

# Arrested development

As towers topple and investor interest cools,  
what is the future for vertical farming?



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## Welcome

**Thank you for taking the time to read this, our latest annual Fruit Logistica Trend Report.**

This year's publication takes a deep dive into the world of vertical farming and considers its role in shaping the future of controlled-environment production.

Previously heralded as the future of fresh fruit and vegetable production in this increasingly urban world, this cutting-edge industry has struggled in the past year. In many cases, it has failed to deliver on its early promise.

But, as some investors and innovators head for pastures new, it's important to consider the continued potential of advanced technologies to have a lasting, positive impact on the sustainability of indoor farming operations.

And let's not forget that vertical farming itself represents only a small – albeit very interesting and exciting – part of the much wider controlled environment agriculture business. Lessons can be learned which will keep that business growing.

We hope you enjoy reading this special report, and we look forward to seeing you at Fruit Logistica in Berlin on 7-9 February 2024.

**Mike Knowles**

Managing Director · Fruitnet Europe

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## Arrested development

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Cover image: AeroFarms

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**Author**  
Mike Knowles, Fruitnet

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**About Fruitnet**  
Fruitnet Media International is the world's leading publisher and congress organiser for the global fresh fruit and vegetable business. Delivering informed industry coverage, it helps the fresh produce business grow worldwide by providing useful information, insight and ideas.





## 1 A place called vertigo

ABOVE—Vincent Callebaut's 132-floor Dragonfly concept features a total of 28 farming plots

Photo: Vincent Callebaut Architectures

Until very recently, the energy and enthusiasm around vertical farming was white hot. With the advent of cutting-edge technologies, it is now possible to grow products like salads and herbs and even berries within closed-loop environments, in hydroponic substrates, under LED lights, and all without the need for open air, soil, or sunshine. As a result, entrepreneurs and investors alike have spent much of the past decade picturing some fantastic farms of the future, many of them far closer to urban centres than the fields of old. Nowadays, in theory at least, they can be planted on an industrial estate, or housed in an old aircraft hangar, or dropped on to the roof of a city-centre high-rise. The sky, quite literally, is the limit.

But in the past couple of years, that interest has cooled considerably. In just a few months, a concept that was championed as the epitome of modern, urban-centric food supply now seems a step too far for all but the most informed investor. In the new, global economic landscape, rational commercial thinking no longer supports the idea that vast centres of production can sprout so easily and energetically out of our concrete jungles.

Or so the prevailing media narrative suggests.

True, many of the tech entrepreneurs and venture capitalists who once dreamt of building great pillars of production inside big, beautiful skyscrapers have been found wanting and rudely awakened from their fantasy. And even those with more modest ambitions and less luxurious architecture – repurposed shipping containers, for example – have discovered previously unknown cracks in their business models. Energy prices have spiked. Market demand has declined. For vertical farms of all shapes and sizes, the walls have crumbled.

But like every tale of boom and bust, the downturn does not necessarily mean the end of the story for every participant. After the dotcom bubble burst in the early 2000s, California-based grocery home delivery startup Webvan bought its struggling competitor HomeGrocer for US\$1.2bn in stock. A year or so later, it too had gone out of business. But the concept itself, the idea of delivering groceries to people at their homes and saving them the inconvenience of a trip to the supermarket, was a sound one. Two decades later, home delivery is a thriving industry and one that practically every modern, mainstream retailer now incorporates into its own business. Some companies even work exclusively in that arena.

*RIGHT*—Israeli startup Vertical Field is one of several indoor farming startups that have created closed-loop farms inside shipping containers



The central premise of vertical farming is rooted in reality, but it urgently needs to evolve. In 2009, Belgian ecological architect Vincent Callebaut designed the Dragonfly, an utterly preposterous New York "farmscraper" that would stand 250m taller than the Empire State Building. At the time, it was described as "two oblong towers symmetrically arranged around a huge climatic greenhouse that links them, and deploys itself between two crystalline wings". But it was a pipe dream, never to be built. Economic reality now requires vertical farming to emerge from its chrysalis as a more viable version of its former itself. For many, that means a shift towards controlled environment agriculture, or CEA for short, which is now touted as the more rational, sustainable option. Although the term still incorporates vertical farming, its focus is more on the use of tech to manage and, where possible, automate every aspect of the growing environment. ●





## 2 Spreadsheet farmers

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ABOVE—Infarm's value has fallen sharply from a high of US\$1bn  
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Photo: Ken Schluchtmann

**The name Dickson Despommier is virtually synonymous with vertical farming. It is widely accepted that he coined the phrase back in the late 1990s, during a medical ecology class at Columbia University Medical Center, where he remains Emeritus Professor of Public Health and Microbiology. In 2010, the publication of his book *The Vertical Farm: Feeding the World in the 21st Century* set out the notion of highly efficient, ultra-local centres of production as a means to create closer, reliable food supply in an increasingly urbanised world.**

His idea sparked the imagination of planners, developers, producers and retailers across the globe. Distinct from conventional greenhouses by virtue of their closed-loop environments and artificial inputs, vertical farms can be found today across the world. But in contrast to five years ago, when it might have been said that Despommier's vision was in full bloom, the present-day reality is that many of those promising buds have withered and died.

The question must therefore be asked, does Despommier's vision of a sustainable, self-sufficient future for urban food supply remain viable?

Cindy van Rijswick is global strategist for the fruit, vegetable, and floriculture sectors at RaboResearch Food & Agribusiness, and one of the world's most respected commentators when

it comes to the controlled environment agriculture sector. In September, she and her colleagues published a report into the state of indoor farming in the US. “High-tech leafy green indoor farming is facing a moment of reckoning,” states the report’s summary. “Over the last six years, the industry has gone from a dollar magnet to a graveyard for some hundreds of millions of dollars’ worth of failed businesses, leaving many barely standing.”

The main reasons for those failures? According to the report, these include systemic risks, competition with conventional agriculture, and untimely demand-related trends. There are those in the industry itself who remain bullish about the future potential of vertical farming, but the most optimistic reading of the report’s conclusions would be that the various bankruptcies seen over the past 12 months or so represent a healthy and necessary correction. Or, as the report suggests, “a shake-up that will eventually make the industry much more resilient”.

*RIGHT*—Cindy van Rijswick, RaboResearch Food & Agribusiness



As Van Rijswick points out, it is not uncommon for new industries that are based on the emergence of disruptive technologies to go through some form of boom-and-bust business cycle. That’s certainly what she expects to happen to the indoor farming sector. “The good news for incumbents and new entrants is that the industry as a whole is determined not to repeat the mistakes of the past,” she observes. “Rather, it will focus on delivering high-quality, affordable, sustainable, and profitable products while being agnostic to the underlying technology.”

The idea of vertical farming is by no means a bad one either. At its core is a perfectly logical proposition: make use of the best technologies available in order to overcome geographical constraints and create food supply as close as possible to where consumers live. As a result, it should be easier and more affordable for those people to eat a healthier diet; the food miles and carbon involved in distributing the products should be less; and the production itself should be more immune to the world’s increasingly unpredictable weather.



