

# Vertical farming – science fiction or the future of agriculture?



Self-sufficient village with a vertical farm (<https://weburbanist.com/2016/05/22/off-grid-self-sufficient-regen-villages-with-vertical-farms/> (<https://weburbanist.com/2016/05/22/off-grid-self-sufficient-regen-villages-with-vertical-farms/>))

As an environmental science student living in a vibrant, entrepreneurial city like Amsterdam, I'm being flooded with hipster-environmentalist buzzwords like rooftop farming, aquaponics, food coop or even just the attribute green, sustainable or healthy. Whoever knows me will have noticed, that I easily fall for all these exotic concepts, secretly hoping they will save the world. While being intrigued, I often find myself dismissing these ideas as utopian and unrealistic. After all, I want to make a change now, not sometime in the distant future. However, it might be worth having a closer look at one of these slightly crazy ideas...

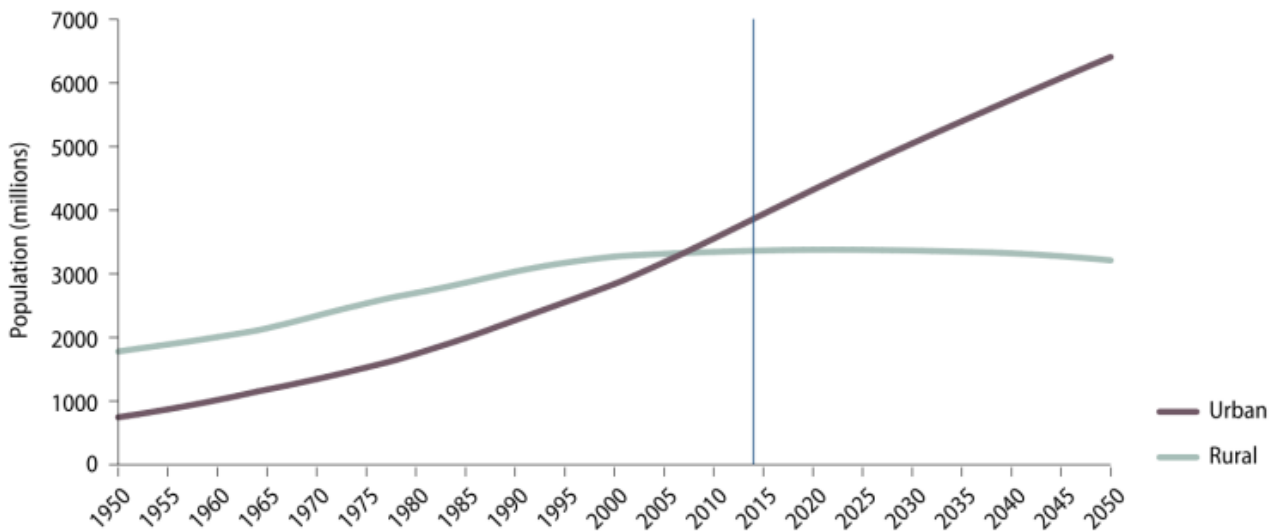
Vertical farming - science fiction or the future of ...

<https://auclimate.wordpress.com/2018/04/05/verti...>

numbers of people are migrating to cities. Around 50 percent of the human population is already living in urban areas and this fraction will quite certainly continue to grow (United Nations, 2014). At present, an area of the size of South America of the world's landmass is dedicated to growing crops, and this is excluding livestock pastures. So around half of the size of South America is needed to feed the city dwelling population. An entire continent solely dedicated to agriculture really is a big footprint.

