MAKING AQUAPONICS ACCESSIBLE

A Schumacher Institute Challenge Paper

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The Challenge: The need to rapidly intensify global food production, coupled with the declining availability and affordability of the fuels, fertilisers and other inputs on which our current agricultural systems depend, mean that we must now radically rethink the food system. If more food can be produced locally with fewer and more effectively used (and re-used) resources, it may be possible to improve urban food security and combat food poverty. Aquaponics - growing fish and plants symbiotically – is a food-production technique which vastly reduces the need for water and nutrients during production, can be undertaken close to the consumer, and can absorb multiple urban waste streams. The challenge is to make aquaponics more easily accessible to urban communities, and to do so in ways that support their local economies. One possible solution is to develop social enterprise frameworks for community supported aquaculture ventures.

1. Global food supply: nutrient losses, growing demand, insecurity and inequality

Humanity depends on the environment for both development and human well-being, yet in the past 30 years we have lost a quarter of our productive soils and a third of our forests; by 2025 1.8 billion people will reside in countries or regions with absolute water scarcity.[1] The United Nations Environment Programme (UNEP) estimates that global net losses of crop land productivity is on average 0.2% a year due to unsustainable agricultural practices.[2] Recent research indicates that we may have hit the time of "peak" phosphorus production;[3] phosphates are essential to agriculture, but currently only around 20% of phosphorus in the global food system is recycled through composting processes. We may also be at or near peak soil, peak wild fish and peak oil.[4] It is therefore essential that we more effectively manage the flow of essential nutrients: phosphates, potassium, nitrogen, (and to a lesser extent) magnesium, selenium, zinc and copper. For the most part it is in our urban areas that these vital nutrients are lost, by being buried in landfill or flushed into streams, rivers and oceans. This suggests that urban areas may be one point in the human food system where effective interventions can ensure the recycling of these essential resources.

Growing demand acts as a multiplier of the sustainability challenges already facing agriculture. Around 75% of people in developed countries live in urban areas; by 2050 this is likely to increase to 86%.[5] For Europe's 27 member countries, that would mean that by mid-century over 450 million people will live in cities. This puts huge pressure on the agricultural system, which must increase supply to urban areas by approximately 50% within the next 40 years.[6] Globally, the FAO estimates that for demands to be met, food production must increase by as much as 70% by 2050; although

1 Steffen, W., Sanderson, R.A., Tyson, P.D., Jäger, J., Matson, P.A., Moore III, B., Oldfield, F., Richardson, K., Schellnhuber, H.-J., Turner, B.L., Wasson, R.J. (2004). Global Change and the Earth System: A Planet Under Pressure. London: Springer.

2 UN-HABITAT (2006), The State of the World's Cities, 2006/7. London: Earthscan.

3 Sverdrup, H. & Ragnarsdottir, K.V. (2011) Challenging the planetary boundaries II: Assessing the sustainable global population and phosphate supply, using a systems dynamics assessment model. *Applied Geophysics*, Volume 26, Supplement 1, June 2011, pp. S307-S310.

4 Ragnarsdóttir K.V., Sverdrup H.U. and Koca D. (2011) Assessing Long Term Sustainability of Global Supply of Natural Resources and Materials. In C. Ghenai (ed.) *Sustainable Development*. Intech. Available from: http://www.intechopen.com/books/

5 FAO - The United Nations Food and Agriculture Organisation (2011) Food agriculture and cities: Challenges of food and nutrition security, agriculture and ecosystem management in an urbanizing world. *Food for the Cities multi-disciplinary initiative* (www.fao.org/fcit). Accessed October 2011.

6 Adapted from the Eurostat Population Projections – see http://epp.eurostat.ec.europa.eu

even this is seen by some to be an underestimation.[7] Increasing and increasingly volatile food prices tend to affect the poorest first, undermining the possibility of those communities to meet their basic needs. Even in affluent Europe food security is an issue for vulnerable groups such as the elderly, low income, disabled and isolated. It is estimated that 16% of the EU population - around 1 in 5 Europeans - live below poverty level, and 13 million people use domestic food aid. Poverty promotes food insecurity and the consumption of unsafe foods of low nutritional value. Amongst the more affluent, consumer habits trend towards a demand for greater convenience and higher quality, whilst in low income areas the distance to retailers increases. This drives up food prices, further disadvantaging the lowest income families.[8]