But in the rush to sell that dream, too many entrepreneurs have failed to test the technology itself in advance. The market demand is almost certainly there, even if inflation has dampened it. But the production and supply of fresh fruit and vegetables is already a game of slim margins, which makes a switch to considerably more expensive, tech-reliant supply chains a move that is laden with risk. After all, conventional greenhouse operators have also struggled of late. No wonder so many of those startup founders have earned themselves an unfortunate reputation as delusional outsiders or “spreadsheet farmers”. It’s an unfair nickname, but one that reflects a frustration at those who have prioritised apps and gadgets and over agronomy and agricultural best practice.

There is one other key challenge that is often overlooked: space is extremely hard to come by and very expensive in cities. A recent study by The Paris Urbanism Agency worked out that it would be necessary to cultivate 16,000ha to make the French capital’s population (including non-resident workers) self-sufficient in fruit and vegetables. That’s 1.5 times the city’s total surface area. Nevertheless the world’s largest urban farm, Nature Urbaine, currently occupies 14,000m<sup>2</sup> on top of Paris Expo Porte de Versailles, a giant exhibition and conference venue in the north of the French capital. It is not an indoor operation – the crops are grown on a rooftop in the open air – but it does achieve a notable reduction in food miles. If vertical farms could find a way to establish themselves in cities without their costs spiralling out of control, this would help urban centres move a little closer to self-sufficiency. ●

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*BELOW*—Vertical farms have sprouted all over the world

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Photo: Unfold







### 3 Vertically challenged

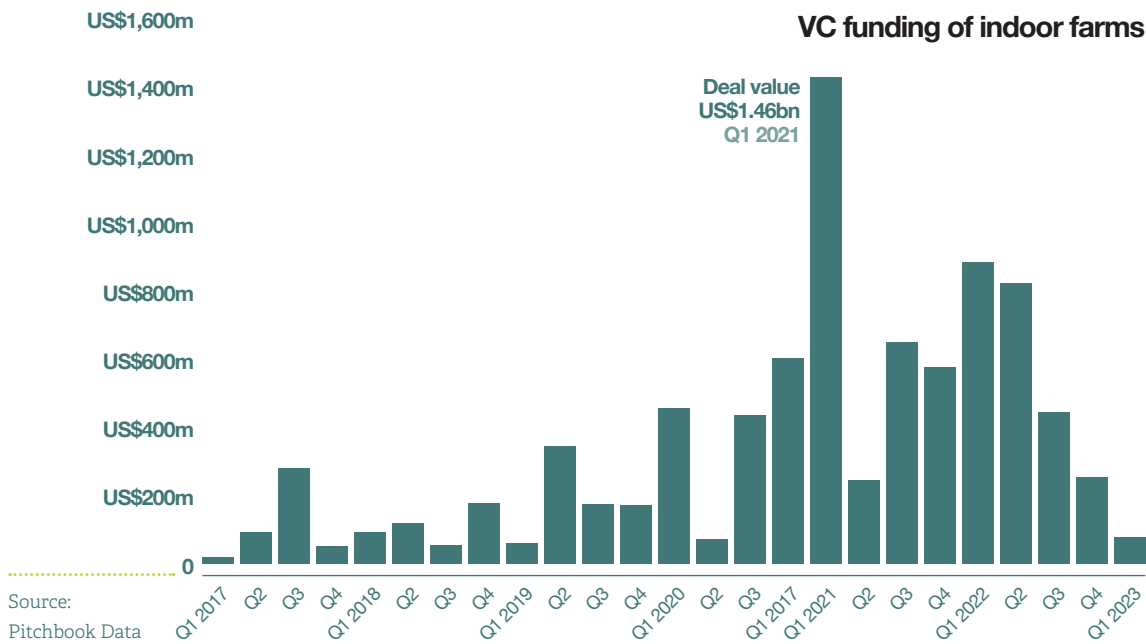
ABOVE—Kalera was delisted from the Nasdaq last April

Photo: Kalera

**Not every vertical farm project has come unstuck. But like all indoor farms, all have seen their costs rise and their access outside investment greatly limited. Russia's invasion of Ukraine caused a sharp spike in energy prices, which meant several conventional greenhouse operators had to switch off their lights and pause production. Suddenly, pressure on those even costlier vertical farms to deliver sellable produce and bankable profit was ramped up. At the same time, the vast funding stockpiles that were harvested in previous years were quickly consumed. In several cases, startups failed, while others are left limping. Many millions in venture capital investment have been left to decompose in the form of shrivelled salads and homeless herbs.**

In late 2023, *AgFunder News*' global editor Jennifer Marston published a list of major injections of venture capital into indoor farms over the past decade. It features some very big names, and some huge sums of money; together, just four companies – AeroFarms, Bowery Farming, BrightFarms, Plenty – attracted more than US\$2bn in less than ten years. Last year, the vertical farming market was reckoned to be worth just over US\$5bn, and forecast to triple in value by 2028, according to *Markets & Markets*. Adam Bergman, global head of agtech investment at Citigroup, observes that the vertical farming industry raised more than US\$1bn in 2022. But by mid-2023, he notes, less than US\$100m had been secured. Data collated by *PitchBook* illustrates this dramatic decline in venture capital support for the sector. The flood of economic irrigation has slowed to a trickle.





In an interview with the Indoor Agtech Innovation Summit, Bergman described what he saw as “a very different economic landscape” for the vertical farming business. “A lot of companies have been very successful going from pilot plants to actual production sites, and in some cases having multiple sites and an international footprint,” he commented. “However we’ve seen other companies be unable to effectively scale and get to positive unit economics. They will struggle to raise new capital, and we are likely to see consolidation in the sector.” For the survivors, the challenge now will be to secure funding without overloading on cost. “When winners start showing that they could be profitable and start to scale, then you see lots of capital come in. I think it’s really exciting. Those companies are going to figure out ways to find cheap capital, which is really important in any capital-intensive sector.”

The demise of Berlin-based Infarm offers a stark reminder that not every vertical farming startup that attracts hundreds of millions of dollars in funding has, by virtue of that sponsorship, guaranteed its future success. The company, which pioneered the installation of miniature indoor herb and salad farms in supermarkets and restaurants, has been declared insolvent in Germany, the Netherlands and the UK. It has also pulled out of Denmark and France. That’s a major uprooting exercise for a business that branched out so far, and was once valued at a cool US\$1bn. If you read Miriam Partington’s excellent article about InFarm, published on the *Sifted* website in December, you get a feel for the kind of mistakes that the company apparently made as it sought to deliver on its early promise. In many cases, it seems, sales and marketing tended to promise something – strawberries, for example, or small pots of basil – before the R&D team had been able to identify a method of producing it. Others have no doubt done the same and succeeded.

“Fancy PowerPoint presentations won over common sense in various vertical farming business cases we have seen in the last decade,” says Van Rijswijk. “Telling and selling great stories is a skill that enables startups to raise loads of money. And that money can be burned shockingly quickly if a company cannot deliver on its promises and basic issues like energy and staff costs are overlooked.”