Figure 2.  
Urban and rural population of the world, 1950–2050

A majority of the world's population lives in urban areas



World urbanisation prospects (United Nations, 2014)



Area needed to feed the world  
(Despommier, 2011, p. 76)

Nonetheless, we need solutions feed the growing masses of people. For example, we could intensify agricultural production. However, 80% of farmlands are already over farmed, which has negative consequences for water quality, soil erosion, biodiversity and more. How about GMOs? Advocates of the second green revolution hope to squeeze out even more produce from deteriorated farmland by using new crops, usually lots of pesticides and even more fertilisers, while we don't know much about their long term health risks. Expanding agricultural area into native forests is not an option either because we cannot risk losing the last fragments of our planets lungs. If all goes wrong we could force everyone to go vegan or switch their T-bone steak for [insect burgers](https://www.jumbo.com/damhert-nutrition-insecta-) (<https://www.jumbo.com/damhert-nutrition-insecta->



[groenteburger-met-buffalowomen-2-x-75g/151485PAK/](#), but first let me show you how we could avoid this kind of eco fascist dystopia after all.

## Agriculture Yesterday

Around 10.000 years ago, humans gradually stopped hunting for game and gathering wild plants and started settling down to cultivate edible plants: agriculture was born. And despite many developments, the basic principle of farming hasn't changed since the neolithic revolution. Yes, today we have machines, special crops, pesticides and fertilisers, but for the most part it still comes down to spreading seeds out on an open field and hoping for the best. This might leave you wondering, why we are [growing meat in labs](#) (<https://www.wired.com/story/lab-grown-meat/>) but haven't really found alternatives to traditional agriculture. Well, actually we have, and I think we are on the brink of a revolution that would take farming into the third dimension.



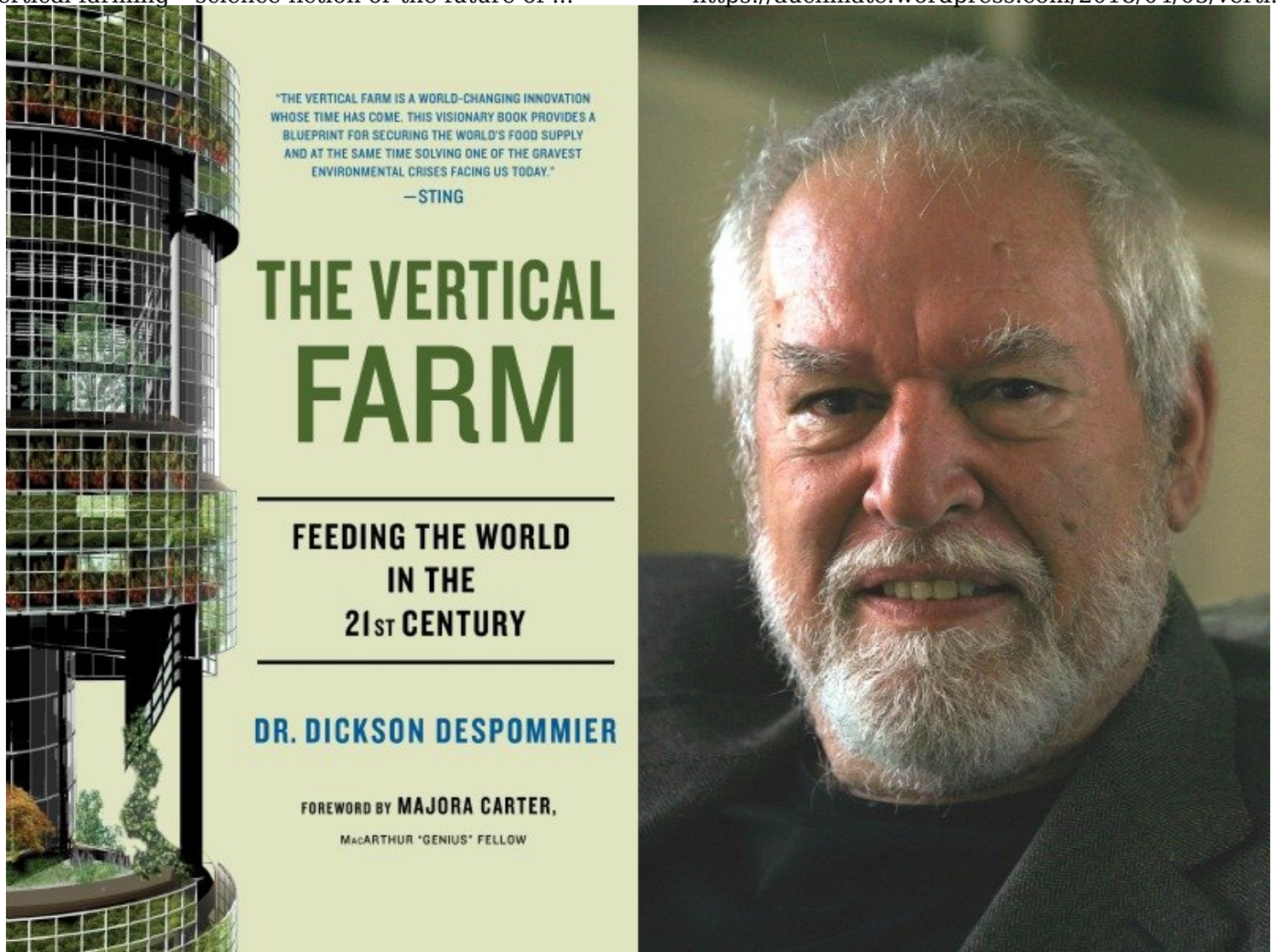
Conventional agriculture (<http://www.miller3group.com/wp-content/uploads/2016/09/agriculture.jpg>  
(<http://www.miller3group.com/wp-content/uploads/2016/09/agriculture.jpg>))