2. Local food and the producer - consumer divide

In parallel with concerns about food security, another trend is emerging: increasing consumer demand for locally produced, good quality, safe and sustainably-grown foods. In the UK during 2011 a leap in demand for local food followed the *E.coli* outbreaks across Europe.[9] The view that local is somehow safer and more reliable seems to extends across Europe; research examining local food culture in Norway and France has shown that foods sourced nearer to the consumer are considered to be sustainable foods, both because of 'food miles' and because smaller scale of production is implied by proximity, in contrast to the intensive, large-scale agriculture typical for long-distance food chains.[10] It was found that, what constitutes 'local' is a 'borrowed reality', not restricted to geography; it involves consumer relationships, human know-how, culture and tradition. In urban areas it is this 'borrowed reality' that is driving demand for urban, local open markets, run by real producers. This consumer trend may be part of a wider change taking place in European cities, where the distinctions between urban and rural, producer and consumer, brownfield and greenfield appear to be blurring. This emerging climate of localism offers considerable opportunities for small to medium enterprises (SMEs), which in some sectors are outperforming their corporate counterparts. For example in the UK, where the alcohol industry has generally been loss-making over the past 5 years, micro-breweries have seen increased sales and profits even through the economic downturn.[11]

3. The Regenerative City - a vision for sustainable urban food systems

In 2010 the urban ecologist and futurist Herbert Girardet published his vision for self-regenerating urban areas as: "...places where people, their developments and structures as well as culture are a symbiotic part of the ecosystem."[12] Girardet uses the notion of *Ecopolis* to describe how a regenerative, sustainable city functions: it does not depend on the extraction of resources - oil,

7 See Tilman D. (2010) Understanding the present and projecting the future of global food demand. *Proc. AAAS Annual Meeting 2010.* San Diego: AAAS; Tilman, D., Cassman, K. G., Matson P. A., Naylo,r R., Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature* 418, pp 671-677; Schmidhuber, J., Tubiello F. N. (2007). Climate change and food security special feature: global food security under climate change. *Proc. Natl. Acad. Sci.* 104 (50) pp 19703-19708; Smedshaug C. (2010). *Feeding the world in the 21st century – a historical analysis of agriculture and society*. Anthem Press, London.

8 World Health Organisation (WHO) European Action Plan for Food and Nutrition 2007-2012. http://www.euro.who.int/__data/assets/pdf_file/0017/74402/E91153.pdf [accessed 31st October 2011]

9 On demand see Day-Farnsworth. L, McCown, B., Miller, M. & Pfeiffer, A. (2009). Scaling Up: Meeting the Demand for Local Food. UW-Extension Ag Innovation Center & UW-Madison Center for Integrated Agricultural Systems. On the impact of health concerns see e.g. Home, J. (2011) Boost for local produce after e-coli scare. *Farmer's Weekly* 09 June 2011.

10 Amillien, V. Fort. F, and Ferras. N, Hyper-real territories and urban markets: changing conventions for local food – case studies from France and Norway. *Anthropology of Food S2* (March 2007): From local food to localised food.

11 Doward, J & Wilkinson, B. (2011) 'After real ale, brewers cash in on trend for 'real lagers'. The Observer, 21st August 2011.

12 Girardet. H, 2010. *Regenerative cities: Commission on cities and climate change*. Hamburg: The World Future Council and Hafen City University, Hamburg.

phosphates, and metals - from the earth's crust; its food system uses energy from renewable sources interconnected through smart grids while urban and peri-urban agriculture provides food and also energy from biofuels, heat-exchange composting, and anaerobic bio-digestion. The flows of finite materials through Ecopolis are aligned to bio-geochemical cycles - rhythms that provide and naturally restore them - and wherever finite resources are used, they are upcycled[13] in the system, indefinitely and with a high degree of efficiency. In the regenerative city, 'wastes' are turned into assets: food and human waste are composted; phosphates are recovered from urea in waste water, and used for fertiliser; waste heat from industry is used to heat water for brewing or aquaculture; packaging is multiple use, derived from recycling and upcycled into other useful products. As conceptualised by Girardet, the stocks and flows of material and energy through an urban area comprise a cyclical urban metabolism: each outflow - whether of food waste, waste heat, waste water rich in nutrients, solid waste, CO2 emissions *etc.* - provides an input for another process. This biomimicry, *i.e.* thinking of a city as a living organism, is the key to creating a cyclical urban metabolism where 'waste is food', either for nature or another industrial process.[14] The sustainable use of outputs from one process as inputs for another is referred to as 'closing the loop'.

