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How can **Urban Agriculture** Play a Role in the City of the **Future?**

by **Dr. Rob Simm**

When you look at a city's resource balance (water, energy, food) you really need to ask the question: "do modern cities really make sense?" What can we do to turn cities from nonsensical to sensical?

In a previous ***blog***, I talked about how humanity's biggest problem will likely be the fact that we will not be able to feed ourselves in the not so distant future. I do not know about you, but these last six months – living through the COVID-19 pandemic – highlighted for me some of the vulnerabilities of modern society. In particular with our food system. Personally, I found the sight of empty grocery store shelves and shortages of some staples like eggs, beef, rice, beans, and even frozen foods at the beginning of the pandemic unnerving.

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Measuring food security

I have been thinking more and more about where our food is coming from and how vulnerable city dwellers are if we are not able to transport food from rural areas to the city center. Are cities becoming more vulnerable? Is the pandemic a bit of a wakeup call?

I decided to look at the food security index rankings published by ***The Economist's Intelligence Unit (EIU)***. ***The Global Food Security Index*** measures three core factors: affordability, availability, and quality and safety.

Affordability encompasses several factors, including the ability of consumers to purchase the food, vulnerability to price shocks, and the presence of programs to support consumers when shocks occur. Availability assesses factors like sufficiency of the national food supply, risk of supply disruption, capacity to disseminate food, and research efforts to expand agricultural output. The final category is quality and safety. This measures the nutritional quality of the average diet, as well as food safety.

The small island nation of Singapore was rated number one in global food security in 2019. This is interesting given approximately 90 percent of Singapore's food is currently imported from approximately 170 countries.

Importing a high amount of food does not necessarily mean that a country is food insecure. For many countries, food is imported to create more variety for the consumer, not to prevent starvation within the population. The United States, being one of the world's largest economies, imports a total of $133 billion USD worth of food and food products. China is next at $105.26 billion USD, followed by Germany ($98.90 billion USD), Japan ($68.86 billion USD), the United Kingdom ($66.54 billion USD), and the Netherlands ($64.38 billion USD). But what happens if trade is disrupted or if net exporters can no longer meet demand?

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How does North America rate?

Both the United States and Canada rank in the top 10 for food security (United States 3rd and Canada 8th). Both are considered self-sufficient in terms of food production with an abundant food supply (producing between 30 and 50 percent more than what is needed to meet the populations food requirements).

Although not a criterion considered for mainstream rankings, the EIU looks at how exposure to climate risks, as well as the three natural assets crucial to food security (water, land, and oceans) can affect a country's overall picture. According to the EIU, Canada is more vulnerable to drought, flooding risk, and its associated impact on agriculture than the US. Both countries are susceptible to coastal eutrophication and the associated impacts on aquaculture and human health. When one adjusts the scores for natural resources and resilience, Singapore drops from number 1 to number 12 in the rankings. The US and Canada drop to 7th and 9th respectively.

The above analysis suggests things appear fine, for now. However, what does the future hold? Several authors and researchers have tried to answer this very question. Springmann et al (2018) have suggested the current food system is a major driver of climate change. The biggest factors? Changes in land use, depletion of freshwater resources, and pollution of terrestrial and aquatic ecosystems through excessive nitrogen and phosphorus inputs.

Can the planet sustain current food production systems?

Springmann et al (2018) predict that between 2010 and 2050 the environmental effects of the food system could increase by 50 to 90 percent in the absence of technological changes and dedicated mitigation measures. In fact, we could reach levels that are beyond the planetary boundaries for global freshwater use, change in land use, and ocean acidification that define a safe operating space for humanity. Clearly, there is no room for complacency.

So, what kind of technological changes do we need? In my previous blog, I talked about how the Green Revolution – which took place between 1950 and the late 1960s – consisted of a series of initiatives that increased agricultural production around the world. As Earth's population rapidly increased, we were able to feed people with only a 30 percent increase in the land area required for agriculture. Increases in agricultural productivity came from boosts in crop yields, new crop strains, fertilizers, and mechanized agriculture. This was a great achievement for science and humankind in general.

