



## SATURDAY ESSAY

Vertical farms, with multistorey containers of food growing under a synthetic sun, were a sci-fi fantasy a century ago but are now a realistic solution to many problems facing humanity, argues **Tom Whipple**

There is a part of Dundee where the sun always shines. In a tall windowless shed, beyond the stormy mouth of the River Tay, this little bit of Scotland lies untouched by dreich days of drizzle. Here, a light breeze keeps the air fresh, a heating system keeps the temperature constant and the dark northern winter never ruffles the Mediterranean plants within.

It is not, though, an environment easily confused with the south of France. Sometimes, when David Farquhar goes in to inspect the crops in his vertical farm — each plant in racks that lie, one on top of the other, stretching far above his head — the sun is purple. Sometimes it is pink. Often the light is the full white spectrum we get from the sun, only with the green taken out. Green light, after all, is just the sun being wasteful. Leaves are green because they reflect green light — why waste energy making something that just bounces off them?

Then when each plant is ready, sunned by synthetic light and irrigated by synthetic rain in a process largely controlled by robots, it finds itself an agricultural paradox: the least natural crop in the world, but also — with its luscious pest-free and pesticide-free leaves — the most organic.

Is this the future of food? Will we soon be farming not only in fields that cover the surface of our crowded planet but also in ones that take advantage of the third dimension to stretch into the sky, too? Amanda Little, a professor at Vanderbilt University in the United States, thinks so. In *The Fate of Food*, a book out this month, she argues that with the global population growing and usable agricultural land running out, “It stands to reason that eventually we’ll need to grow our food upward as well as outward”.

Alternatively, as sceptics claim, will the energy required to create Farquhar’s artificial pink and purple sun always make this kind of agriculture a niche activity?

Twelve thousand years ago, humanity underwent its first great technological revolution. In Mesopotamia, where the Euphrates meets the Tigris, nomadic groups began to settle down. Rather than scavenging for grasses, and laboriously gathering their seeds, they happened upon an innovation that would change the course of our species for ever: they grew them in one place.

Tending their crops, breeding them, cherishing them, these people ultimately prospered from them. Seven billion humans rely on those advances for their existence today. Oddly though, the revolution is incomplete. With their wheat, corn and rice our neolithic ancestors freed us from seeking out food, but not from the greater constraints of the rest of nature. We still need soil, sunlight, weather and — most of all, for a population that is still growing — space.

Our modern, connected, technological world with its smartphones and satellites still relies, either directly or through the need for livestock feed, on clearing patches of land, putting seeds in holes and waiting to see what turns up.

This is strange. A human from 10,000 BC would see that computing had moved from counting stones to silicon, warfare from bows and arrows to nuclear



# Welcome to the future of farming

JAMES GLOSSOP

is in their eating. A quarter of the Earth’s ice-free surface is used for grazing, a tenth for arable farming. The issue with farming, all farming, is land. “The best reason for wanting to do this,” says Professor Despommier, “is it removes soil as a limiting factor to make food. If we want to save the planet we need to use less land. That is why money is starting to flow into this from all directions; it enables us to produce as much food as we want without using the natural landscape as a victim.” If agriculture did not need land, he argues, “we could rewrite the entire planet”.

All of which can make you wonder, why is Despommier’s map merely a chicken pox of red dots? Why has he not turned the globe pink as he creates an empire of vertical farming on which the (also pink) sun never sets? The answer, or one answer at least, is sunlight and energy.

David Farquhar did not begin his career managing an eerily lit farm in Tayside. Before he became CEO of Intelligent Growth Solutions, which works with the James Hutton Institute in Dundee to develop prototype indoor farming systems, he spent three decades in the technology sector. Nowhere, though, has he seen excitement like this. “I’ve never come across a proposition that has attracted so much interest globally,” he says, before adding: “I’ve also never seen a sector filled with so much BS.”

It takes a lot of energy to replace the sun. This means that at present the crops worth growing are limited. “If you want to grow things at a market-acceptable price, you are talking about baby greens, micro greens, and salads.”

These are the plants that are physically light, so need little sun to build biomass, and perishable, so have high wastage if not grown locally. The staples, which are dense, easy to transport and provide most of the world’s calories, are not viable yet, and some think they will never be.

“People are claiming they can grow a wider and wider range at a profitable price. People are making claims about power consumption,” says Mr Farquhar. “People are making claims about what they can grow, the yield and quality. Our fear is there will be high-level casualties who have had a lot of money put into them. That doesn’t do the industry any good.”

He is right to be worried. Even as Google announces investments of \$90 million in farming startups and Amazon’s Jeff Bezos \$200 million, some of Despommier’s red dots have already disappeared — lost to economics, hype and hubris. This month though, another startup, Square Roots Farming, signed a contract to work with a major US food distributor growing herbs at each of its depots. This wasn’t about virtue signalling or novelty, but something far more exciting: rational economics. Or as Tobias Peggs, the British entrepreneur who runs it with Elon Musk’s brother Kimbal, says, it is “not just about feeding foodie hipsters in Brooklyn”.

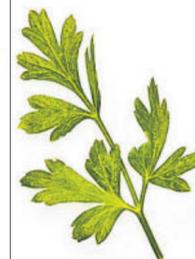
Their company specialises in using refurbished shipping containers that have the built-in ability to mimic a climate of your choice. “For instance, I can hit the ‘basil’ button and configure the climate to northern Italy,” Peggs says. “The lights will go on at the same time the sun rises in Genoa. The temperature increases and decreases to match the weather. You can grow literally the best basil in the world, located in New York City.” This works, he concedes, because basil is expensive. But, he says, five years ago this was still uneconomical. “We are right at the very beginning of a technology journey.”