4. Closed-loop aquaponics as a potential option for sustainable urban food production

Aquaponics provides an excellent example of a closed-loop food production process suitable for sustainable urban and peri-urban food production. It involves the growing of plants and fish together in a specially constructed, recirculating environment, thus combining two sophisticated modern food production techniques – aquaculture (farming aquatic animals and plants) and hydroponics (growing plants in sand, gravel, or liquid, with added nutrients but without soil). In contrast to hydroponics or aquaculture carried out separately, where both depend on the regular introduction of fresh water and nutrients, the symbiotic relationship between fish and plants in aquaponics largely removes the need to discard water or use chemical fertilisers. Furthermore, the 'plant' side of the closed-loop food production process can be undertaken both horizontally and vertically, making it ideal for growing in constrained urban spaces. While outdoor aquaponics makes use of greenhouses and the sun's natural light and warmth (which can be complimented with additional synthetic heat, Co2 and light as required), indoor systems employ artificial heat and light.[15] Currently, most aquaponics projects involve using high amounts of energy to heat water to encourage speedy development of the species in the aquaculture component of the system. While cold-water aquaponics reduces the amount of energy required by the system and thus could potentially vastly reduce the cost of farming in the manner, so far research in this area is limited.[16]

Although the commercial benefits of closed-loop food production in urban areas have not yet been thoroughly investigated, some small-to medium scale aquaponics enterprises are emerging that are both producing foods commercially and determinedly closing material loops. In the Swiss Alps, the Tropenhaus Frutigen[17] uses waste geothermally-heated water from a nearby railway tunnel to warm its greenhouses where vegetables, flowers and fish - Siberian Sturgeon – are cultivated. Tropenhaus connects directly to its consumers who can tour the greenhouses, shop and also eat in the on-site

13 *Upcycling* is the process of converting waste materials or useless products into new materials or products of better quality or a higher environmental value.

14 On biomimicry as a concept see Benyus, J. (2002) Biomimicry: Innovation Inspired by Nature. New York: Perennial. Ways of extending this approach to materials flows in urban and peri-urban agriculture are explored by Braungart and McDonough through their 'cradle to cradle' business model; see Braungart, M., McDonough, W, (2002). *Cradle to Cradle: Remaking the Way We Make Things*. New York: North Point Press.

15 A demonstration of indoor urban aquaponics can be seen at the FARM:shop in Dalston, London. See http://farmlondon.weebly.com/farmshop.html

16 In the UK, research into Aquaponics is taking place at the University of Stirling through their consultancy Aquaponics UK. See http://www.aquaponics.org.uk/

17 http://www.tropenhaus-frutigen.ch/en.html

restaurant. Another inspiring example is The Plant in Chicago, USA.[18] Part vertical farm, part food-business incubator, part research and education space, the project has re-purposed a 8690 m^2 former meatpacking facility where it farms fish and plants aquaponically for sale to the local market. The Plant aims to divert over 10,000 tons of food from landfill annually to its on-site anaerobic digester, meeting all of its heat and power needs with almost no CO2 emissions while creating 125 jobs.

5. Making aquaponics accessible: drawing on emergent modes of ownership

Despite the pressing need for new modes of sustainable local food production, many urban and peri-urban agriculture start-ups fail. This can be attributed in part to a lack of management skills and competencies, lack of budget for technical advice, competition for land, lack of infrastructure, water management issues, and escalating production costs. There are currently modes of ownership emerging in both rural and urban food production which provide useful pointers toward overcoming these barriers. One is the US method of SPIN farming – 'how to farm commercially on less than one acre' - a Small Plot INtensive method designed to get the most from organic sub-acre cultivation, partly by connecting geographically distinct plots into one larger 'farm'.[19] In the UK, there is Community Supported Agriculture (CSA), a partnership between farmers and their local community which involves consumers renting or buying (through *e.g.* a community share offer) a plot of farmland and having vegetables grown on their behalf. CSA shareholders can get involved with the running of a farm, supporting a farm shop or receiving a weekly box of vegetables, and may also undertake work in exchange for discounted or free produce.[20] In terms of legal frameworks, a Community Interest Company (CIC), is a new form of incorporation in the UK designed to support business for community benefit. CIC's are registered and subsequently monitored by a government regulator; a 'community interest test' and 'asset lock' ensure that company activities are for community purposes and that assets and profits remain dedicated to those purposes.[21] These new kinds of production techniques and business frameworks may facilitate the establishment of successful urban food production enterprises wherever limitations would otherwise prevent commercial scale production. They can compensate for the typically small scale of these types of projects by recycling urban resources, eliminating transportation costs, creating active, face-to-face relationships with neighbours and customers, and enlivening and enabling new forms of community support. By supporting the closing of material loops, meeting the growing demand for sustainable, local, healthy food and bridging the producer-consumer divide, aquaponics has the potential to play a major part in creating Ecopolis, the regenerative city. There is now an urgent need to build up detailed information on which modes of aquaponics are best suited to different urban and peri-urban areas, and to identify ways of channelling the skills, capacities and information necessary to overcome the barriers to success. As the examples outlined above demonstrate, closed-loop aquaponics is both technically feasible and socially and economically desirable; the challenge now is to make it truly accessible in those areas and communities where it is most needed.

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18 See http://www.plantchicago.com/

19 See http://www.spinfarming.com/

20 For an overview of CSA and examples in the UK, see http://www.soilassociation.org/communitysupportedagriculture

21 For more on CICs see http://www.bis.gov.uk/cicregulator/