---

## Agriculture Tomorrow

One of the more unintuitive solutions to the food crisis and many other problems urban centers are facing today (e.g. air pollution, water purification and traffic congestion) has been proposed by visionaries like Dickson Despommier: the Vertical Farm.





Dr. Dickson Despommier "The Vertical Farm" (<https://inhabitat.com/review-amp-interview-the-vertical-farm-by-dick-despommier/> (<https://inhabitat.com/review-amp-interview-the-vertical-farm-by-dick-despommier/>))

Growing enough healthy food for everyone and repairing the environment at the same time appear to be two mutually exclusive goals in our current agricultural regime. If we could concentrate agriculture in vertical farms within cities, vast amounts of farmland could be given back to the ecosystem it belonged to before. Forests would grow, wildlife and plant biodiversity could recover, cleaning air and water streams while sucking carbon from the air. At the same time, cities would have access to fresh produce without the footprint of long transport ways and convoluted supply chains. Producers and consumers would reap health benefits because controlled environment cultivation in vertical farms eliminates the need for pesticides and herbicides. Vertical farms could also purify water through plant transpiration and improve urban air quality by filtering aerosols and producing oxygen.



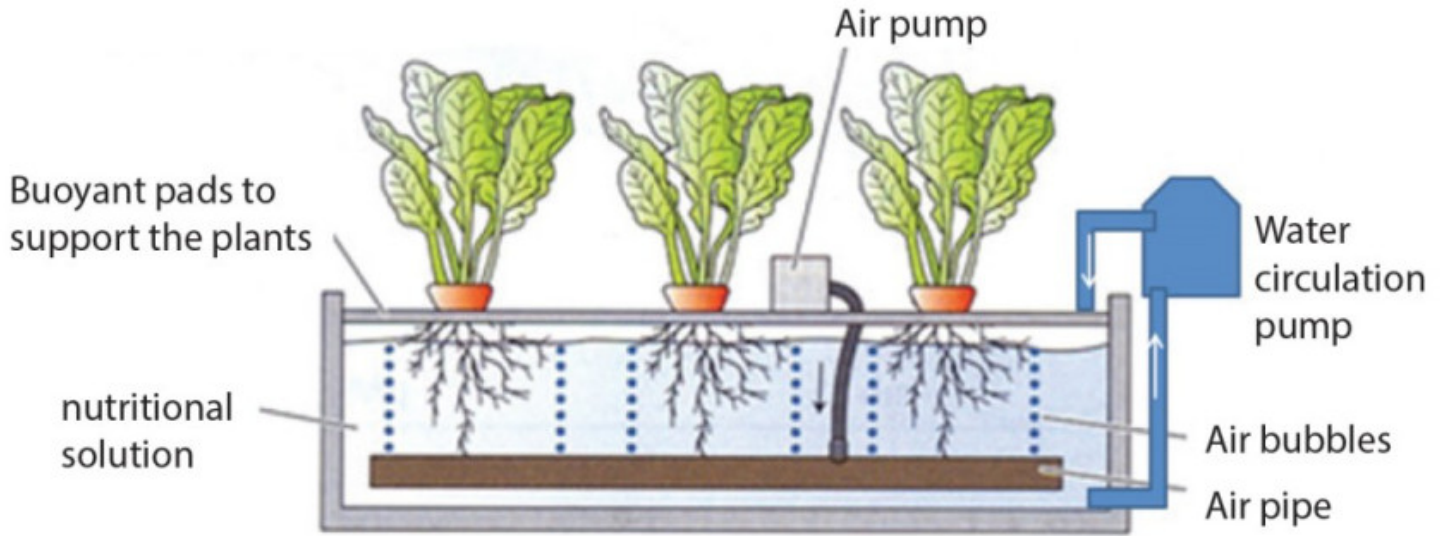
Traditional vs. vertical supply chain (<http://www.plantlab.nl/lets-get-real-agriculture/>  
(<http://www.plantlab.nl/lets-get-real-agriculture/>))

## Soilless Farming

Of course weight and space efficiency is crucial when planning to stack up farms in a multi-story building. In a hydroponic growing system, plant roots are submerged in water with an added solution of nutrients. Not only is this highly water efficient, but also every input can be precisely monitored and adjusted for optimal plant growth. This way, plants can be cultivated extremely densely while saving a lot of weight. On the downside, not all crops are well suited for hydroponic cultivation (e.g. grains, legumes, root vegetables). The best results have been found with fast growing, leafy vegetables. And even then it is very difficult to maintain the right nutrient mixture and growing environment, which translates to cumbersome trial and error on a daily basis. With a steadily growing body of knowledge and experience in soilless agriculture, we can expect these issues to be resolved.