There have been several other high-profile casualties. Kalera, a salad grower with farms in Orlando, Atlanta, Houston and Denver, filed for bankruptcy and was delisted from the Nasdaq in April 2023, having agreed a US\$5.1m financial rescue plan. Elsewhere in the US, vertical farming and robotics startup Fifth Season went into liquidation last November, a year after it closed the doors on its leafy greens factory next door to a giant steel mill in Pittsburgh. As Van Rijswick observes, this represented another low point for vertical farming on what seems like a continued downward trajectory for the industry. “Fifth Season had raised over US\$75m of investments,” she notes. “The bankruptcy filing estimates the company’s assets to be less than US\$100,000, which is just about the value of a nice car.”

Back in Europe, the recent closure of French startup Agricoool feels very much like the end of a chapter in vertical farming history. Its plan to place small, self-contained soft fruit production units in cities and towns across the continent made some sense in an age when consumers thought far more about food miles and wanted convenient access to healthy, locally grown fruit. Spend two minutes in one of Carrefour’s two Potager concept stores and you can see how much Parisians now value a source of farm-fresh produce right in the heart of the arrondissement they call home. The Agricoool co-founders’ back story also felt reassuringly progressive. Guillaume Fourdinier and Gonzague Gru both grew up in the French countryside and wanted urban dwellers to experience the same taste and quality in their strawberries as they themselves enjoyed as children. So they set about growing the fruit in old shipping containers to eliminate the need for flavour-sapping truck journeys. Other companies, like Ikea’s partner Bonbio in Sweden, tried the same trick.

At one stage, Agricoool was valued at more than US\$100m. Between 2015 and 2019, it raised some €28.5m in funding. Its containers were thought to yield more than 50 punnets of strawberries per day. But in March 2022, the venture went into receivership and was eventually sold for a reported €50,000 to Vif Systems. “We made a lot of mistakes in day-to-day management,” said Fourdinier in a recent blog post. “Certainly not close to enough cash, too few experts, too greedy in terms of the number of projects launched, probably too young. Let’s be clear, we could – I could – have performed much better.”

According to Fourdinier, Agricoool’s big mistake was to focus on the profitability of a single farm in order to develop a model that could be replicated at scale. “It was a strategic error, because we failed to secure the funds with this farm,” he wrote. “We had to choose: either aim for the profitability of the company, and therefore its future independence from capital (with the cost cuts that go with it), or favour pure growth and raise twice as much each year, without putting the focus on the balance of the model. We made a half-choice in 2019, and half-choices always mean double trouble.” That weakness was exposed when production costs soared.

Henry Gordon-Smith, the CEO of Agritecture, advises companies around the world on urban and controlled environment agriculture (CEA). He believes too many of the vertical farming ventures around today are doomed to suffer the same fate as Agricoool. “Understanding the past is something that will help us prepare for the future,” he wrote in a comment piece for *AGFunder News*. “Unfortunately most of the newer entrants to CEA, whether farmers or investors, know little about the history of vertical farming.” ●





## 4 Bubbling over

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ABOVE—AppHarvest used AI tech and robotics to build vast indoor farms

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Photo: AppHarvest

**AppHarvest is not strictly speaking a vertical farming company, but it certainly qualifies as controlled environment agriculture. The Kentucky-based group uses greenhouses to grow fresh produce close to major conurbations. What's more, it has also benefited from the same kind of appetent investor activity that inflated the vertical farming bubble: US\$82m in series A funding in 2019; an US\$11m top-up from early venture capital, plus US\$28m more from series C funding in 2020; and then, in February 2021, an initial public offering that valued the company at US\$1bn.**

Buoyed by those financial nutrients, it has set out to operate some of the world's largest high-tech indoor farms, with robotics and artificial intelligence among the key ingredients in its recipe for a reliable, climate-resilient food system. It has also been eager to point out that it uses technology in support of natural resources – principally sunlight and rainwater – not instead of them. “AppHarvest’s farms are designed to grow produce using sunshine, rainwater and up to 90 per cent less water than open-field growing, all while producing yields up to 30 times that of traditional agriculture and preventing pollution from agricultural runoff,” it told the world, as it built a 165-acre supply base across four indoor farms to grow salads, strawberries, cucumbers, and tomatoes.

In October 2022, after it secured a US\$30m loan from grower-marketer Mastronardi, it opened a high-tech facility in Berea, Kentucky. Complete with ‘touchless’ growing system and autonomous

harvesting, this was believed to be the world's largest indoor farm for leafy greens. Mastronardi sold the salads under its Queen of Greens brand. Just weeks later, however, AppHarvest said it had "substantial doubt" about its ability to continue. Then, in July of last year, it declared itself bankrupt. AppHarvest Products and eleven affiliated debtors owed tens of millions of dollars to companies including Dutch greenhouse construction firm Dalsem (US\$14.8m), Bayer Crop Science (US\$398,000), and Rijk Zwaan (US\$149,500). It has since sold its Berea operations to Mastronardi, for an initial US\$3.75m.

*RIGHT*—This farm in Berea, Kentucky, was one of AppHarvest's largest. It is now owned by Mastronardi



At the time, it would be fair to say that AppHarvest talked a good game. "According to USDA reports," it wrote, "the value of US fruit and vegetable imports rose to a record level in 2021 and has been projected to keep increasing in 2022. Changing weather patterns – ranging from mega-drought in the southwest of the US to more frequent flooding to catastrophic wind events – are making it harder than ever for open-field farmers to predict the duration of their growing seasons and to have conditions that result in a quality harvest."

It was a message that rang true. As a result, major food retailers showed considerable interest in this new breed of high-tech indoor production. AppHarvest promoted its farms as a good way to "de-risk fruit and vegetable production with a more climate-resilient, more sustainable, year-round growing solution that uses far fewer resources". It also glanced admiringly across the Atlantic at Europe, which at the time was estimated to have "nearly 520,000 acres of CEA production compared with an estimated 6,000 acres in the United States". The European grass was greener indoors.

Whether or not the same kind overblown interest in vertical farming's technological wizardry had anything to do with AppHarvest's own struggles is a moot point. Either way, AppHarvest's strategic planning must have been off course, and it appears to have overlooked some of the most crucial of cost calculations. "We really were in a hype cycle," Vonnie Estes, vice-president of innovation for the International Fresh Produce Association, told *Bloomberg* in June 2023. "There was a lot of money that rushed in without really understanding that this is actually just farming." ●





## 5 Plenty to sustain growth

ABOVE—Fischer Farms' giant facility in Norwich, UK

Photo: Fischer Farms

**The outlook for vertical farming in 2024 appears bleak. But all is not lost. Among the biggest enterprises to run into trouble in the past year is New Jersey-based AeroFarms, one of North America's largest suppliers of leafy greens. In September, it emerged from Chapter 11 bankruptcy with a slimmed-down version of its previous business plan. Back in 2021, there was talk of the company going public with a value of US\$1.2bn.**

Now, with support from investors including Grosvenor Food & AgTech (GFA) and Doha Venture Capital, it says it has “eliminated spending on all projects that do not contribute”. It also predicts it will return to profit after the completion of several automation projects, to boost throughput and efficiency at its flagship microgreens farm in Danville, Virginia. Its backers are reassured that “the fundamentals remain sound”. After all, Nielsen data reportedly suggest AeroFarms is the fastest-growing packaged salad greens brand by revenue at retail in the US. That’s a statistic that backs up the company’s own opinion, that consumer demand for its high-quality, year-round products remains “extremely strong”. Assuming all that is true, it looks well placed to keep supplying big retail operators like Whole Foods, Ahold Delhaize, and Harris Teeter.