Over time, we started to notice issues with modern food production systems. This time around, we do not need to just produce more food. We need to produce food in a more sustainable manner. Why? Currently, the Earth's population sits around 7.7 billion. The United Nations estimates that number to reach 10.5 billion by 2070. To feed that additional 2.8 billion people, we need a new arable land area – land that can produce crops – about the size of Brazil. And that is just not available.

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A growing issue – cities as net consumers

Urban settings now contain over 50 percent of the global population (including nearly 500 cities with populations >1 million and 28 megacities with populations >10 million). By 2050, approximately 68 percent of the world's population is expected to live in cities.

The problem is that Cities are net consumers of resources. According to the UN (2016), urban areas currently account for 2 to 3 percent of the world's land area and consume about three quarters of the natural resources and nearly two-thirds of the energy. They also contribute more than 70 percent of the greenhouse gas emissions.

Currently the flow of resources into modern cities is linear. A very high proportion of food flows into cities where it is processed or consumed, creating organic waste in the form of discarded food, byproducts, or sewage. The majority of which is currently not recycled. Less than two percent of the nutrients in the food entering most cities get recycled for productive use.

The linearity of resource usage in cities is a significant contributing factor to the excessive inputs of nitrogen and phosphorus to the environment referenced by Springmann et al (2018). Wielemaker et al (2018) have suggested: "to maintain the city as a viable concept for human dwelling in the long term, a circular metabolism needs to be adopted that relies on recovering, reusing and recycling resources, in which output ('waste') from one metabolic urban conversion equals input for another."

By 2050 approximately 80 percent of all food is expected to be consumed in cities, but only up to 15 percent of food production takes place in these urban areas. This means the food will need to come from outside the city. But what happens if there is a disruption in the food supply network?

Khan and Zaman (2018) conducted a literature review of various notions of desirable cities promoted under various labels. Their work suggests that cities of the future would need to be dynamic and intelligent in every aspect from social and economic to environmental. Their paper concludes by pointing out the need to ensure that the overall focus of scholars dealing with the built environment at any given time provides a balanced regard to all aspects of sustainability. This would obviously include food.

There is a lot of discussion these days about smart cities and how the internet-of-things (IoT) is going to make our cities better places. Collecting and processing mass amounts of data should help us to make better decisions. But will we be much smarter?

In November of 2019, I led a discussion group at the American Water Summit in Houston where I asked the participants: "Can a city truly be smart if it is a net consumer of energy and materials and can't at least provide the minimum needs to feed its population?" Most participants suggested the answer to this question was a resounding "no". So then, what can cities do to change the current situation?

"There is an urgent need for technological innovations in the area of food security."

Urban agriculture – a piece to the puzzle

As we march towards 2070, natural resources are going to become increasingly precious commodities. With the rise in global population and urbanization, there will be a decreasing amount of natural resources – like land – for food production using traditional methods. For instance, India is slated to become one of the most land-scarce countries by 2050 due to rapid urbanization (Shukla, 2017).

There is an urgent need for technological innovations in the area of food security that maximize the diminishing land and natural resources to produce sufficient, safe, and nutritious food.

According to the Food and Agriculture Organization of the United Nations, approximately 10 to 15 percent of all food production in the world is currently happening through urban agriculture. Of course, most urban agriculture consists of rooftop gardens and communal gardens. That is not going to cut it. We need more space.

Analyses conducted for the report "Cities and the Circular Economy for Food" (2019) suggests a theoretical maximum of one-third (by weight) of the food needed for urban consumption could be grown within cities. However, when one looks at the analysis it focuses solely on the main food types that are currently known to be produced through urban agriculture namely – leafy greens, tomatoes, other vegetables, fruits, and fish.

What the analysis is missing is that it does not account for future innovation in urban agriculture practices and techniques to grow additional food types. Hypothetical analysis suggests the share of total urban area that would be required to produce 100 percent of the food types currently grown outside in indoor farms today is only 1.4 percent.

So how is Singapore, currently ranked as number 1 for food security, preparing for the future? The government recognizes their country's current situation as a vulnerability and has adopted the Singapore "30 by 30" strategy whereby they plan to raise food self-production levels from the current 10 percent to 30 percent by 2030.