## Diagram of the Hydroponic System

[www.mmjdoctor.com](http://www.mmjdoctor.com)



Schematic drawing of a hydroponic growing system (<https://mmjdoctor.com/> (<https://mmjdoctor.com/>))





A hydroponic greenhouse (<http://www.interiordesigninspiration.net/wp-content/uploads/2013/07/Hydroponic-Gardening-104.png> (<http://www.interiordesigninspiration.net/wp-content/uploads/2013/07/Hydroponic-Gardening-104.png>))

---

### Advantages of Vertical Farming



Fresh vegetables and herbs for everyone! (<http://www.plantlab.nl/radical-new-plant-logic/>  
(<http://www.plantlab.nl/radical-new-plant-logic/>))

---

Although the concept of vertical farming is very simple, essentially stacking a bunch of high-tech “Venlo”-type greenhouses on top of each other, imagining skyscrapers full of vegetables seems quite far fetched. Obviously vertical farming is a very radical departure from the traditional ways of farming, and realising the potential benefits outlined below will require the combined expertise of horticulturists, architects, engineers and many other experts. However, vertical farming masterminds like Dickson Despommier have thought about this long and hard and it turns out there are good arguments why vertical farming, although complex, actually is the future of agriculture. After all, humanity has mastered other difficult things like heart surgery or sending people to the moon. So let’s keep calm and take a closer look at some of Despommier’s arguments:

#### 1. Year-round crop production

If crops can be grown in climate controlled indoor farms, seasonality would not be an issue anymore. Instead of importing tomatoes from Spain and Italy, they could just be grown next door. In fact, this is already happening in huge gas-heated green houses in the Netherlands. The vertical farm of the future, as imagined by Despommier, would be largely energy self-sufficient, heated and powered by renewables like solar and wind power or (self-grown) biomass.

