A BASIC GUIDE TO

FOOD SECTOR TRANSFORMATION

MAY 2024

SWEDEN FOODTECH

STOCKHOLM SCHOOL OF ECONOMICS

HOUSE OF INNOVATION

Sweden Foodtech
Sweden Foodtech is a leading think tank on the future of food. We produce strategic insights, connect innovators with those in need of innovation and produce globally relevant meeting spots. Based in Stockholm, we have a global perspective on food transformation.

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A NOTE ON (AND TO) THE READERS

While the first readers of this guide have been the students of the Innovation course at the Stockholm School of Economics, Sweden, we hope they will be far from the last. The guide has not been written explicitly with students in mind, but it is rather aimed at everyone interested in food transformation, no matter where in the world they sit: business people, policymakers, chefs, scientists and the general public. While it has been written in the context of a western world food system, we do want to acknowledge that there are plenty of other food systems out there, so please bear with us if you find the text to be excluding of certain, to you obvious, solutions or analyses.

However, please see such shortcomings as an open invitation. There is no way we can build a singular food system to sort all things around food, rather we need to create a new web of connections and meanings, sourcing innovations from near and afar, irrespective of where we live. But the closer we can come to joint insights, the closer we will be to achieving the necessary solutions.

So, read this guide, and if you like it, recommend it to friends, family, schoolmates, business associates or whomever you think would benefit from a deeper understanding of food and its ongoing transformation. It is, after all, the greatest sector you can engage with, be it for the chance to do good, build great new companies or just enjoy life through the lens of food.

A NOTE ON COPYRIGHT

All diagrams used in this booklet are from Our World in Data, this great source of information, easily reached at https://ourworldindata.org and released under the Creative Commons license https://creativecommons.org/licenses/by/4.0/

The magic illustrations of food from then and now have been produced by the Australian science teacher and textbook author James Kennedy and can be found on his blog: jameskennedy-monash.wordpress.com. James has been kind enough to grant us permission to publish these illustrations and they indeed tell us more about selective breeding than what a thousand words could describe. A million thanks James!

And thanks also to NASA for providing wonderful maps. You could spend hours on end at their online Earth Observatory site, and you probably should!

PREFACE

Welcome to the bold new world of food! The purpose of the coming pages is to introduce you to one of the great developments that will to define your life; the transformation of the global food system. Food stands shoulder to shoulder with other tectonic shifts such as AI, climate change and the energy transition, but in spite of the massive size of our global food system the coming transformation is relatively little understood and discussed.

Sweden Foodtech and the Stockholm School of Economics (SSE), spearheaded by the House of Innovation, have for quite some time discussed this development. Together we see a new paradigm arising, shifting away from an almost singular production efficiency focus towards a rising focus on the effects that our food system has on the planet and the people that inhabit it. These effects – the negative externalities of food – are larger than the value of the sector itself and have grown too large to be ignored. At the same time, we are probably undervaluing food as a tool for achieving strategic goals such as increased productivity, social cohesion or building attractive and well-functioning urban habitats. All this while we have an urgent need to address current inefficiencies, such as waste.

This guide, written by Sweden Foodtech and used for educational purposes at SSE, is meant to provide you with a 30,000 foot view of food and some of the challenges that all of us face. We also want to point in some directions regarding the upcoming transformation, along with all the innovation that will ensue, as well as all the research that will be necessary to produce in order to make sure that this transformation is beneficial to businesses, the planet and the people. For this, the House of Innovation is building a unique academic capacity and ambition.

It is important to point out that we do not have the intention to go after our farmers or food producers – they do an amazing job every day to put food on our tables; a true miracle – rather

we want to discuss the system in which they operate. We hold the firm belief that food is fundamentally undervalued and that a next generation food system for our next generation(s) can provide health and enjoyment in a sustainable way for every man, woman and child on the planet. But that requires that science, society, businesses and civil society work together in order to gain insights and develop novel solutions, policy measures and technology. And it requires us to think way outside the current food value chain, its prevailing models and players.

As for every major transformative shift we will see bold innovations and new thinking lead the way. Some of these will glance towards the past, others will be entirely new. What they have in common, however, is the ambition to understand food in today's context, which is very different to the context in which much of our current food system was defined.

