and poor diets - will the prevalence of obesity and diabetes start to decline, bringing with it healthier populations who live longer.

### **The Impact of Urban Agriculture**

Due to the linkages between lifestyle choices and the primary risk factors of NCDs, the majority of premature deaths are largely preventable by tackling the associated risks (WHO, 2013). Although it can be argued that these risks cannot be directly resolved through urban agriculture, the integration of agriculture within urban environments can promote alternative lifestyles to those currently offered to help reduce their impact.

Human well-being consists of security, the basic materials for a viable livelihood (food, shelter, clothing, energy, etc., or the income necessary to purchase them), freedom, choice, good health, and good social-cultural relations (Millennium Ecosystem Assessment, 2005). Ultimately, all aspects of human life are defined by the access to ecosystem services such as food, clean water and fresh air. It can, therefore, be argued that the wellbeing of mankind is directly proportional to the health of the biosphere.

If the above factors of human well-being are combined with the primary causes of NCDs, three distinct categories emerge with which the impact of urban agriculture can qualify; physical health, psychological well-being, and financial security. The following will discuss how urban agriculture can benefit society in these three key areas.

### ***Physical Health - Food Production***

The most prevalent way in which urban agriculture can affect physical health is through the improved access to organic foods. In an effort to quantify city-wide food production, the authors of this paper designed and constructed a working elevated aquaponic food system in 2012/13. This system was constructed within a disused mill in Manchester, England and was capable of producing 16,500 crops per annum (Jenkins, et al., 2015). As part of this experiment a food producing facade prototype was also developed to explore the possibilities of vertical growing upon buildings (Jenkins, et al., 2014). Taking the crop production metrics of these two systems - 26.66 crops/m<sup>2</sup> and 15 crops/m<sup>2</sup> respectively, it was possible to calculate city-wide food production, using the city of Manchester, England as a case study. Through the use of three-dimensional modelling, an annual city-wide daylight study was produced and the vertical and horizontal data from the elevated aquaponic food system and façade prototype was applied. The resulting data concluded that the city centre of Manchester was capable of growing an estimated 180.4 million crops per year upon its vertical and horizontal surfaces (Jenkins, et al., 2015). Such production levels of organic foods would at the very least promote an increase in fruit and vegetable consumption, leading to improved urban diets.

### ***Physical Health - Air Pollution***

To progress this research further the same area studied for the daylight analysis of Manchester was investigated further to analyse the provision of green space within the city. It can be seen that the current proportion of green space within the city is particularly low (see Figure. 1). The city centre of Manchester covers an area approximately 402.3 hectares in size, of which green space accounts for only 24.2 hectares; approximately 6 per cent. Urban green space is key to improving air quality as it not only helps sequester carbon and produce oxygen, but also aids in the reduction of particulate matter, and can in some cases absorb ozone, nitrogen dioxide and sulphur dioxide

Taking into account only horizontal food systems upon flat roofs in Manchester, urban agriculture would add an additional 76 hectares of green space to the study area; increasing total green space by 314 per cent (see Figure 1). If vertical growing was also taken into consideration another 94 hectares of green space would be added - taking into account the

reduction in crops/m<sup>2</sup> compared with horizontal systems. Therefore, the total cumulative addition of green space within the city through the integration of urban agriculture would be 170 hectares; an increase of 702 per cent - making the city eight times more efficient at processing air pollution. The improvement of air quality within urban environments will not only better protect those suffering from respiratory diseases but it could also lead to the reduction in the development of respiratory diseases within cities.



Figure 1. Current green space within Manchester city centre (left) with possible green space (right)

### ***Psychological and Physiological Wellbeing***

Natural environments are said to have restorative qualities, which help the human body recover after periods of stress. This theory suggests that humans evolved a positive psychological response to unthreatening natural environments to allow fast and effective recovery from the stress response. It is believed that modern humans retained this positive response to natural environments and it is still as crucial today as it was many millennia ago (Ulrich, 1993). In this context, restoration is defined as 'the process of recovering physiological, psychological and social resources that have become diminished in efforts to meet the demands of everyday life' (Hartig, 2007). These restorative qualities include, but are not limited to, the reduction in blood pressure, levelling of heart rate, reduction in muscle tension, reduction in stress hormone levels and the strengthening of the immune system (Hartig, et al., 2003; Park, et al., 2010). This natural connection between humans and ecosystems is so strong, that restoration can even be achieved through non-tangible experiences - i.e. when viewed through a window - allowing people the opportunity for 'micro-restoration' in their everyday indoor environments. Although brief, these micro-experiences can combine to form measurable cumulative benefits (Kaplan, 1993).