#### 2. No weather related crop-failures

Outdoor farmers are traditionally pushed into a precarious situation. Floods, droughts, hail and storms can destroy a seasons worth of work and dedication in the blink of an eye. These extreme weather events are intensifying with progressing climate change and often all there is left to do for the farmer is to diversify crops and hope some of it survives. Indoor farmers don’t have to worry about the weather anymore, as their produce is always protected.



Controlled indoor growing environments can be sealed off from the outside world, keeping out unwanted insects and pathogens, which is already routinely practiced in labs and factories. This means, no need for pesticides and herbicides anymore. Uncontrolled agricultural runoff, the main cause of water pollution worldwide, would be history.

#### 4. Ecosystem restoration

The easiest way to restore natural landscapes is to leave them alone. Nature is typically much more resilient than commonly believed, and given enough time, even the most disturbed ecosystems will eventually recover when left alone. Take the dust bowl of the American Midwest, which restored to tall- and short-grassland just 20 years after the area was abandoned from farming and written off as a dead landscape. Vertical farming would free up vast amounts of area to be given back to nature, restoring biodiversity and ultimately relieve the pressure on the natural world.

#### 5. Use of 70-95 percent less water

The current land-based agricultural regime uses around 70% of the world's fresh water supply. If soilless growing systems are implemented in sealed indoor environments, huge amounts of water can be saved by collecting water vapor transpired by plants in dehumidifiers and feeding it back into the growing solution.

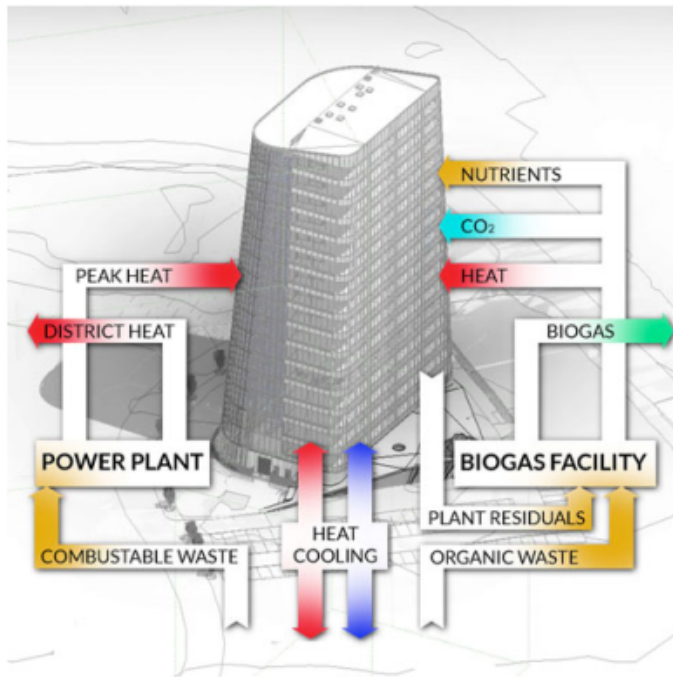
#### Circularity

In theory, everything within the vertical farm can be recycled: water is collected and reused, plant residues are transformed to biofuels, and heat can be stored and exchanged with the neighbourhood. If city planners begin to implement food production into the metabolism of urban settlements, vertical farms could soon prove to be a stepping stone towards a truly circular economy.