For a school dedicated to social sciences like economics, food transformation might intuitively feel like an odd area. Is not food something more for the technical institutions? They are of course crucial, but when we talk about large-scale sector transformation and potentially massive shifts of value on a global scale it is in fact schools such as SSE and institutions like House of Innovation that will take center stage in the research and understanding. Food might be the largest sector on the planet, but the characteristics of transformation are the same as for other sectors, such as telecom, media, or transportation. We believe that together with the current food sector players and the ones that stand to be added to the future food web, we can provide understandings, insights, co-creation and much new science in this intriguing field.

Stockholm, May 2024
Sweden Foodtech and the Jacob and Marcus Center for Innovative and Sustainable Business Development at the House of Innovation (Stockholm School of Economics)

THE SIZE OF THE OPPORTUNITY. AND THE PROBLEM.

What is the value of the global food system, you might wonder? Approximately $14 trillion[1]. The global GDP (gross domestic product), in comparison, is estimated at around $100 trillion[2]. But it does not stop there. The fundamental realization we must reach is that food costs as much or even more outside the plate than on it. While the exact costs differ from country to country, the Food and Agriculture Organization of the United Nations (FAO), has estimated that the global hidden costs for our food system totaled a whopping $12.7 trillion dollars in 2020[3]. Of that more than $9 trillion relates to negative health effects, or as the FAO writes; "health-related costs from dietary pattern-induced productivity losses". The rest comes in the form of negative environmental effects and is likely underestimated, according to the FAO.

The word "productivity" should make any economist or policymaker sit straight up. Our food system directly impacts the very fundament that our societies are built upon, and it does so in a negative way rather than in a positive one. Intuitively this seems wrong; isn't food supposed to fuel us with the energy we need in order to be productive members of society? And if it is not, should not this issue be one of national urgency?

The insight that FAO provides is hardly new to those who

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1 https://www.undp.org/blog/unlocking-sustainable-investments-food-systems

2 https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD

3 https://www.fao.org/3/cc7724en/online/state-of-food-and-agriculture-2023/hidden-costs-global-level.html

have been studying food, but as a society we have for way too long swept this knowledge under the rug. When it now emerges from its hiding it promises to have profound effects on the way we see and interact with food, making massive innovation unavoidable. How big of a transformation, we might ask? If we look at the global energy sector – a market that in size ($10 trillion) is almost as large as food – 60 percent of the $2.5 trillion in yearly investments now go toward renewables[4].

The big unknown is where in the innovation cycle food lies and if there are any factors that can speed up the pace of change. This makes for an interesting jockeying for position between nations and individual companies and the race has started. After all, when the world's largest sector finally transforms, enormous fortunes will be won and lost, power will shift, and the fate of nations will hang in the balance. Will today's market leaders emerge victorious on the other side of the transformation? We are not so sure. If history is a guide to trust, it will be the innovators that capture the podium, be they from the current crowd or newcomers. The losers will be the ones who ignore the forces behind the transformation and resist change. It does not feel out of scope to quote the great American advocate of liberty and independence, Thomas Paine: *"We have it in our power to begin the world over again. A situation, similar to the present, hath not happened since the days of Noah until now."*[5]

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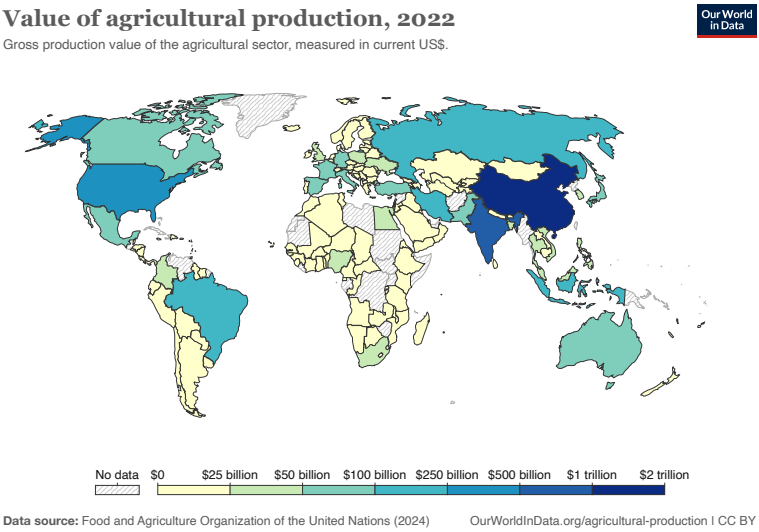
4 https://www.iea.org/reports/world-energy-investment-2022/overview-and-key-findings#

5 Thomas Paine, Common Sense (1776)



Source: "Gross production value of the agricultural sector", part of the following publication: Hannah Ritchie and Pablo Rosado (2023) – "Agricultural Production". Data adapted from Food and Agriculture Organization of the United Nations. Retrieved from https://ourworldindata.org/grapher/value-of-agricultural-production

Do remember; in the future every company is a food company. Over the next pages you will understand why and how you can be part of the value building and value re-distribution when the planet's largest system once again transforms.

