Low impact urban design by closing the urban water cycle The systems approach to urban planning and its application to tackle the food production for cities

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Abstract

Introduction

In an increasingly urbanised world (UN, 2007) it is clear that there will be a need to radically rethink the approach used in the planning of our cities and agglomerations. The role of city planners of today will be to design the cities of tomorrow, or to retrofit the cities of today, such that they provide the space to house growing resident and employed populations and the systems to feed, move and clean the inhabitant population. All this at minimum expense of non-renewable resources.

If we use a conceptual framework that considers the urban development cycle as (i) the evaluation of the city according to a series of indicators, (ii) development of Policies/Plans that move to improve the Indicators, (iii) a resultant impact on the System of the city. This can then be re-evaluated and the cycle continues (as in Figure 1 below). The challenge to the policy makers and professionals of the built environment is two-fold: firstly to identify a vision of where we want to be in the future (that can be defined by a set of Indicators), and secondly to develop a sufficient understanding of the System to write policy or make plans to move us towards that vision.

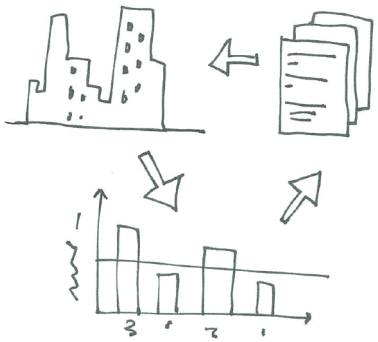

Figure 1 in the City development process the **System** (top left) needs to be evaluated by a set of **Indicators** (below) which give the evidence necessary to deliver policy in the P**lanning Process** (top right). This eventually affects the system and the cycle continues.

One such vision could be the "Entering the Ecological Age" vision (Head, 2008). Head (2008) considers the engineer's role in creating an Ecological Age by the year 2050, where we would live in harmony with the complex ecological system of our planet. The paper clarifies that it has become clear in recent decades that there is no viable future for humanity without a healthy planet. The extremely complex web of life with Earth is being altered in the space of a few generations by using up most of the Earth's fossil fuel resources and their transfer to the atmosphere. In our conceptual framework above, the vision of Entering the Ecological Age can be summarised to the following indicators:

- CO2 Emissions Reduction of 80% by 2050.
- Ecological Footprint Decrease: A transition of Ecological Footprint to the global earth share in all countries, 1.44gha/person, based on a projected global population in 2050.
- Human Development Index Improvement: Raise overall wellbeing in GDP/capita, life expectancy, and education.

These metrics were formulated based on the knowledge that whilst a major reduction in carbon emissions is vital in a transition towards an Ecological Age, we also need to ensure that humanity continues to grow and develop. The Ecological Footprint is a vital tool in this as it is a measure of the resource constraints available to us. The Human Development Index then allows us to gauge overall well-being in three basic dimensions.

Food production today: the concern

When considering the elements of society that have the most significant impact on achieving the above target the understanding of the food-behaviour of inhabitants is critical.

It has been shown that our food behavior can the average impact of food on the Australian inhabitant's carbon footprint is 28% (ACF, 2007). The way we produce our food today is simply too demanding on our resources. The mood is captured in Sindliger 2010:

Our food production and supply system has evolved to become highly dependent on external, non-renewable inputs. It is therefore vulnerable to the impact of peak oil, peak phosphate, water depletion and climate change. It also shows signs of struggling to cope with the challenges a rising global population poses, while meeting the demands for non-food related products and agricultural outputs. At the same time food production is both a significant contributor to the causes of climate change as well as a key victim of its consequences.

Using the systems approach to weed out the win-wins

Having identified how we are doing at the moment (according to our targets) and where we think the key area for improvement may be (in this case food production), the next challenge for the built environment professional is to understand what the Spatial and Policy changes are to be made that will help restore the balance. This involves an understanding of the System defined in the first part, the systems approach.

This approach is founded on the same principles as those of 'Total Architecture' or 'Total Design'. This approach strives towards a goal where all relevant design decisions have been considered together and have been integrated into a whole by a well organised team empowered to fix priorities. This is an ideal which can never – or only very rarely – be fully realised in practice, but which is well worth striving for, for artistic wholeness or excellence depends on it, and for our own sake we need the stimulation produced by excellence. (Arup, 1970)

The Systems approach to planning is used by Arup to understand and model the relationships between resources. When considering the production of food in the same systematic way as we considered the development of other urban infrastructure then for some situations it becomes clear that a more localised food production system may help us achieve our targets for the future. It is possible to observe benefits and synergies due to the localised food production that include:

- The possibility to use household waste water as a resource, thereby reducing the water depletion due to agriculture and possibly closing the nutrient cycle.
- The possibility to use household kitchen waste as a resource, again closing the nutrient cycle.
- The possibility to reduce surface water runoff within buildings/cities and reduce the need for peak flow capacity
- Depending on climate, a chance for evaporative cooling and a reduction of urban heat island effect
- Reduction of transportation resources needed to take food from farm to plate
- The possibility to bring an increase in biodiversities to urban areas
- Using greenery close to populations to combat sick building syndrome
- Using urban greenery to generally promote well being!!