(<https://auclimate.wordpress.com/2018/04>

[/05/vertical-farming-science-fiction-or-the-future-of-agriculture/screen-shot-2018-04-02-at-11-40-17/](https://auclimate.wordpress.com/2018/04/05/vertical-farming-science-fiction-or-the-future-of-agriculture/screen-shot-2018-04-02-at-11-40-17/))



(<https://auclimate.wordpress.com/2018/04/05/vertical->

[farming-science-fiction-or-the-future-of-agriculture/screen-shot-2018-04-02-at-12-01-03/](https://auclimate.wordpress.com/2018/04/05/vertical-farming-science-fiction-or-the-future-of-agriculture/screen-shot-2018-04-02-at-12-01-03/))

### Drawbacks

However rosy Despommiers vision might sound, many obstacles need to be overcome before vertical farming takes off.

First and foremost, farming in three dimensions will be costly: The technology itself is expensive in many ways and will require lots of further research for market optimization. Additionally, the energy costs of a temperature controlled Vertical Greenhouse would be immense if the energy supply is not designed very carefully. Lastly, land within cities is scarce and expensive, the most realistic option seems to combine vertical farming with other uses like office spaces, [schools \(https://www.e-architect.co.uk/copenhagen/new-islands-brygge-school-in-copenhagen\)](https://www.e-architect.co.uk/copenhagen/new-islands-brygge-school-in-copenhagen) etc.

So far, soilless growing systems are best suited for specific crops, and time will tell, whether this technology can be adapted to staple foods like root vegetables, grains and legumes.

### Conclusion

Vertical farms are far from replacing traditional agriculture, but they bear a huge potential in moderating the stress inflicted on the natural world, improving sustainability of our food system and upgrading peoples diets. If cities are to continue growing, provide a healthy environment for its residents and reduce their environmental footprint to their real aerial extent, they have to start behaving like ecosystems and become self sufficient in energy, food and water. One step towards the true eco-city will be vertical farming. Does this still sound crazy?





The eco-city (<https://zearz.deviantart.com/art/Eco-city-395739541> (<https://zearz.deviantart.com/art/Eco-city-395739541>))

## Recent News

Paris to turn a third of its green space into urban farms: <https://edition.cnn.com/style/article/urban-farms-in-paris/index.html> (<https://edition.cnn.com/style/article/urban-farms-in-paris/index.html>)

Is the Future of Farming Vertical?: <http://www.brinknews.com/is-the-future-of-farming-vertical/> (<http://www.brinknews.com/is-the-future-of-farming-vertical/>)

## Projects in the Netherlands

The Hague (running project): <https://www.urbanfarmers.nl/en/>

Den Bos (running project): <http://www.plantlab.nl/>

Amsterdam (startup): <https://www.onefarm.io/>

## References

Tommyer, D. D. (2011). *The vertical farm : feeding the world in the 21st century*. New York: Picador.

Posted on **April 5, 2018** by **jan**

## *Related*

**Cities to the power! How climate governance can be revolutionized in the age of rapid urbangrowth** With 3 comments

**Tricky Trade-Offs in Sustainable Development Policy Making** With 4 comments

**On the psychology of climate change** With 9 comments

# 6 thoughts on “Vertical farming – science fiction or the future of agriculture?”

## 1. SOFIE SAYS:

**April 5, 2018 at 9:54 pm**

Hey Jan, I really liked your post! You mention that if the energy supply is not designed very carefully, the costs of a temperature controlled vertical greenhouse would be immense. I was wondering if you know anything about the difference in terms of energy input between traditional agriculture and these vertical farms (approximately)? And how this energy supply could be designed? It would be desirable to have self-sufficient vertical greenhouses in terms of energy but I wonder whether this is possible.