WHAT ABOUT CURRENT INNOVATION IN FOOD?

This has the potential to be the shortest chapter ever written. While no sector wants to be singled out as the least innovative, let us crown food the dubious "winner".

It is not just the use of technology that lags behind other sectors (the US Department of Agriculture actually still asks farmers if they have a computer or access to the Internet[6], and now we are talking about one of the most advanced agricultural nations on the planet). The food sector generally spends around 0.2 percent of turnover on research and development[7]: that is nothing.

How come? And where will we go from here?

When a transformation starts, the natural reaction from the incumbents mimics the five stages of grief connected to death: denial, anger, bargaining, depression and acceptance. Eventually we move on. We have to.

In the corporate world such rapid transformations are common, and the key feature of Schumpeterian creative destruction. The one-time chemical film dominant Kodak is a classic example, as are the cell phone businesses of Nokia and Ericsson, the whaling industry, steam engines, and mechanical calculators. And it can happen fast. In 2008 Blockbuster CEO Jim Keyes famously stated that 'Neither RedBox nor Netflix are even on the radar screen in terms of competition'. In 2010 Blockbuster filed for bankruptcy, in part due to strong competition from Netflix.

It would seem that the harder they resist, the harder they fall.

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6 https://release.nass.usda.gov/reports/fmpc0823.pdf

7 https://swedenfoodarena.se/wp-content/uploads/Forskning-och-innovation-livsmedelssektorn.pdf

FOOD AND ECONOMICS

When thinking about the future of food it is absolutely vital to embrace the notion of so-called externalities, costs inflicted on a third party. The externalities coming from food are massive and absolutely impossible to ignore, especially if we want to stop climate change and preserve human health. Just think about it for a while. A system that produces about a third of all greenhouse gases[8] and has rendered 43 percent of all adults over 18 overweight[9] is problematic on a planetary scale.

It is impossible to go through all aspects of food and economics in one chapter, rather it is an underlying current in the continuation of this Guide. However, it is important to internalize that this cannot go on. Our food system has become system-threatening. That is also why transformation will happen. Irrespective of how strong an industry is, or how much political clout it has, it is not strong enough to keep going in the face of reckoning, even though that reckoning will take time. Just look at the energy transformation – even though the fossil fuel sector has been extremely capable in delaying change, what chances do you give it a few decades down the road?

Back to the notion of externalities. If something is sold at a fraction of its true cost, then we have killed the price signal (true costs is a term anybody with an interest in food should embrace). If we do not have a correct price signal, we do not have a functioning market economy. If we believe that a correctly functioning market economy is part of the solution to the world's ails, then we better get pricing right!

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8 https://www.un.org/en/climatechange/science/climate-issues/food

9 https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

NATURAL CAPITAL

We cannot talk about money and food unless we talk about natural capital. Natural capital is the value delivered to us for free by nature, the so-called ecosystem services. These are things such as crop pollination, oxygen, clean water, flood protection and carbon sequestration, and they underpin all life on Earth. Nature graciously delivering these services for free has for sure not led to us to appreciate their full value.

While the notion of natural capital might feel completely obvious these days, it is a fairly recent addition to the political discourse. It was only at the G7 meeting in Canada in 2018 that the assembled Heads of State recognized that GDP alone is "insufficient for measuring success". And ahead of the consecutive gathering of G7 in France in 2019 the OECD[10] prepared a report that jumped up and hit us in the face. Natural capital is being lost at a pace of $10–30 trillion per year (remember, global GDP is about $100 trillion per year). Food is a major culprit, if not the one.

And we are not just losing natural capital. The United Nations estimate that a staggering $44 trillion of yearly economic output is moderately or highly reliant on natural capital[11]. If we lose natural capital, that is not the only thing we lose.