Stephan Dolezalek, managing partner at GFA, remains convinced that vertical farming still has a future. “As an investor dedicated to creating a more sustainable global food supply chain, we see

vertical farms as a critical part of the solution,” he comments, “and are now focused on efficiently scaling our operations to deliver a market-leading product through a profitable business model.”

Daphni, one of Agricoool's original backers, says it still shares the startup's original ideals. “We are convinced that our current agricultural system needs to be collectively reinvented,” a spokesperson comments. “Fortunately, Agricoool was not the only player to share our vision of a more sustainable and local agriculture. We wish to see these projects accelerating their growth and demonstrating that this model is profitable at scale.”

It would be unfair to suggest that the vertical farming landscape is a barren one, entirely bereft of success stories. Jennifer Marston's list of investments included a US\$100m late-stage funding round for Sundrop Farms back in 2014. A year later, the company built a 20ha, solar-powered greenhouse facility in South Australia, where it turns seawater and sunlight into energy and water, before it uses “sustainably sourced” carbon dioxide and nutrients to maximise the growth of its crops. Completed in 2016, the farm reportedly now produces over 15,000 tonnes of on-the-vine tomatoes each year for Australian supermarket operator Coles, and has a ten-year contract to do so.

In February 2022, Dutch urban farming group PlantLab raised €50m to expand its production of salad vegetables, herbs, tomatoes and cucumbers. Its technology employs light from specially developed LEDs that generate the specific wavelength needed for photosynthesis. That same kind of system has already been deployed in commercial production at its largest facility in Amsterdam, as well as on farms in Indianapolis and the Bahamas. According to the company, it will soon open further production sites outside in North America and in Europe. The goal, as before, is to produce crops close to large population centres and therefore to reduce transport costs, CO<sub>2</sub> emissions and food waste.

In the eastern UK county of Norfolk, meanwhile, a 25,000m<sup>2</sup> climate-controlled facility owned by Fischer Farms was completed in November 2023. It has been labelled “the world's biggest vertical farm” and promises to yield 250 times more leafy green salads than a conventional site, across just four acres of land. It also grows berries, and plans to trial rice, wheat, peas and soya beans.

One of the fresh produce industry's most striking forays into vertical farming belongs to Plenty Unlimited, which in September 2022 announced plans to build a 48ha indoor farm in the US state of Virginia. The facility, which is estimated to cost US\$300m, is the first in the world to grow strawberries at scale. That fruit is destined to be sold under the Driscoll's brand. And its potential annual production capacity could apparently exceed 9,000 tonnes across multiple crops including strawberries, leafy greens and tomatoes.

“Through more than a decade of investment in research and development Plenty has cracked the code on a scalable platform that makes indoor farming increasingly economical,” says Arama Kukutai, Plenty's chief executive. “That innovation makes it possible for us to grow a wide variety of crops with a fraction of the land and up to 350 times more yield per acre than conventional farms. Channelling that into the largest vertical farm complex in the world propels us to the level indoor farming has to operate at to truly transform our food system.” ●



## 6 An oasis of opportunity

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**BELOW**—A concept image of the Neom Oxagon, an automated port and logistics hub  
.....  
Photo: Neom

**If the future for vertical farming is to resemble anything like the utopian vision that previously wowed investors, then this tantalising prospect remains more likely outside of the first-adopter markets of Europe and North America, where investor interest has slowed and the industry’s development has stumbled. With the benefit of hindsight, it’s easy to say the whole concept was overhyped. But the Middle East is now a part of the world where the same level of hype may be repeated. For now at least, the technological advances trialled and tested elsewhere over the past decade have begun to generate some new and fervent demand in the region.**

When asked whether Infarm was leaving Europe, CEO Erez Galonska told *Sifted* it had “decided to shift its geographical focus from Europe to high-potential regions better suited for indoor farming”. The group is on the record as saying that the Middle East would feature in any future expansion plan. Lessons have been learned, you might imagine, which can now be transplanted to the region. And for companies that have been able to prove their own smart-agri models without running their financial reserves dry, where better in the world to establish local, climate-resilient supply? After all, the Middle East has to source the majority of its fresh produce from outside. According to Alpen Capital GCC Food Industry, its countries import as much as 90 per cent of their food. What’s more, the area’s climate very often makes it impossible to produce items like tomatoes and salads using conventional, open-field methods.



Of course, it helps that there is plenty of money in the Middle East. Saudi Arabia's Crown Prince Mohammed bin Salman has set aside US\$500bn to transform an area the size of Belgium into a high-tech urban expanse called Neom. And one day, this will apparently be home to millions of people, all of whom need to be fed. A recent *Bloomberg* article suggested Neom will need a thousand hectares of greenhouses to produce its target of 300,000 tonnes of fresh fruit and vegetables in the next eight to ten years.

In December, the green shoots of a new company called Topian appeared in Tabuk, the dry corner of Saudi Arabian desert where Neom has started to take root. An oasis of ambition and opportunity, with a very real and laudable objective: to create sustainable, ethical, and climate-proof food supply for the region and its future inhabitants. Topian has secured the help of various organisations to achieve its goal. Among them is Dutch greenhouse expert Van der Hoeven Horticultural Projects, which has signed an agreement worth a reported US\$120m to create two separate horticultural test facilities in different climate zones. Both will serve as commercial scale trials across a combined area of 110,000m<sup>2</sup>. At one of these locations, a novel system driven by solar energy and seawater promises to keep the greenhouse cool in the extreme summer heat. As Van der Hoeven CEO Michiel Schoenmaeckers, points out, this will all happen without making use of fossil fuels or drawing on local energy supply.



***"In the challenging conditions of the Middle East, it makes sense that players share knowledge and expertise, and start working together"***

Van der Hoeven has also just launched a project called Circular City Greenhouses, which it unveiled at the United Nations Climate Conference COP28 in Dubai. This sets out a plan for sustainable fruit and vegetable production in high-tech greenhouses which, crucially, draw their four key resources – water, energy, nutrients, CO<sub>2</sub> – from waste or industrial byproducts. Circular City Greenhouses certainly seems like a sensible approach if economies – and food systems in particular – are to become more circular, more sustainable, in a rapidly urbanising and increasingly populous world.