## 2. CHARLOTTEYBL SAYS:

**April 6, 2018 at 10:24 am**

Thanks for the interesting post! One way I could imagine these urban farms to work is by applying building integrated agriculture. If waste heat from buildings can be used to heat the greenhouse on the rooftop (with aquaponics or hydroponics), we not only solve the problem of high energy costs and additional energy requirements, but at the same time we could reduce waste heat and thereby mitigate the urban heat island effect. Eli Zabar’s Vinegar Factory Greenhouse on the Upper East Side in New York City, for example, has been growing vegetables for the restaurant located below since 1995 using waste heat from the store’s bakery (<http://www.elizabar.com/The-Vinegar-Factory.aspx>).

And on a side-note: The Dutch architecture firm MVRDV has proposed a model of so-called “Pig City” – an urban vertical pig farm. So we might not only see towers full of green in the future, but if meat consumption continues like that, we might also soon be hearing and smelling animal agriculture in cities – who knows....

Check it out here: <https://www.mvrdv.nl/projects/181-pig-city>

## 3. DALEXIEVA SAYS:

**April 6, 2018 at 12:08 pm**

Cool blogpost! You mentioned water-based vertical farming, but what about just using soil? Do you

12 of know if is it too heavy or difficult to have deep-rooted plants vertically? Because if this is also [http://www.mvrdv.nl/projects/181-pig-city](#)



I don't see why we couldn't also grow the main staples needed (legumes and grains that is). Also, we were talking about agro-forestry sometime ago. Do you think that combining agro-forestry as a main agricultural method with vertical farming in cities will be the solution to our messed up way of producing food?

4. **JAN SAYS:**

**April 6, 2018 at 12:16 pm**

Thanks Sofie!

It's hard to say at this point how exactly vertical farms will become energy self-sufficient. A large part of the solution will be clever, self-regulating architecture with lots of glass to harvest the heat and light of the sun (<http://terrypcarter.com/wp-content/uploads/2010/02/Eco-Laboratory-Diagram-Energy-Cycle-weber-thompson.jpg>). This will minimise necessary additional input which could then be generated with renewables. Despommier also speculates about advancements in these technologies (e.g. transparent solar panels). However, hard to say until someone actually tries it. Recently technological advancements like LEDs helped to make indoor/vertical farming profitable, for example in Japan (<https://edition.cnn.com/travel/article/kyoto-vertical-farm-spread/index.html>).

About the comparison with traditional agriculture: I have no idea. Conventional agriculture is energy intensive due to the production of fertilisers and pesticides, high emissions from transport and storage which would be cut out in a vertical farming scheme. Again, whether vertical farms will be less energy intensive depends on many factors, but I think it's possible!

5. **JAN SAYS:**

**April 6, 2018 at 12:23 pm**

Charly,

Agreed! I think its crucial to combine these different uses and try to "close the loops" as much as possible. This is what I meant with integrating into a cities metabolism, everything should be interconnected.

Wow, the dutch always seem to be two steps ahead. Check out this floating dairy farm in rotterdam, it is currently under construction! <https://floatingfarm.nl/>

6. **JAN SAYS:**

**April 6, 2018 at 1:26 pm**

Thank you Dia!

Soil based farming is also an option in some cases, however it is a lot heavier and therefore less feasible for very high buildings with multiple stories of cultivation. However, here is an example of a rooftop farm in Brooklyn, New York using soil as their growing medium <https://letitgrow.org/city-culture/brooklyn-grange-farm-future-urban-agriculture/>.

I don't know enough about agroforestry and vertical farming to tell, whether these two concepts could be combined. I know that a lot of the benefit of agroforestry is due to the wind protection of the main crop from the added trees/shrubs. This wouldn't be of much use in vertical farms because they're protected anyway. But there are also benefits from symbiotic relationships between plants (intercropping, on-farm biodiversity etc.) which I'm sure could be useful also in indoor farms. One concept along these lines is Aquaponic farming: This method incorporates fish into the soil-less system, using the closed-loop nutrient cycle from fish digestion to their advantage (fish live in water tanks closeby, poop in the water thereby fertilising it, this water is used to grow plants hydroponically which clean it and round we go again).

