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Vertical Farms: Are They Sustainable?

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SYNOPSIS

Vertical farming seems like the perfect solution to tackle land-scarce Singapore's unique food security challenges. Given Singapore's energy mix, however, a more holistic analysis will help measure and manage the performance of vertical farms to support the local agri-food industry's role in Singapore's sustainable development agenda.

COMMENTARY

WITH A population of over 5.7 million and a land area of 726 square kilometres, Singapore imports 90% of its food and allocates less than one per cent of land for agriculture. Juxtaposing this, with the recognised vulnerability to global supply chain disruptions, Singapore has embarked on bolstering the local agri-food industry to address food security. There are also aspirations to make Singapore a hub for technology creation in urban farming.

This is a sea change from past policies to downplay agriculture due to limited land and the potential for higher value creation by using land for manufacturing, industrial and other activities. Implicitly this recognised that agriculture, in its traditional form on land, could not be sustained, or justified in a small island state. Today's food production in Singapore has taken on a different form with new farms, whether to produce vegetable, fish or alternative protein, hugely dependent on technology. How sustainable are these in Singapore with the high costs of production?

Vertical Farms

Vertical farming has emerged as one of the potential solutions to grow more on limited land. The benefits of vertical farming and other urban farming innovations are well

documented. Most notable among these benefits include lower water consumption, reduced food transportation needs (and corresponding greenhouse gas [GHG] emission reduction) and higher yields.

Together, these outcomes support the Singapore Food Agency's 30by30 Goal and the recently announced Singapore Green Plan 2030. But from an overall sustainability perspective, sustainability assessments must include all the visible and non-visible costs and benefits of vertical farming.

One such approach is a life-cycle analysis (LCA) which, among other things, includes a review of energy consumption, and can provide a more meaningful insight on the impact on vertical farms on Singapore's sustainable development agenda.

What Powers Vertical Farms

Vertical farms need electricity. Lots of it. While different types of vertical farming systems may vary in their energy needs, energy consumption is more intensive in the indoor, controlled environments of vertical farms. The difference in energy requirements for vertical farms, as compared to conventional farms, are significant.

For example, strawberries grown on a conventional farm in Chile require 0.4524 kiloWatt hours (kWh) of electricity per square metre per year (sq.m/year). Whereas strawberries grown on a vertical farm in Russia require over 3,000% more energy at 1,404 kWh/sq.m/year. To put that in context, a four-room HDB's average electricity consumption is 3.99 kWh/sq.m/year.

Isolated comparisons like this are not without criticism and often do not factor in one critical element: the source of the electricity being consumed. For example, frozen chicken imported to Singapore from Brazil has 15% lower GHG emissions than chicken from Malaysia despite the transport distance differences.

Brazil uses hydropower renewable energy during the production and processing stages while Malaysia relies on fossil fuels. The source of energy affects the GHG emissions footprint and therefore plays a large part in the sustainability assessment of an activity.

What Powers Singapore

Singapore relies on imported natural gas for 95% of its electricity. Although deemed to be the cleanest fossil fuel, natural gas still generates GHG emissions. Therefore, the Singapore Food Agency's 30by30 Goal of the local agri-food industry producing 30% of local nutritional needs by 2030 will inevitably increase local energy consumption.

Emissions from increased local production, however, will offset emissions from decreased overseas food import activity, return of farmland to carbon sequestering natural ecosystems and other impacts. Yet, this leaves us with the crucial question of whether the city-state is eventually on a more sustainable path or be worse off than before.

To answer this, it is important to quantify the energy consumption of vertical farms in an LCA for a deeper understanding and calculation of the net emissions generated or saved. Any LCA effort would require energy consumption data from the various vertical farming systems. In Singapore, at least one vertical farm enterprise (SkyGreens) uses natural sunlight while another vertical farm (Sustenir) uses LED lights for crop cultivation.

From an economic viability and sustainability perspective for these enterprises, energy supply and costs also factor into an LCA for vertical farming. At the moment, there is no aggregated data on this. Such data would allow for more accurate calculations to then allow a meaningful and sustainable electricity consumption strategy.

Reconciling a Sustainable Way Forward

The 1987 Brundtland Report is widely cited for the definition of sustainable development: "*meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs*" (https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf).

Vertical farming promises to achieve higher crop yields on less real estate. This outcome, if combined with renewable energy innovations, can address the impacts of GHG emissions and climate change. But if the energy consumption and GHG emissions therefrom are at odds with the impact to climate change, then the sustainability of vertical farming remains in question.

There are yet to be industry-wide standards on sustainability metrics for vertical farming. Extrapolations of energy usage and kilograms of CO2 equivalent emissions appear in various literature, but overall data is sparse. Measuring data and tracking performance on quantifiable metrics from vertical farming activities would assist in improving energy efficiency and managing the carbon footprint to support the sustainable development agenda of the Singapore Green Plan 2030.

Ultimately though, policymakers will need to balance the immediate needs for fruits and vegetables (food security) against the longer term desires to improve the carbon footprint of vertical farms (sustainability).

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