VERTICAL FARMING: SCIENCE FICTION IN PRACTICE?

Dr Dirk Troskie
Specialist Advisor: Agricultural Economics

The popular press (and e-mails doing the rounds) often present images of skyscrapers (farmscrapers / skyfarms?) full of plants with dairy cows enjoying the view from the 27th floor. The underlying argument is that conventional (rural) farming’s day has passed and it is time for those silly agriculturalists to start thinking out of the box.

While there are good arguments in favour of vertical farming...

All roads lead to Rome. Any enquiry into vertical farming will very soon lead to Professor Dickson Despommier from Columbia University in New York, the undisputed doyen in this field. Despommier (2010) argues that urbanisation, population pressure and limited (and depleted) natural resources force us to consider vertical farming as an option in order to feed (in addition to the current 1 billion malnourished) the more than 3 billion people that will be added to the global population by 2050. He lists the following advantages:

a) As production takes place in an enclosed and regulated environment, year-round production of crops from various climatic regions can be produced.

b) Agricultural runoff is eliminated and the use of post-control chemicals can be contained.

c) Production takes place in cities with the result that fossil-fuel emissions (through crop transportation) are reduced.

d) Abandoned or unused properties can be used (brown-fields projects).

e) Weather related risk is eliminated.

f) The sustainability of urban centres is enhanced.

g) Employment opportunities in urban areas are created.

h) Black and gray water can be converted to drinking quality.

i) Methane generation adds energy back into the grid.

j) Transfer of diseases between production regions is reduced.

k) Farmland is returned to nature.

...and the remaining challenges can be solved...

The necessary technology for vertical farming already exists. The Economist (2010) argues that hydroponics provides the technological foundation for vertical farming and it is claimed that almost any plant, from root crops to cereals and fruit, can be grown in this environment. Hydroponics has reached such levels of sophistication that a semi-automated hydroponic facility at the Amundsen-Scott base at the South Pole provides fresh fruit and vegetables year-round for the 65 permanent staff members at the base. This type of closed-system will also prove to be essential for any long-range space mission such as the planned human exploration of Mars.

Nevertheless, there are a number of limitations that needs to be kept in mind. Hydroponic farming usually takes place in single-story glasshouses specifically designed to allow maximum volumes of natural light to filter through. Although artificial lighting can replace (whilst much more effectively controlled) direct
sunlight in a multi-story building, its use will increase energy requirements. Given the rapid progress in renewable energy generation, this additional energy requirement will soon not necessarily lead to an increase in carbon emissions. However, as the current rule of thumb is that the area of solar panels required will be 20 times the area illuminated, renewable energy requirements will lead to additional design specifications and visual pollution (Economist, 2010).

Added to the illumination requirement, is the energy required to pump water to the top of a multi-story building. A further limitation is the carbon dioxide requirements of plants. Although this feature may create a “green lung” in cities, provision must be made for appropriate ventilation systems. Of course, there are those who proclaim that hydroponically grown tomatoes, although visually perfect, is totally tasteless. The good news is that these people are getting used to drinking recycled water and will probably not be too concerned about “black water” being used in the hydroponic process.

...It is economics that will determine feasibility.

It is calculated that a 30 story building with a base of approximately 2 hectares (about a block in an average city) should provide sufficient space to produce food for 50,000 people. The floor space of this building would be just over 607,000 square metres. The construction cost of office buildings in New York (where the calculations were made) is currently equal to approximately $200 per square foot (Gudeman, 2010). At the current exchange rate of just over R6.81 for one dollar, this is equal to R14 876 per square metre and, according to Turner & Townsend (a global consultancy and operations firm in the fixed assets business), the construction cost in the Cape Town area is on average about 56.4% of that in New York (Turner & Townsend, 2010). This means that the construction of our 30 story office building in Cape Town would cost approximately R5,02 billion.

However, this is the construction cost of a normal office building and additional features (inter alia lighting, ventilation and structural reinforcement) needs to be included to sustain animal and plant life. Gudeman (2010) calculates that these features would add 50% to the cost with the result that our building would cost R7,54 billion to erect. To put this amount into perspective, there is currently 140 000 hectares of irrigated land in the Cape Winelands District. If we accept that the cost of irrigated land ranges between R120 000 to R500 000 per hectare, this means that the capital outlay to purchase all irrigated land in this District would be R2,63 billion. In other words, just over a third of the construction costs of the vertical farm.

If the financier of such a megaproject would accept a return (only) equal to the current prime rate (3%), this will require an annual payment of R826 million over 20 years just to settle the construction cost of the vertical farm. As the average price for all vegetables sold at the Epping Market in Cape Town during 2010 was R3 040 per ton (DAFF, 2010), the implication is that 272 000 ton of vegetables needs to be produced in the vertical farm just to cover repayment of the capital outlay (no maintenance or operational costs are included). As, on average, 192 000 tons of vegetables (supplying roughly half the requirements of the 3.6 million people in the Cape Metropole) are annually being sold at the Epping Market (DAFF, 2010), the implication is that the vertical farm needs to produce 1.4 times Epping’s vegetable turnover just to cover capital costs.

Fact or fiction?

Hence, farming in vertical structures is technically possible but not yet economically feasible. In the immediate future the most appropriate approach will be to make use of hydroponics structures on rooftops and the area immediately adjacent to windows (supplying natural light) in multi-story office blocks. That is, if we can convince health-conscious office workers to refrain from snacking during lunch breaks on the carrots, lettuce leaves and celery sticks next to their desks. Talk about vertically integrated supply chains!

REFERENCES

Department of Agriculture, Forestry and Fisheries, Pretoria.


Economist (2010) Does it really Stack up?

Gudeman, S (2010) Vertical Farm: What is the Cost to Build?
Morris Engineering.
http://www.green-buildings.com/content/781267-vertical-farm-what-cost-build


IMAGES (from left to right)
VertiCrop http://www.valent.eu/Media_docs/Other_Images.html
Dragontail Vertical Farm for a Future New York by Alexander Kain
http://inhabitat.com/dragontail-urban-agriculture-concept-for-ny/

Pyramid farm


Dickson Despommier http://www.verticalfarm.com/

AgriProbe | March 2011

5