The introduction of urban agriculture to the city of Manchester, England would add an additional 170 hectares of restorative infrastructure to the city. Although the majority of this newly created foliage would be inaccessible to most, the views out from buildings within the city would be transformed into a sea of vegetation spreading across rooftops, spilling down facades and engaging with the public realm. This in itself would bring with it a multitude of opportunities for micro-restoration throughout the day as well as opportunities for full psychological restoration through the creation of vegetative social spaces and centres for commerce.

Physical activity, although primarily linked with physiological well-being, has a profound effect on the psychological wellbeing of an individual. Exercise is key part of mental health but within urban environments, exercise in the traditional sense is hard to fit into daily life. However, even brief five-minute spells of green exercise can lead to large

benefits (Barton, et al., 2010). Consequently, green exercise projects are increasingly seen as a valuable form of treatment for mental health problems.

### ***Financial Security***

It is estimated that the city of Manchester can grow approximately 180 million crops per annum, achieving a sale value of between £360 million and £720 million per year (Jenkins, et al., 2015). Such massive levels of crop production would require a substantial workforce. For the proceeding approximation of job creation within the city of Manchester the lower of the two estimates will be used for annual turnover; i.e. £360 million. This value is the sum of profit, human capital and running costs, which are extremely sensitive to external pressures and complex to calculate. Hence, simple existing information will be used to inform this data.

Tesco is a large supermarket chain in the UK and reported operational profits of 9.2 per cent in 2015 (Tesco, 2015). If this is applied to the projected turnover of urban agriculture in Manchester, approximately £33 million would be set aside as profit for future investment. The percentage spent on human capital by larger companies is approximately 70 per cent (Human Capital Management Institute, n/d); i.e. £229 million per annum. The remainder would cover utility costs, cost of repairs etc. at a cost of £98 million per annum. If the cost of human capital is compared to the average distribution of wages per 1 per cent of population within the UK (HMRC, 2015) the job creation of urban agriculture within Manchester can be calculated. For example, the 1st percentile of the labour force in the UK earns, on average, £8,370 per annum and the 99th percentile of the workforce earns, on average, £150,000 per annum (HMRC, 2015). By using the same proportions of wage spend per 1 per cent of population and applying it to the workforce of urban agriculture within Manchester, it can be calculated that 8,385 jobs would be created within the city at varying levels of importance and income. For the purposes of this exercise a sample of the data has been provided indicating 84.7 jobs are created for every one per cent of workforce, equalling 8,385 jobs in total (see Table 1). It should be noted that the top one per cent of earners have been removed from the study due to extremely high wages.

Table 1. Sample data of job creation when applied to percentile earnings in UK (UA=Urban Agriculture)

Percentile	Annual Wage	Percentage of wage bill	Money for UA Job Creation	Jobs created in UA
1 <sup>st</sup>	£8,370	0.31	£708,949	84.7
50 <sup>th</sup>	£21,000	0.78	£1,778,726	84.7
99 <sup>th</sup>	£150,000	5.55	£12,705,188	84.7

### **Conclusions**

By the year 2050 it is expected that 66.4 per cent of the world's population will be living in cities (ESA, 2014). Although cities are primarily man-made, techno-centric environments, they depend entirely on ecosystem services well beyond their civic boundaries. If cities are to become more sustainable and resilient to change it is likely that they will have to engage with ecosystem services at increasingly localised levels. Urban agriculture, in most respects, provides a solution to producing food where demand is highest. Although the food produced by urban food systems through non-intensive farming techniques (i.e. natural lit polytunnels and facades) will never be able to meet the full demands of urban populations,

it can help reduce the need for imported foods, as well as reduce the need to cultivate natural environments elsewhere.

Air pollution, poor diets, physical inactivity, depression, anxiety and financial insecurity are all issues which affect the wellbeing of urban populations and urban agriculture can help remedy these issues to varying degrees. The integration of urban agriculture can greatly increase vegetation within the city, improving air quality and reducing the probability of urban populations suffering asthma attacks or developing chronic obstructive pulmonary diseases. Additional green vegetation within cities, even if not entirely accessible by the public can aid in reducing depression and anxiety through the restorative healing power of natural landscapes, and can aid in promoting exercise through the use of green corridors and the provision of engaging public spaces. Finally, urban agriculture can produce vast quantities of fresh organic food, promoting healthier diets, reducing obesity, and creating thousands of new jobs within greener, more engaging cities.

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