They have some hurdles to jump, for sure. First, rapid economic development has resulted in a population increase of 87 percent from 3.047 million to 5.7 million in 2019 (Department of Statistic Singapore, 2019). Singapore is also not a very big country. It has a land area approximately 0.92 times the city of New York. This population increase has meant a rapid decline in the amount of land allocated for agriculture.

In 1965, Singapore was partially self-sufficient in food supply with farmlands occupying approximately a quarter of the country's land. However, by 2014, farmlands occupied less than 1 percent (Ludher, 2016). But Singapore is making gains and on track to achieving their "30 by 30" goals (Teng, P., & Montesclaros, J. (2019)). Much of this gain is thanks to urban agriculture. Are there lessons we can learn from Singapore?

"People are now starting to look at optimized urban agriculture within the built environment."

Overcoming urban agriculture obstacles

The expanding interest and increasing innovation in urban agriculture could certainly be part of the solution. However, urban agriculture is certainly not perfect and although it can be a big part of the overall solution, it is unlikely to be the entire solution. The Macarthur Foundation (2019) suggests adopting regenerative farming practices in the peri-urban areas (within 20-kilometers of a city) where approximately 40 percent of the world's food is currently grown, along with a significant reduction in food wastage as being critical to future success.

One of the knocks against urban agriculture is that it will always have to compete for land. And that land will always go to the highest (perceived) value. I would argue, what is of more value than feeding our population? My suspicion is that as more of us continue to work from home post-pandemic, online shopping continues to increase, and with the eventual advent of self-driving vehicles, we are going to see a lot of office, retail, and parking garage space become available. This space could be repurposed for urban food production.

How? People are now starting to look at optimized urban agriculture within the built environment. These techniques – such as aquaculture, hydroponics, aquaponics, and vertical farming – have a much higher yield in terms of kilograms per acre. These techniques are less water intensive and more efficient in the way we use the land.

Another potential obstacle is that only limited food types can be produced by urban farming. Today, this would certainly appear to be the case when considering agriculture within the city limits. However, I have a lot of faith in the ability of agricultural and engineering scientists to develop new crop production methods to expand urban agriculture choices. Insects and microalgae are just two new food source variables that come to mind.

The last obstacle could be the challenge of becoming circular. The circularity of urban agriculture includes renewable energy, water, and the use of nutrient inputs, as well as circular fish feed for fish production. This topic is currently being researched by several groups.

For example, Wielemaker et al (2018) have suggested that linking new sanitation, including source separation of waste and wastewater streams, collecting organic kitchen waste, black water (urine and feces), grey water (shower/bath, sink, laundry, dish washer), and urban agriculture could lead to mutual benefits in terms of resource recycling, especially for fertilizers. In an example from the Netherlands, researchers estimated the demand for nutrients and organic matter for urban agriculture (ground and rooftop based) can be minimized by 65 to 85 percent. A self-sufficiency of 100 percent for phosphorus can be achieved by recovering nutrients from new sanitation techniques.

The new agrarian society – is it possible?