Like Infarm, AeroFarms also seems to have shifted its focus to the Middle East. Last February, it opened AeroFarms AgX in Abu Dhabi, a facility reckoned to be the largest R&D-focused indoor farm in the world. The 65,000ft<sup>2</sup> centre brings together engineers, horticulturists and scientists who will conduct organoleptic research, precision phenotyping, and phytochemical analysis. They will also investigate next-generation technologies that use machine learning, robotics, and automation. The US-based firm has also signed a joint venture deal with Saudi Arabia's Public Investment Fund to build and operate an indoor farm in Riyadh, a centre that will apparently boast annual output of more than 1,000 tonnes per annum.

There has also been some notable M&A activity in the Middle East when it comes to controlled environment agriculture. In mid-December, in a move that underlined some shifting priorities among different players, UAE-based Pure Harvest Smart Farms agreed to acquire a 6ha production facility near Riyadh operated by RedSea. The latter has made the strategic decision to become a pure-play technology company, rather than a grower. Pure Harvest, for its part, wants to deploy an “asset-light, technology-enabled service model” which it terms “franchise farming” – in other words, it will partner with local farmers in any market to build up sustainable production. “In the challenging climate conditions of the Middle East, it makes sense that players share knowledge and expertise, and start working together,” says Van Rijswijk.

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*RIGHT*—AeroFarms CEO David Rosenberg (centre right) and UAE Minister of Climate Change and Environment Mariam bint Mohammed Saeed Hareb Almheiri (centre left) open the R&D centre in Abu Dhabi

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Photo: AeroFarms



Meanwhile, in the United Arab Emirates, Dubai ruler Sheikh Mohammed bin Rashid Al Maktoum has a similar ambition to enhance his country’s food security and decarbonise its food industry. With his backing, later this year a consortium called ReFarm will start to build a closed-loop production centre called GigaFarm. Its vertical farming towers were first prototyped at the James Hutton Institute’s Advanced Plant Growth Centre in Invergowrie, Scotland, and they can apparently grow more than 250 different types of plant, from salads, herbs and leafy greens to fruiting crops and more. “No mains or groundwater connection will be required to grow fresh produce, since water will be recovered as a by-product from the organic-waste-to-value technology and fed into the vertical farm, which is up to 98 per cent more water efficient than growing in a field,” explains Saeed Al Marri, chairman of ReFarm member SSK Enterprises.

The farm’s projected numbers certainly warrant closer attention: on the 900,000ft<sup>2</sup> site, more than 50,000 tonnes of food waste will be recycled in order to grow 2bn plants and produce 3,000 tonnes of every year. But there is one statistic in the GigaFarm announcement that best underlines the scale of the task ahead for the entire indoor farming industry. Despite its undoubted scale, this individual facility will replace only 1 per cent of the UAE’s food imports. For its developers, that’s undeniably huge. But in national, regional and global terms, it’s just a drop in the ocean. ●





## 7 Three-dimensional chess

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ABOVE—Smartkas'  
strawberry vertical  
farm in the UK  
.....

Photo: Smartkas

**Given everything that has happened in the vertical farming business over the past 12 months, it's no surprise that more measured, less hyped-up ideas have emerged. They are still based on a technologically advanced future that can produce fruit and vegetables more efficiently and sustainably. But out of necessity, you might argue, the first word in the phrase 'controlled environment agriculture' (CEA) now takes on a new importance: control in the sense of caution and care, reflecting the need for more realism when it comes to big technological investments in indoor production.**

Most definitions of CEA point not to vertical farms specifically but to any indoor production that enables a grower to monitor and adjust a crop's various inputs. For US-based trade association CEA Alliance, it means precisely this, with fruit and vegetables grown either in vertical farms or greenhouses. For one or two visionaries, the term might one day even be stretched and applied to outdoor production, but this would depend on some very advanced technologies – some of them not yet invented – which could bring natural environments under control. “Controlled environment growers employ a variety of agricultural production methods and technology to create optimal growing conditions with rigorous environmental controls,” says the alliance. “Growers utilise innovative technologies such as hydroponics, aeroponics, aquaponics, and soil-based systems to grow a wide variety of fruits and vegetables. CEA producers work to deliver the freshest, best-



tasting, and most nutritious fruits and vegetables to consumers, with the least environmental impact; reducing use of water, land and other scarce resources; and employing the most rigorous practices to ensure the safety of our products.”

In other words, the term CEA covers a range of techniques. For most indoor growers, this happens in greenhouses not vertical farms. But the line between a traditional greenhouse and the more space-age indoor facilities conceived by vertical farming companies is becoming more and more blurred. Why? New technologies which were once science fiction are now an affordable reality.

Lighting is the most obvious area where rapid advances have made a big difference to mainstream glasshouse production. Companies like Signify, Osram, Kroptek, Vertically Urban, iBond and many more now offer LEDs that give crops precisely the right spectrum of light to optimise their growth. But, as if to underline the complexity of this fast-evolving industry, that step forward has created a new problem. Traditionally, greenhouse irrigation levels were tailored to sunlight and old-style lamps. But the arrival of dynamic LED lighting, which basically give off less heat, means adjustments are required.

Delphy, a renowned centre for horticultural research in the Netherlands, knows better than most that advances in lighting and irrigation must interact better if they are to make a viable difference to all kinds of indoor farming, not just the vertical type. It recently began working with lighting specialist Sollum Technologies on a new pepper trial at its Delphy Improvement Centre. The hope is that Sollum's LED systems – which can be dimmed, switched off and on in certain zones, or adjusted in terms of their colour spectrum – will mean the pepper plants themselves will be even more productive. “Among the first questions we get from growers transitioning to dynamic LED lighting is how they should manage irrigation, especially as they play with the spectrum, dimming, etc,” says Sollum's chief horticultural specialist Sam Soltaninejad.

As more of these types of system are honed, greenhouse production can catch up and eventually overtake the ambitions that vertical farms set out to achieve. Swiss company Vivent's vision of the future, for example, involves indoor farms receiving real-time alerts from the crops themselves. That's because it has developed technology which, when hooked up to probes, can interpret signals that alert the grower to poor conditions, pests or diseases. In other words, it will be possible to hear what plants are saying, then feed that data into systems that can react using artificial intelligence. “Many indoor growers install our sensors at the start of each crop cycle,” explains commercial director Carl Rentes. “The sensor stays in place throughout the crop cycle. Growers receive email or SMS alerts when crop stress occurs.”

Other industry players like Kubo, another Dutch company that builds greenhouses all over the world, has a big role to play in making indoor production facilities more sustainable. In Arizona and Mexico, it has helped vegetable grower Wholesum to overcome freezing winter conditions and scorching summer temperatures by building what is referred to as a “semi-closed greenhouse” with its own positive air pressure and just a single air inlet. Infrared cameras are used to detect internal temperature differences, which means improved climate control. And soon, solar panels will make the company 75 per cent self-sufficient in terms of its electricity needs.

While most agree that the underlying idea behind CEA is sound, opinions differ over the best way to future-proof it. For some, AI could play a more prominent role in its development and future success. In the past year, discussion around the possible opportunities and potential pitfalls of AI has intensified. Indeed, many in the fruit and vegetable business as a whole say they have already started to see the benefit of AI in areas such as robotics, crop monitoring, yield forecasting, grading machinery, traceability, and communications.

