A vision for urban agriculture in the modern city:

Dr Harry Langford

The northern powerhouse cities are cities of enormous potential. Not only does their heritage provide an urban fabric of architectural history, intertwined public green space and mature tree-lined streets, it critically also provides affordable and large plots of former industrial land that can become foci for change and for sustainable re-development in particular. We feel that such re-development should be focused around a localisation of resources, embracing urban (inclusive of gardens, allotments and orchards) and controlled environment agriculture (inclusive of hydroponics, aquaponics, aeroponics and controlled greenhouse environments), sustainable energy, circularity and interaction.

As population increases and global resources become increasingly scarce and expensive, market demand for local, fresh, healthy produce from sustainable sources is rising rapidly. Obesity and diet-related illnesses account for a significant number of premature deaths in the UK, with urban low-income populations being particularly vulnerable. Indeed, the concept of 'urban food deserts' is a reality for parts of our major cities[1], with access to affordable fruit and vegetables, within walking distance, often limited. With the UK becoming increasingly urbanised (~82%[2]), and 'conventional' agriculture being squeezed by resource and labour pressures, and anthropogenic climate change adding significant uncertainty into the system, the time is right to look towards healthier urban ecosystems with a simplified supply chain and reduced urban-rural fluxes.

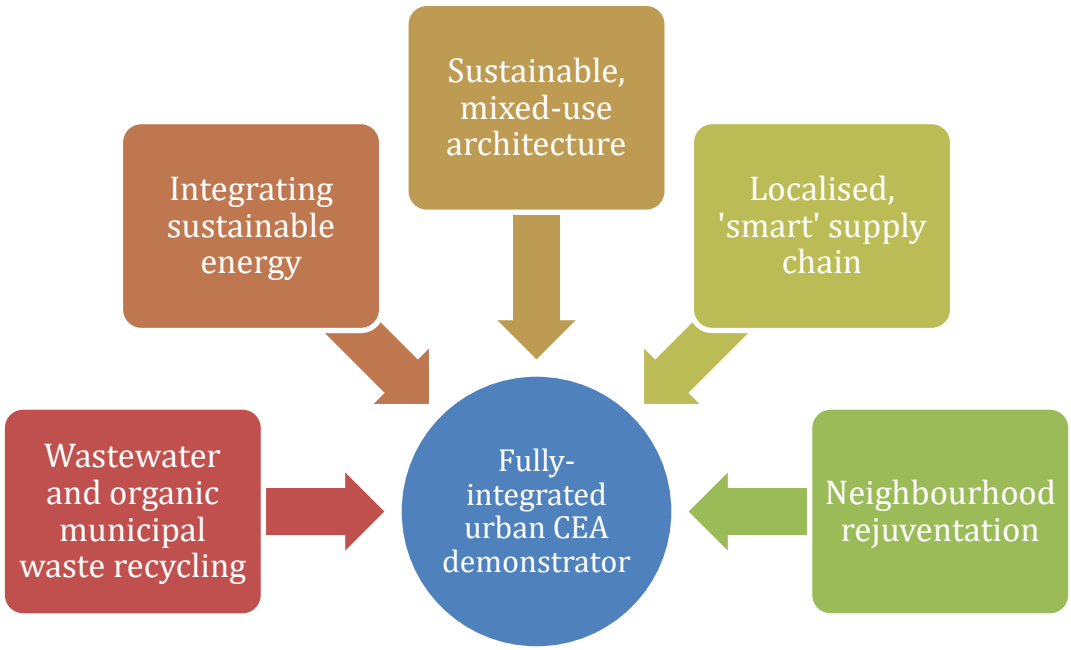
Urban agriculture answers the desire of many to decrease the ecological footprint of food production, bringing with it a multitude of socio-economic and environmental and health benefits, including: reduced transport costs and packaging waste, decreased CO_2 emissions and improved soil health, and increased human activity and community cohesion. The effect upon human health and wellbeing, in particular, has been a recent focus for substantive research, with several studies demonstrating that such factors as life satisfaction, overall mental health, fatigue recovery and social networking are significantly improved through engagement with urban agriculture. Furthermore, such urban farms can create a neighbourhood food access point, upon which a stronger and more diverse local economy can develop; all of this leading to increased urban vibrancy and uniqueness. If urban agriculture were globally implemented to its potential, it could produce as much as 10% of the global output of legumes, root, tuber and vegetable crops[3].