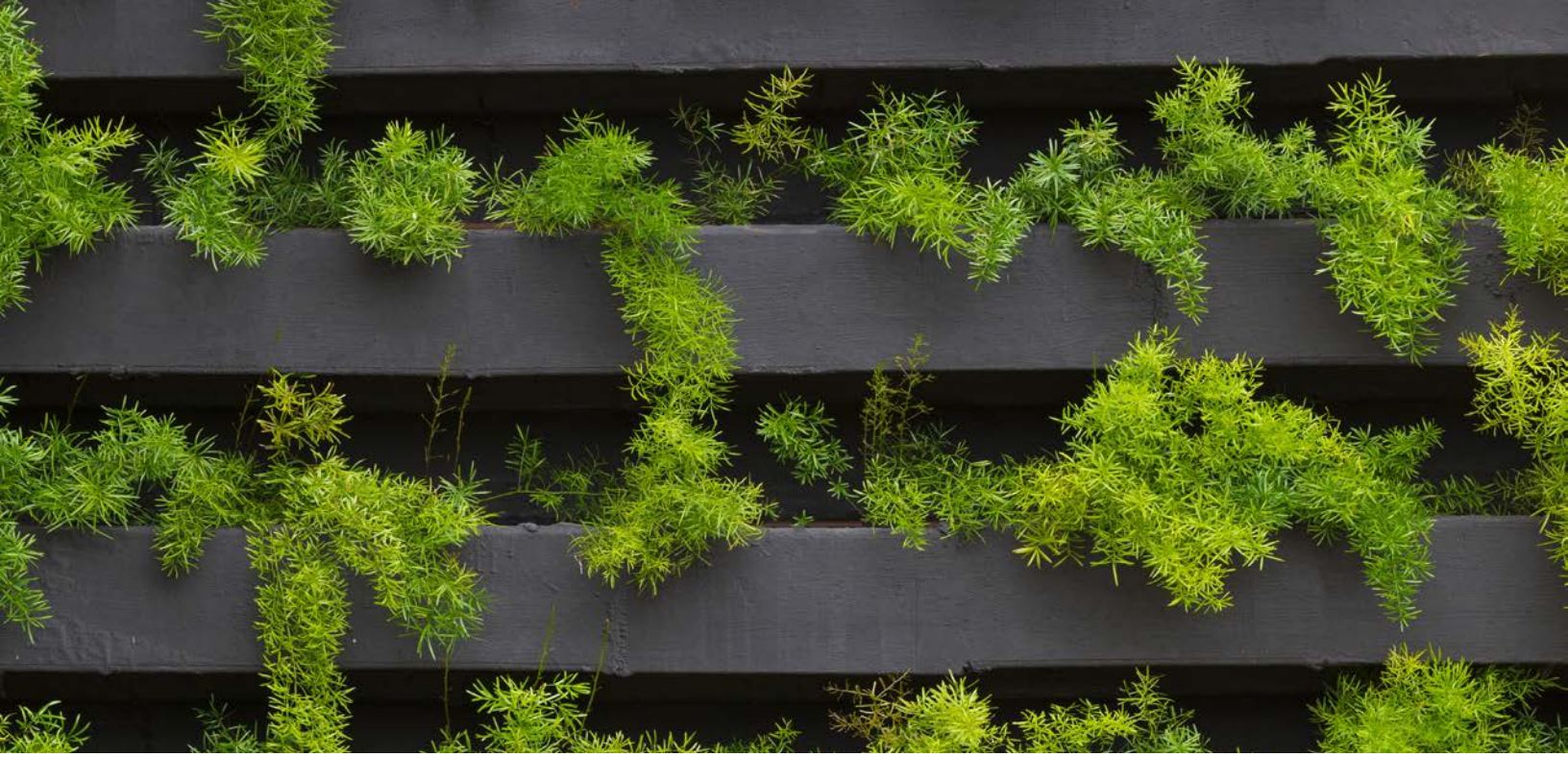
Aside from optimizing our use of land and water, urban agriculture techniques will put food production close to the people consuming that food – making our cities more sustainable. This generates a smaller carbon footprint, and as a bonus, the food will taste better because the nutrition value is higher thanks to a faster route to our tables.

I foresee a possible "back to the future" situation, where industrialized nations return to agrarian societies. But these agricultural communities will be different than what we have seen before. They will be based upon the combination of optimized nutrient management and urban agriculture, with people working in facilities dedicated to aquaculture, hydroponics, aquaponics, and vertical farming along with future innovative techniques.

There are certainly challenges that need to be addressed. However, none of these are insurmountable.

As the Singapore Minister of Environment and Water Resources Masagos Zulkifli suggested, the food sector could emulate the success of the water sector. At one-point Singapore imported all its water from outside the country. Today, Singapore enjoys 70 percent self-sufficiency in water through recycled water (40 percent) and desalinated water (30 percent). The process of addressing domestic water needs also created more than 14,400 jobs, and $2.2 billion in revenues, supported by 200 companies and 25 research and development centers. Just imagine what the world could do with a sustained focus on urban agriculture.

We have to be more efficient with our land and water if we hope to produce enough food for future populations. A push towards urban agriculture – and a possible Second Green Revolution that focuses on circular economy principles – might be what keeps us fed.



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