RIGHT—Swiss grower Julien Stoll (right) checks on his plant sensors alongside Vivent co-founder Nigel Wallbridge

Photo: Vivent



At *Fruitnet*'s recent Global Tomato Congress, agtech startup *Source*'s co-founder and CEO Rien Kamman spoke enthusiastically about the benefits of AI. He also downplayed some of the fears that people have about its adoption. "AI has the potential to empower growers, who wield tremendous power, have an enormous responsibility and do a complex job," he says. AI is already being utilised in a number of key areas in the fruit and vegetable supply chain, he observes, including smart monitoring, sales assessment, planning labour, monitoring strategy and risk, and executing plans autonomously. "Growers are three-dimensional chess players," he continues. "You need to find the right strategy across these multiple dimensions – pruning, costs, irrigation and more – and every day you are presented with new information. This is where AI plays a massive supporting role."

*Source*'s early adopters include greenhouse operators, who are understood to have completed "hundreds" of simulations every week as new information come in, before they alter and hone their strategies accordingly. "You need a good digital representation of what is happening in the greenhouse, a virtual overview," Kamman says. "The AI can simulate the actual biology of crops, to see how different strategies can affect the outcome. If you do this virtually, you can do it in seconds without any risk to the actual operation. We simulate strategies, simulate the biology, the production. You can model how good a strategy is from a financial point of view too, how much revenue will it bring in, how much profit." While Kamman understands the concerns surrounding the rapid development of AI and the perception it could usurp some in the supply chain, he says this is not the end goal. "AI is a partner to help growers, not replace them," he argues. "It will reduce risk and help produce more food through expanded and more efficient production."

The advantages offered by AI are also championed by Itamar Zisling, business development and pilots manager at robotics developer Metomotion, who points to numerous challenges faced by growers producing in greenhouses. “Labour price and availability, energy crisis uncertainty and the market itself with people wanting more for less with better quality and variety are all considerations,” says Zisling. “Robots are here and they will help tackle not only the widespread labour issues but the others mentioned with advanced AI and technology.”

The mechanical arms of Metomotion’s Greenhouse Robotic Tomato Harvester can detect, approach and harvest vines. They carry with them potential labour cost savings of 50 per cent, and an overall labour reduction of 80 per cent. It’s a thought-provoking glimpse of a more efficient and cost-effective process. “What does the future look like?” Zisling asks. “The technology of AI is already available and it allows us to go to the next level – not replacing people in the greenhouse but adding to them. AI offers new ways of working and new insights.”

David Meszaros is founder and CEO of Dutch company Smartkas, which builds climate-neutral fruit and vegetable production centres that embrace a wide range of new technologies. For him, AI will be more useful in some situations, less so in others. “I would say that AI can have far more radical and extreme applications in open-field farming, less in greenhouses, and almost nothing in vertical farms,” he outlines. “That’s because the level of control increases in greenhouses and even more so in vertical farms, therefore the variables narrow down. If there are no variables, he says, all of the parameters are known exactly. “Like the PPFD [photosynthetic photon flux density] of the light, or the CO<sub>2</sub> ppm [parts per million]. So what is there for the AI to think about?”

Out in a more natural environment, however, Meszaros believes there is huge potential. “AI can thrive in open field, where there are insects, birds, rain, and so on,” he suggests. “There, with a predictive algorithm, it can start modelling, because everything changes all the time.” In practice, this would be achieved through the installation of systems like low-frequency ground sensors, GPS-controlled tractors and other automated units, and drones. “But I’m not talking drones for irrigation and pest control,” he explains. “Drones can help create something called an orthomosaic, a stitched-together array of 4K images. This is almost true AI, which creates an accurate live map of your farm. It can use all kinds of inputs to create a model that shows where your farm is most fertile, where it has a hotspot for bees, for flies, for birds, for whatever. And then you don’t have to spend millions on pesticides and all kinds of preventive measures.”

In that sense, the future for CEA might not lie solely indoors, but in a far more sophisticated and tech-enabled iteration of open-field production. In many fruit orchards around the world, systems are now connected up in different ways to databases which then allow growers, technical managers and packhouse operators to monitor things like irrigation levels and yield projections. “These are my ‘eyes on the ground’,” says Daniel Viljoen, as he points to a graph on the screen of his smartphone. He is general manager of Lushof Farm, a vast commercial stonefruit orchard run by Graaff Fruit near Ceres, in South Africa’s Western Cape. “I put 30 probes in the field, linked them to 220 irrigation valves that open and close, and I taught myself how to extract the data and visualise it. Now I can check water levels across the orchard, all from my phone.” ●





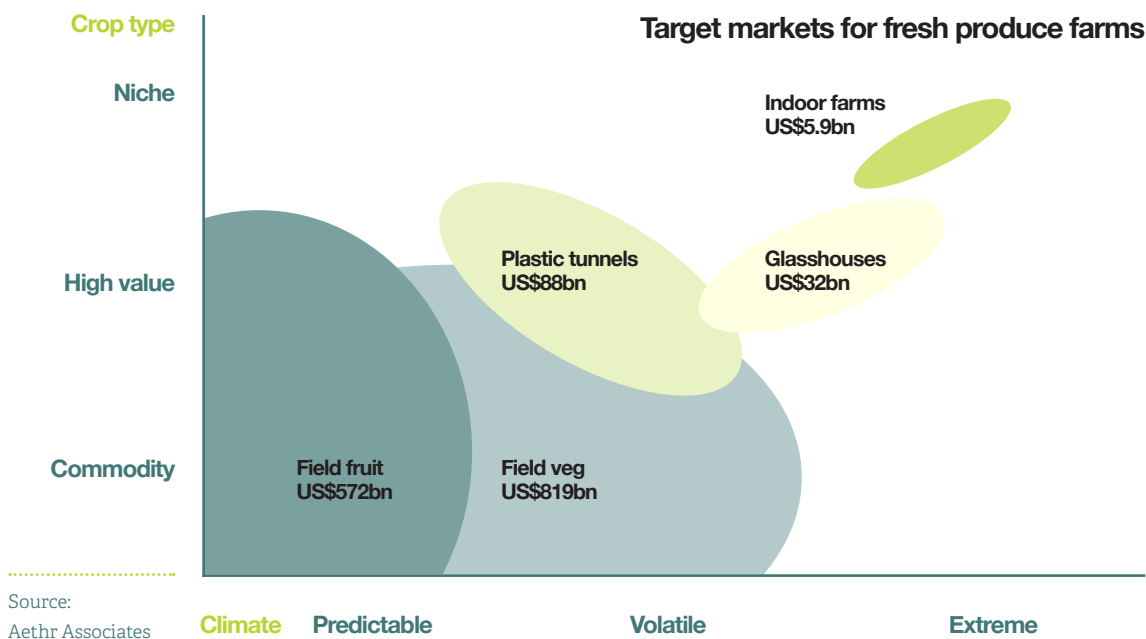
## 8 Time to grow up?