Controlled environment agriculture (CEA) goes one step further than this. Utilising hydroponic, aquaponic or aeroponic techniques, and underpinned by recent advances in LED lighting, HVAC, computation and high-resolution sensing, CEA is truly part of the low carbon economy and actively increases efficiency whilst cutting greenhouse gas emissions. The advantages of CEA are numerous: it typically uses far less water (up to 95% less in aeroponics), space (typically 1/10)

and pesticides than conventional agriculture to produce crops over shorter growth cycles with minimised waste streams and critically no land degradation. All of this allows for high productivity throughout the year. Leafy vegetables and herbs in particular are already being produced in controlled environments in the UK's cities, due to the cost savings associated with transport and the ability to both maintain 'freshness' and meet 'spikes' in demand. Indeed, across Europe, indoor horticulture as a sector is a key growth sector already generating an impressive €46,000 of output per hectare[4].

CEA is a focus for research within the ***N8 AgriFood programme*** because it brings together interdisciplinary challenges from across agri-food, including urban and supply-chain integration, advanced sensing and IoT systems, integration of (waste) side streams, food safety and smart regulation, to name just a few. CEA is also an R&D priority for many of the UK SMEs and growers engaged in it, and an innovation hub with huge potential for knowledge transfer. Sectors beyond the conventional that could play an important and increased role within CEA include machine learning, carbon capture, robotics, wastewater treatment, spectral imaging and material diffusion science, for example. Further, the integration of approaches offers yet more potential, e.g. combining plant phenotyping with control system manipulation, advanced sensing and analytics could allow us to shape the growth of crops for automated harvesting, increase nutrient uptake at key points along the growth cycle, or maximise particular traits such as texture or sweetness.

Through a series of stakeholder innovation workshops, the N8 consortium has identified our academic research strengths and co-designed, with industry, four critical sub-themes of urban and controlled environment agriculture in which we want to strategically focus. These are: 1) system efficiency and operator costs, 2) urban society and the localised supply chain, 3) yield, resilience and trait optimisation, and 4) artificial intelligence and data analytics. Still further, and linked in particular to sub-theme two, we are beginning to explore and outline our 'vision' for a fully-integrated urban CEA demonstrator – how do you build a farm for a city?



How do you build a farm for a city?

In several European cities at present (Germany, Netherlands, Portugal), major supermarket retailers are working with architects, engineers, technology companies, SMEs and academics to deliver new concepts for what a city could look like, centred upon "making markets relevant again" and creating new 'hubs' around localised food production. Beyond Europe, the burgeoning 'plant factory' sector across China, Japan and SE Asia in particular provides for excellent technology export markets as well as opportunities for collaboration and inwards investment in the UK; China has seen 162 plant factories (*source: Chinese Academy of Agricultural Sciences*) open in the last 4 years and CEA will form part of the Innovate UK Smart Farm 2.0 Roadmap in Beijing in September. Across the N8 partnership universities, linking beyond agri-food to our urban institutes, architecture, engineering and health schools, there is a critical mass of research expertise that could be co-opted to work alongside an engaged network of innovative businesses to deliver a concept for **localised and integrated urban food systems in the UK**, as well as engaging with the flourishing global market in this sector.

Next steps

We would like to expand our academic and stakeholder network in this area, to engage such diverse sectors as urban infrastructure, architecture, IoT and robotics, to explore both technology- and knowledge-based opportunities, and to deliver transformative research and development within this interdisciplinary challenge area. We consider 'integrated urban food systems' to be crucial for the sustainability of our agri-food supply chain and a topic that warrants further collaborative research and development.

References

[1]*Wrigley, N., 2002. 'Food deserts' in British cities: policy context and research priorities. Urban studies, 39(11), pp.2029-2040.*

[2]*Rae, A., 2017. A land cover atlas of the United Kingdom. Figshare, https://figshare.com/articles/A_Land_Cover_Atlas_of_the_United_Kingdom_Document_/5266495*

[3]*Clinton, N., et al. 2018. A Global Geospatial Ecosystem Services Estimate of Urban Agriculture. Earth's Future 6.1: 40-60.*

[4]*European Parliamentary Research Service, 2016. Precision agriculture and the future of farming in Europe, Scientific Foresight Study PE 581.892.*