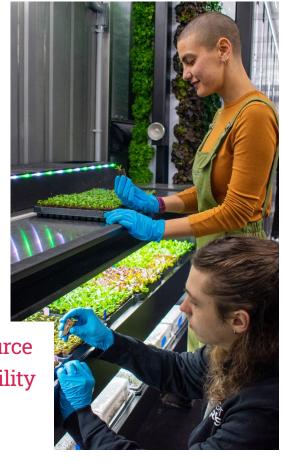# Freight Farms
# Raspberry Pi 4-powered vertical hydroponic farms let customers grow and monitor fresh produce anywhere

Freight Farms requires powerful compute together with flexible I/O and IoT capability for their high-yield container farms. Raspberry Pi 4 offers high performance and friction-free development at "an unbeatable cost", all within the compact form factor their product demands.

**Raspberry Pi solution**      Raspberry Pi 4
**Size of business**          SME
**Industry**                  Agriculture

With food insecurity increasing, and global temperatures rising, two graduates from the Massachusetts Institute of Design began working on a business idea to address how to increase food production in non-agricultural settings, beginning with rooftop gardens in Boston. Their idea was to increase "local food access and create a replicable model and a product that could be used to grow food anywhere, all across the world." Backed with a modest amount of seed funding, which they put towards a Kickstarter campaign, co-founder and current president John Freeman and co-founder Brad McNamara came up with the innovative idea of retrofitting shipping containers as locations for vertical hydroponic farms. Sensors would monitor pH levels, nutrients, light, temperature, air, and soil moisture while cameras checked on plant growth. Container availability and relative ease of shipping, given their original purpose, plus a temperature-controllable environment, meant the self-contained farms could be delivered and set up almost anywhere.



"ease of development, open source traceability and driver availability at an unbeatable cost"

## The challenge

Turning a lofty ideal into a successful business plan and making good on the promise that early investors anticipated is a challenge for any startup. However, it was clear from the outset that container farming had potential. Freight Farms' first offering — the Leafy Green Machine, launched in 2013 — featured a climate-controlled seeding section and a main growth area where vertical crop columns saw a variety of leafy vegetables flourish. The container farms featured high-efficiency LEDs, used relatively little energy, and effectively filtered and recycled the water they consumed, making them particularly efficient with this essential resource. They were able to produce up to four tonnes of food per year.



"We also looked at some microcontroller solutions as well as other SBCs, but nothing came close"

Despite attracting high-profile customers, Freight Farms was keen to improve the efficiency of its container farms along with the range of crops that could be grown, and thus boost their appeal to a wider range of customers. Both would help unlock the business's potential beyond the US and beyond its original base of campus and community organisations. Freight Farms set about creating preconfigured farms, marketed as turnkey products that could be set up remotely by the customer and would be seen as a practically failsafe investment.

Accordingly, Freight Farms has spent the past few years "honing what a container farm looks like, improving the tech behind it and the yields" in order to demonstrate its validity as a grow-anywhere option, explains supply chain manager Meaghan Holmes. Yields had the potential to be a particular challenge, since certain crops are very difficult to grow or to provide the right conditions for, especially as a location's climate changes. "One of our goals — and our farmers' goals — is to make the most use of a small amount of space by growing as much as possible," says Holmes. Monitoring improvements required an increased focus on IoT and the in-house development of a camera with a much wider field of view, while customers were also keen to be able to check on their container farm remotely, necessitating an app for remote viewing.

## The solution

Freight Farms recently launched its Raspberry Pi 4-powered Greenery S flagship model. As well as using the top-of-the-line Raspberry Pi, this container farm features a bespoke camera unit. Prior to this, Freight Farms had used off-the-shelf security cameras to monitor plants. "These were limited in terms of setup and configurability, and did not have enough resolution or FOV in a small enough package to embed inside the walls of the farm," explains Jakes Felser.

His team designed their own camera to overcome these issues. Along with demanding performance requirements, these must be small enough to fit inside the panels of the farm; Raspberry Pi provides the small form factor that Freight Farms requires in the computers to which the cameras connect, along with the necessary compatibility with these bespoke, high-quality devices.

The cameras take us to that next level of the farm really being foolproof, adds Holmes, while the app helps the crop grower to notice problems promptly. It gives them access to high-quality photographs in which symptoms such as yellowing foliage are clear to observe, so they can top up the container farm's nutrient supply or adjust environmental factors such as temperature or humidity.

## Why Raspberry Pi?

By the time Freight Farms was successfully crowdfunding, Raspberry Pi was becoming a success story in its own right. With a great reputation among the engineers and computer technicians tasked with creating Freight Farm's "turnkey" growing containers, it was an obvious choice of hardware.

CTO Jake Felser outlines the reasons for choosing Raspberry Pi: "ease of development, open source traceability and driver availability at an unbeatable cost for the performance." This was coupled with a stable supply chain and a large support base. "We also looked at some microcontroller solutions as well as other SBCs, but nothing came close to the performance at the given cost," he concludes.

Meaghan Holmes maintains a close relationship with Freight Farms' engineering and manufacturing team, ordering critical items such as Raspberry Pi units, sensors, and lights to measure and monitor plant growth and health. She praises Raspberry Pi's reliability, its user-friendliness, and the reassurance of it being so widely known — a platform with which almost all of the company's engineers were already familiar. For a business-critical component, "you wouldn't want something super-obscure", she points out, while the engineering team knew that Raspberry Pi has "a really high measure of success in terms of support".

## The results

Freight Farms' Raspberry Pi-powered Greenery S container farms offer the most productive environments in their field, with a 30% improvement in yield between the original Leafy Green Machine and the current Greenery container farms. A thorough onboarding programme in which potential sites are checked for appropriate electrical voltage, robust plumbing, and water access kickstarts each new customer relationship.

The straightforward management of each farm, with "recipes" for growing each crop plus a dedicated support team available by email or phone, has meant the Freight Farm concept has been embraced by non-farmers who perhaps speculatively invest in a single container farm, as well as leisure resorts where agricultural expertise is in short supply but where the restaurants pride themselves on offering fresh locally grown produce. They are particularly proud of working with community kitchens, food banks, and non-profit organisations, such as Lotus House in Miami which supports women and children who have experienced homelessness.

Core crops grown in the container farms include varieties of lettuce, leafy greens such as kale and chard, herbs, beans, and root vegetables. Some customers have even begun experimenting with berries and edible flowers.

There are now more than 200 Freight Farms running productively in more than 50 countries. The Covid-19 pandemic brought into sharp relief for some remote islands how dependent they were on imports not just for discretionary goods and services, but for food access, says Meaghan Holmes. Freight Farms' customers include a significant number of island nations that were previously dependent on regular shipments to supply food staples that could not be grown locally.

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