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*ABOVE*—Plenty has pioneered the development of vertical farms in the US, including this salad centre in Compton, Los Angeles

.....  
Photo: Plenty Farms

**So where does that leave the vertical farming business now, and its role in the fruit and vegetable business? The past year has raised serious doubts about its ability to expand beyond the production of high-value, niche crops; and in terms of location, beyond regions with extreme climates. Many now agree that the potential of vertical farming is more limited than entrepreneurs and investors have previously claimed. But it's also true that in a water-stressed nation like Egypt, for example, hydroponic technology can open valuable new commercial opportunities to grow produce using no more than 10 per cent of the volume of water needed with traditional methods. Or in the far north of Europe, where sunlight hours are scarce, production under LED lights offers a logical alternative. And in the US, a company called Oishii uses a vertical farm to produce strawberries called Omakase and Koyo. The varieties are "like none you've had before," it tells consumers, who pay a considerable premium for it.**

Those who have tried and failed might argue it's not so easy. "Aromatic herbs are profitable, but with a very small market and dozens of players," argues Guillaume Fourdinier. "Salads are, but only for the few products with high added value, not for everyday salads. Fruits and vegetables like strawberries are not, even after seven years of R&D. My current feeling is that no player on the global market... seems to have found the solution to feed the planet via indoor farming today. I deeply hope I am wrong."



Some analysts argue that the sector's prospects are still good, especially in countries where climate change makes local food supply chains more fragile. A report called *\*Food, Water, and Climate Change\**, published by Citi last November, predicted that controlled environment agriculture (CEA) would continue to offer a potential route to sustainable and profitable supply, especially in the face of climate-related challenges. "Vertical farming and ambient-controlled farming... could be solutions for many countries that have a limited supply of water," its authors wrote. "Currently, these technologies are mostly being used to produce leafy greens, but if CEA technology could be extended to produce staple crops and the economics work, it could help some countries meet some of their demand for these staple crops."

Ruud van der Vliet, CEO of consultancy firm Van der Vliet & Van der Oost, says via LinkedIn that he believes the failures of Infarm and other vertical farming startups create a false impression that CEA no longer has the potential to be a sustainable farming model. "It is very unfortunate for all CEA stakeholders that these types of disasters can still occur," he says. "It gives the entire industry a bad name. Within CEA, vertical farming is actually only a niche, and until recently it received a disproportionate amount of attention from investors."

Dickson Despommier's original premise for vertical farming was simple: bring food supply as close as possible to the consumer. In New York, back in 2012, Gotham Greens was about to embark on a new collaboration with Whole Foods that would see it build a rooftop farm above one of the retailer's Brooklyn stores. "People are going to love how the food is effectively oil-free," the academic predicted. "Whole Foods has 300-odd stores in the US and I guarantee this will be the genesis of the start of the commercialisation of vertical farms." Gotham Greens now operates greenhouses in nine US states (it opened its 13th in Texas in January), where it grows leafy greens and herbs that are "always in season". Despommier's attention meanwhile has turned to how cities might transform themselves into self-standing, functional ecosystems that produce a significant portion of their own food. Some of that work has begun in places like Copenhagen and San Diego. But for vertical farms to work and be part of that progress, they also need to be sustainable from the start.



Co-located vertical farms offer clear advantages to retailers in particular. Oslo-based developer Avisomo has just formed a strategic partnership with Norway's second-largest supermarket chain, Coop Norway, to integrate a fully automated vertical farm into its existing distribution centre. The project will cost more than €5m, but once completed the partners will share the burden of energy prices and food price fluctuations. Avisomo will have a direct line to Coop consumers for its year-round fresh salads, without need for an intermediary. Eventually, the farm will produce vegetables and salads at scale and at a competitive cost without any form of human interaction with the plants. This should eliminate the need for imports, and guarantee quality, affordability, and reduced climate impact. CEO Martin Molenaar explains why Avisomo's vertical farm will offer a lower-risk option compared with other models: "Our approach is based on growing produce directly in standard-sized trolleys that are well-established in the food industry, and moving the plants around the facility utilising automation robots."

For many startups, vertical farming was too often understood as something to be created from scratch. Built from the ground up. A wheel to be reinvented, using space-age technology purchased with venture capital investment funds. Turf out the soil, open the floodgates to hydroponics. Switch off the sun and herald the dawn of LEDs. Let the insects fly away and clear the air for drones. Some of these technologies do have the potential to rescue production that would otherwise succumb to climate change; but in too many cases, their development and implementation has been prioritised at the expense of sound business planning.

Are vertical farms so different from what conventional indoor horticulture projects – put simply, greenhouses – will eventually become? Vertical farms have tended to be deliberately different: trays of crops stacked in rotating layers, for example, to minimise space and make their inner-city locations more feasible; and often a complete absence of direct human interaction with the plants and products. But there are some important areas of convergence between vertical farming and greenhouse agriculture, a meeting of methods that promises to salvage some of the advantages of the former and create new opportunities for the latter. The highly controlled nature of vertical farming environments – lighting, temperature, crop protection – has already inspired improvements in more traditional glasshouse projects. New closed-loop systems perfected by vertical farms have also found their way into what is now more generally referred to as CEA.

Van Rijswijk suggests more consolidation will be needed in the technological realm before established growers can more easily access the kind of advanced, all-encompassing systems that the vertical farming startups have sought to engineer from scratch. For now, however, it is possible that the sheer multitude of smart-agriculture apps and tools on the market could be somewhat overwhelming. "Most likely we will see a lot of integrations, partnerships and joint efforts to bring all of this to the next level, and make it easier and simpler for farmers to find their way in this agtech maze," she predicts.

For Van der Vliet, despite recent pressure from rising input costs, high-tech greenhouses around the world continue to produce fruit and vegetables successfully, sustainably and profitably. "Investors and banks should realise that indoor farming is extremely complex," he concludes. "Just like a successful Formula 1 team, not everything depends on hardware and software, but rather

on cooperation between team members, especially the grower and sales. This applies to high-tech greenhouses, but certainly also to vertical farms. With the latter, the energy component is currently a limiting factor.”

Darryn Keiller, founder and CEO at US-based digital agronomy specialist WayBeyond, lists three basic mistakes that vertical farming startups must avoid in future: confusion of purpose, a lack of crop knowledge, and trying to scale up too fast. But, he adds, it also remains a segment of the horticultural industry with huge potential. “In the long run,” he says, “with a growing world population, increased urbanisation, and the desire to eliminate carbon miles, and optimise resourcing and labour, these farming concepts are amazing, and needed.”

Van Rijswijk agrees. “Most indoor farms are economically viable, but it is mainly vertical farming that has been struggling. Although vertical farming has gained a lot of attention, the size of this industry has always been extremely small in terms of production volume, also during the peak of the hype, while there are hundreds of thousands of hectares of greenhouses. And they have been around for over hundred years already and are therefore a proven business model.”