Farquhar, although cautious, agrees. Take away soil, take away the weather, and extraordinary things can happen. Just one example he likes to use: in a shed there are no clouds. “Every crop, every plant species, has evolved defence mechanisms that prevent it being damaged. In bright sunlight, a cloud crosses the sun and it goes into shade, then back immediately into bright light. Plants have a protein that acts as instant sun cream to protect them.” To make that protein, the plant needs a lot of energy. Maybe if you breed it out, you would need less light and so you can graduate from basil to low-hanging fruit. Quite literally — strawberries are approaching economic viability.

“Yes, staple crops are not there yet,” says Farquhar. “But think about what a mobile phone could do 20 years ago. That’s where we are at. Now think what a mobile phone can do today.” They are already trialling potatoes, the crop equivalent of a first-generation iPhone.

“In one way or another we will find a way to grow everything — wheat, barley ... and coconuts.” The Caribbean is coming to Dundee.

Tom Whipple is science editor



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weapons, travel from feet to aeroplanes. These advanced technologies would, in the famous words of Arthur C Clarke, be indistinguishable from magic. Yet the same human would have no problem understanding the most fundamental technology of all, on which all others rely: farming.

Soon though, many scientists believe, that first revolution will reach its logical conclusion. When it does, humans will be freed not only from the constraints of finding food, but from finding land, too. By stacking crops on top of each other and precisely controlling the environment we will, proponents argue, at a stroke solve problems ranging from climate change to water shortage to loss of biodiversity. On the space taken today by a single field, a vertical field will grow 30 times the produce.

By some accounts, the idea of vertical farming first appeared in a *Life* magazine article of 1909, in which an illustration showed stacks of fields and farmsteads, one on another, laid out for cultivation. They existed in a metropolis of mile-high skyscrapers served by flying taxis and were captioned with a mock real-estate advert: “Buy a cozy cottage in our steel constructed choice lots, less than a mile above Broadway ... all the comforts of the country.” It was not, in other words, the product of serious thought.

Which is why some advocates, surprisingly perhaps, prefer to trace the vertical farm’s true origins to

Tiberius. The Roman emperor’s twin passions — as far as we know kept mercifully separate — were sexual depravity and cucumbers. To satisfy the first, he employed little boys in his pools to pretend to be minnows and “nibble” him as he swam. To satisfy the second he did something far more extravagant. In his gardens, he created glasshouses using sheets of rock crystal that could grow cucumbers year-round. He effectively became the first person to control climate.

Dickson Despommier chooses a different date for the start of vertical farming. He likes to begin the practical history much later, with an earthquake. On March 11, 2011, a huge tsunami crashed into Japan, sweeping away houses, roads and, crucially in the province of Sendai, farmland. Further along the coast, the Daiichi nuclear reactor was swamped: 370 sq km were evacuated, and the radiation released meant that Japanese-grown food was shunned by consumers.

“In one hour they lost 5 per cent of farmland,” Professor Despommier, from Columbia University, says. “In supermarkets food was left rotting on the shelves. Japan’s government contacted virtually every shipping-in alternatives — and do so while recreating the precise climate of northern Italy. In Singapore there is even vertical fish farming, a multi-storey carp park.

Taken together, Despommier says, all these red dots mean “the northern hemisphere looks like chicken

a year earlier Professor Despommier had written a book. For over a decade he had taught a popular course on vertical farming — the book, *The Vertical Farm: Feeding the World in the 21st Century*, was the result. But he had no photographs to put in it. “There were no vertical farms then. None.” In 2011, though, the paperback book came out. “I found we had three pictures of vertical farms.”

Now he keeps a map of the world on his wall and puts a red dot wherever he knows there is a vertical farm. Some dots supply salad to airliners, so first-class passengers can receive lettuce picked that day. Some grow herbs for restaurants, who want to boast of growing local (even if consumers might imagine that means something rather more bucolic). In China, there are pig apartments in tower blocks, next to pig fodder farms in another tower. In New York, whose hipster foodies might object to high-rise pigs, there are shipping containers cultivating basil that competes on price with the shipped-in alternatives — and do so while recreating the precise climate of northern Italy. In Singapore there is even vertical fish farming, a multi-storey carp park.

Taken together, Despommier says, all these red dots mean “the northern hemisphere looks like chicken

pox. For me it has been a miracle that the idea has caught on so rapidly.” Vertical farms are, in other words, a technology of futurists no more.

It is easy to see why. If you want local food, a shipping container in your car park couldn’t be more local. If you are concerned about food waste in shipping, well there’s no need to ship at all. If you have almost any environmental concern, in fact, vertical farm evangelists will argue that they can solve it. Seventy per cent of the fresh water used by humans is reserved for agriculture, most evaporating in the process. Grow the crops inside and you lose no water. Pesticides in industrial farming are destroying biodiversity. Grow crops in a sterile environment and they can be completely organic. Crop failure due to drought and bad weather is a big cause of poverty in the developing world. Controlled climates provide the right conditions year-round.

But the biggest problem it solves is space. Officially the population density of Singapore, one of the world’s most tightly packed countries, is 8,000 people per square kilometre. Really though, the ratio of people to land use is rather different. Indeed, as with every country, it is impossible for it to be anything less than about an acre per person — or 250 people per square kilometre. It’s just that in Singapore this true figure is hidden, because they import their food.

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