Developing the link between Grey Water and Localised Food Production

The theory goes that by separating our wastewater into grey water and black water, and in combination with using ecological products that are already sold commercially (eg. Ecover), we can identify a range of sources for feeding greenery in our urban or peri-urban environment.

An elegant system develops where human activity produces the resources for urban greenery, which is then used for growing food for the local human activity, thereby closing large parts of the water and nutrient cycles. For example, in an extreme, desert-like environment with a high solar radiation, a highly water demanding greenery such as clipped grass would need some 7 kg m-2 day-1 of water. The amount of grey water typically produced per person could therefore green up to approximately 12.5 m2 desert.

The Centre for the Study of the Built Environment (CSBE) carried out extensive research from 2002 – 2004 on the use of grey water for irrigation purposes. It is clear from that research that the challenge to the reuse of wastewater for urban agriculture lies in the identification and treatment of contaminants. The contaminants in grey water can range from gentle soaps used for washing, to the residues from soiled nappies put in the laundry and bleaches used for general cleaning. If we assume that users will avoid the disposal of inappropriate substances (such as bleaches, paints, etc), the buildup of sodium over time from soaps and detergents is most likely the most serious potential long-term consequences of irrigation with grey water (CSBE, 2004).

It is also essential to ensure that there exists no vector between the contaminants found in grey water and humans.

There still appears to be a knowledge gap (or at least insufficient visibility of research by built environment professionals) regarding whether there is any significant contaminant build up over time in the soil or plants when irrigated by grey water. On the one hand it is know that certain reeds, etc can be used to process waste water. On the other hand it is suspected that problems such as sodium build up and contact with harmful pathogens may occur when plants in general are irrigated with grey water. Yet there is negligible research to substantiate and quantify this at present.

For this reason legislation tends to require that grey water is only used for sub-surface irrigation, or only to irrigate ornamental greenery with which humans have no contact (CSBE, 2004).

Trends and example projects in localised food production

The challenges facing grey water use in localised food production are clear, but given the potential global benefits these projects still appear to be being developed. What are the trends being observed in real planning and projects? Below is a simple categorisation of the different projects being pursued by individuals, organisations, city bodies, and national bodies:

Single Building Adaptation: These projects seek to use redundant building space for the purpose of growing food. An example of a single building adaptation is the Zabar's restaurant and market, New York. Zabar's owners recognised that their core clients were willing to pay a

premium for organic vegetables and meals. They responded by incorporating a greenhouse on the roof of the existing market.

Vertically Integrated Gardens (VIG) - Vertically integrated gardens have been proposed, but have not yet been incorporated into new building designs. This concept incorporates a vertical garden between a double walled façade. The façade provides a thermal barrier between the outdoor and indoor climate, while the garden further filters light and provides for an aesthetic appeal to building occupants. The VIG uses hydroponic technology, in an automated venetian blind type system.

Purpose built garden buildings/Vertical Food Farms- The vertical food farm is another concept that has yet to be realised. The concept is to incorporate gardens and or animal farms into tall buildings which would ultimately feed all of the building occupants. The concept is immortalised by MVRDV's "Pig City" project to house some 280,000 pigs needed to feed the population of The Hague with pork.

Urban Farms/Redundant Plot Reuse - ongoing inability to generate investment interest to develop and the current surplus of office real estate in much of Europe means that land owners are reconsidering their strategies for empty plots. Zuidas Development has established an urban farm on one of its empty plots in central Amsterdam. The farm has a strong community element with neighbourhood schools invited to celebrate the harvest. It is transforming the perception of the future development among local people.

Eco-communities and Eco-cities - China is one of the first countries to consider planning entire communities around food production opportunities. This concept maximises all available growing space within a community to help address the loss of agricultural land resulting from urban growth. An example of such a project is Arup's masterplan for Whanzhuang. Other European example projects include Arup's masterplan for The Co-operative Eco-town in Leicestershire and the Almere Schaalsprong. Both have a food and farming strategy integrated together and with the resource plans for the city.

A case for cautious optimism?

Some of the conclusions of this discussion can be found below:

- When considering the planning of cities or parts of cities the following conceptual framework is helpful: Indicator – Policy/Plan – System.
- When trying to understand the system (in order to define policies and plans) the resource flow modeling approach can be used. This approach to urban planning is one of the ways to disentangle the complexity of the System. This can be done, as done in Arup, along resource lines.
- The systems approach can clearly be used to break down the issues surrounding the food production for our cities, and draw a line towards where we need to go for the future.
- Localised food production projects (also known as Urban Agriculture) are a trend for the future. One of the reasons is that these projects seem to tackle many of society's resource issues in one go. This can be demonstrated using the resource flow modeling methodology.
- A review of the trends in demonstration projects suggests that significant additional benefits in the realm of waste water reuse still need to be unlocked. Closer

communication between the science and policy makers over for example reuse of domestic waste water for food production.

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