In just two years, vertical farming as a concept has been cut down to size. But many of the strategic and technological advantages that nourished its growth over the past decade can now be transplanted into an increasingly more advanced – not to mention more carefully planned – version of indoor, controlled environment agriculture. Not so much boom and bust then, more a classic example of Gartner's hype cycle: the technology triggers have driven us to the peak of inflated expectations, from where we have descended into a trough of disillusionment. Yet on the horizon lie the slope of enlightenment and beyond it the plateau of productivity.

As CEO of FoodVentures, a firm which project manages the creation of high-tech CEA facilities across the globe, Dirk Aleven believes the pandemic has changed the way buyers and consumers think about the distance their food must travel to reach them. As a result, the local security of an indoor production centre close to market is now seen as more of an advantage. “Resilience is the key after Covid,” he says. “And maybe we were not so aware of how important it is to have local produce for a resilient supply chain, until all of a sudden it was disrupted.”

There is still much to be admired in some of vertical farming's founding principles, which means the future for CEA appears much brighter. Proximity to market can add a premium and save on transport costs. Protection from the elements can shut out unwanted climate risk and guarantee year-round supply. And if profitability can be secured despite some very unpredictable costs, that remains a very promising opportunity for the fresh produce business. ●



## + Appendix I

*Comment piece by Richard Bonn, Co-founder and CEO of Aethr Associates*

**There is no denying the potential of indoor farming as a solution to some of the pressing sustainability and food security challenges we currently face, and will continue to encounter. However, the considerable investment required for this technology sometimes gives the impression that it's merely the latest 'shiny' trend to attract 'green' investors. The allocation of investment needs to be balanced, and it must address productivity improvement in all types of agricultural production, rather than focus solely on high-value or niche crops.**

RIGHT—Richard Bonn, Aethr Associates



It is widely acknowledged that substantial investment in innovation is crucial over the next two decades to meet climate goals. But while high-tech indoor farming can prove effective in meeting the demands of high-value or niche crops in volatile or extreme environments – as exemplified in my own country of the UK by companies like Grow Up Farms or LettUs Grow – it is unlikely to be the cost-effective solution that will feed the world's population.

Diversified investment in innovation across all growing systems and crop types is imperative. Innovative approaches such as controlled environment agriculture glasshouse production, as demonstrated by Pure Harvest in the UAE, shows that even countries with extreme climates and high import dependencies can produce high-quality crops successfully. Similarly, advancements in hydroponic and aeroponic technology within greenhouses demonstrate the potential for water preservation in arid regions without having to go indoors.

Moreover, the adoption of regenerative agriculture principles proves that it's possible to cultivate commodity crops in an environmentally positive manner. This holistic approach, which encompasses a range of technologies and methodologies, is essential to achieve sustainable food production on a global scale. ●

## + Appendix II

*Exclusive interview with David Meszaros, Founder and CEO of Smartkas*

**David, what sets Smartkas apart in terms of its business plan? Why is the vertical farming system you employ at your leafy greens facility in Amsterdam different to others?**

**DM:** I think the first thing to say is that we are not overqualified engineers who are just creating very expensive toys to sell to the market. There are two markets we are talking about here. There's the vertical farming market, or the controlled environment agriculture market, which is about US\$14 billion globally, and then there's the food and retail market, which is about US\$13 trillion. We're targeting this.

*RIGHT*—David Meszaros, Smartkas



We don't want to create some big system that looks nice, sounds nice, and then either sell it – which a lot of agtech players do – or use it to convince private equity investors to keep raking in more and more money, and then get rich but not care about it.

No, we pre-finance future revenue by already having contracts in place, and doing everything – all the analysis, market study, feasibility – at our own cost before we even speak to the first investor. When we do, we don't call venture capitalists or private equity or banks. We seek out private individuals, asset managers, and other people and institutions who are interested in investing in something sustainable.

**Tell us how you have managed to create a sustainable vertical farming model?**

**DM:** We structure it around a project. So it's not just "I'm a big new startup, give me so much money, and I'll decide where to put it". No. This is the project, this is what it's going to look like, these are the different phases, this is who we're going to sell to, this is how much we're going to sell it for.

Then we look at fixed expenses. Biggest one is energy, right? If you have a steady, stable arrangement, that's great because essentially what you're doing with controlled environment agriculture is turning kilowatt hours into kilos of produce. It's not rocket science.

The second is how much your land and buildings cost. For indoor farms, we prefer leasing. That's because the getting-to-market period is much quicker, since it already exists. This [Amsterdam facility] is a brand new building. But we are also interested in greenhouses and open-field farming, in which case we want to own the land.

The third fixed expense we look at is labour. We're lucky, because we have a very high level of automation within our farms. We have skilled labour, but these are technicians who are responsible for maintenance, tweaking, yield improvement, etc.

So we are not just following the beaten path, or doing the same as everybody else. We were not farmers originally, so when we created this company, we drew on the efficiency of previous experience of tech projects, automotive projects, industry projects. Not for show, not for marketing, not for convincing investors.



***"You hear a lot about vertical farms that spend tens of millions of euros researching something that their neighbour has already researched"***

**So how would you sum up the difference between Smartkas and other vertical farming companies that have ended in failure and bankruptcy?**

**DM:** The difference is that we are methodical. We pre-contract for off-peak energy, and all kinds of other variable expenses to bring them down as much as possible. After that, when we raise funds, they don't go into ceaseless R&D, marketing or sales. That's usually how 60 per cent of startup funding is thrown out of the window.

For us, 80-90 cents of every dollar go into bricks and mortar assets that seek to generate revenue. We also have a very high Ebitda percentage, and therefore we can very accurately predict in our models what we're going to make.

**Do you think the CEA business has learned any lessons over the past few years?**

**DM:** Well, if you don't make any revenue, then it's a sham. I think it's all about mindset. Do you believe you have the technology to build something that's going to make money or not? We don't



want to use experimental stuff. Take LED lighting, for example. That technology has been through tremendous changes in just the past ten years. The lumen per watt, the efficiency and efficacy of those lights, has increased five times. This means energy consumption is lower. So we don't need to reinvent the wheel.

*RIGHT*—Leafy salad crops are checked at the Smartkas centre in Amsterdam



You hear a lot about vertical farms that spend tens of millions of euros or dollars basically on researching something that their neighbour has already researched. So I am a huge advocate of scientific dissemination, and information sharing. At the end of the day, we are all working towards one noble goal, which is food security and feeding the planet.

**In order for that revenue to come, customers have to be there. So what tells you that there is a market out there for the kind of products you're going to produce? And how can you be sure that you're not going to produce them too expensively?**

**DM:** Very simple. You just ask them. I think people underestimate that we live in the age of information and communication. So a lot of people just try to Google something and then base their assumptions on half the information or a quarter of the information. If retail is your model, pick up the phone and call an Albert Heijn, an Aldi, or a Jumbo. If you're a smaller-scale microgreens farm, call a restaurant, a hotel. If you want to go super cheap, call a hospital or the military.

There are so many opportunities. But call them before you raise hundreds of millions of euros and dollars and ask them: "Hey, I'm planning this. Is there a market for it?" A feasibility study. You need contact with your future client, because that's the person you're doing it for. ●

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