Seeing nature as free even has an economic term associated with it: the Tragedy of the Commons. A common is a resource that provides users with benefits, but no one can claim them, which means that individuals consume a resource at the

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10 https://www.oecd.org/environment/resources/biodiversity/Executive-Summary-and-Synthesis-Biodiversity-Finance-and-the-Economic-and-Business-Case-for-Action.pdf

11 https://www.unccd.int/sites/default/files/2022-04/GLO2_SDM_low-res_0.pdf

expense of society. Or the planet. Fishing in the high seas, the parts of the oceans that do not "belong" to a specific country, spring to mind as a prime example.

Understanding the concept of wealth is key to understanding the future of food. GDP, the indicator we normally use to understand how an economy is doing, measures economic activity, irrespective of how it has occurred and irrespective of if it has added to or subtracted from our wealth. Selling food to people that later gives them diabetes thus contributes to the GDP both in the form of food sales and the cost for diabetes treatment. But it reduces our wealth.

There is a growing framework for how to calculate natural capital and how to account for true wealth, or inclusive wealth, as the United Nations call it. Basically, you can say that true wealth is measured by how much human capital we can create (for instance through education) plus how much we can manufacture (toys, clothes, cars, etc.), minus how much that costs us in natural capital.

If you want to go down the rabbit hole of measuring true wealth, genuine savings or inclusive wealth, or just want to get a reality check on what humanity really has achieved in economic terms, Our World in Data provides a really good starting point[12]. The United Nations Environment Program also provides a biennial report on the topic; the Inclusive Wealth Report (IWR)[13].

It should be said that it is notoriously hard to define and measure natural capital, but there is no hiding the immense numbers and ravaging effects human activities have on the only asset we can rely on: Mother Earth.

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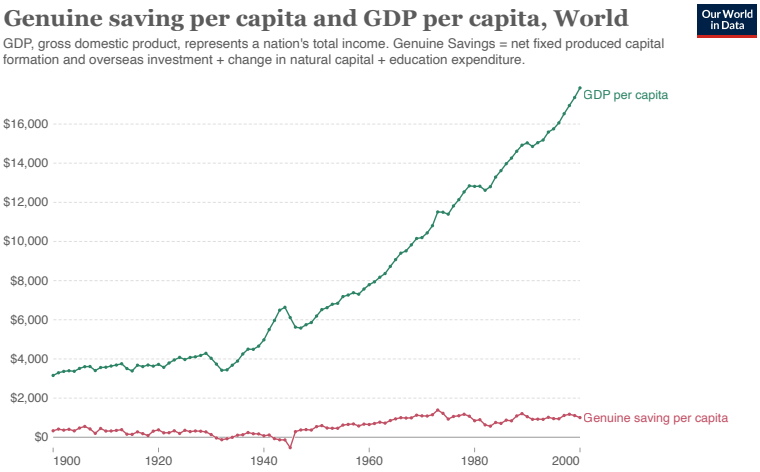
12 https://ourworldindata.org/the-missing-economic-measure-wealth

13 https://wedocs.unep.org/bitstream/handle/20.500.11822/43131/inclusive_wealth_report_2023.pdf

It is perfectly safe to say that future entrepreneurs that find methods and technologies that help us re-build our savings account with Mother Earth Bank stand to become very successful. Food will be one of those areas to work with, if not the key one. A great contender is making degraded land fertile again. Why do we need to terraform Mars? We could instead start on a great renovation of planet Earth.



Source: Sandra Tzvetkova and Cameron Hepburn (2018) – "The missing economic measure: wealth" Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/the-missing-economic-measure-wealth

FOOD – THE ONLY SUSTAINABLE CONSUMPTION GOOD

Let us not brand food as a loser, however. Food might in fact be one of the few things that we can consume in the future. Reflect on the following.

We will all need to adjust our overall consumption patterns towards goods and experiences that have a lower impact on the climate, or even better that are regenerative. Sustainably produced food represents just that; if produced sustainably, fueled by an unlimited amount of energy provided by the Sun, it grows back and back again in an eternal cycle. If you want to lead a sustainable life, food will be one of your core activities and much speaks for us putting far more effort (and share of our wallets) into food. Basic market economics will be the method.

If the price of a good or a service reflects its true costs, for instance on the environment, much of what we today consume will become far more expensive, resulting in new consumption patterns. Something that grows back in an endless cycle would therefore seem to be a good place to strategically focus our consumption on. Chefs have become the new superheroes. That trend only seems to have begun.

True prices might not only move more of our consumption towards food, but they might also shift the consumption within food. A study from 2015[14] stated that without subsidies to the meat and dairy industries a US Big Mac would cost $13 instead of $5, and a pound of hamburger would be $30.

If we are to agree that we live in a world characterized by

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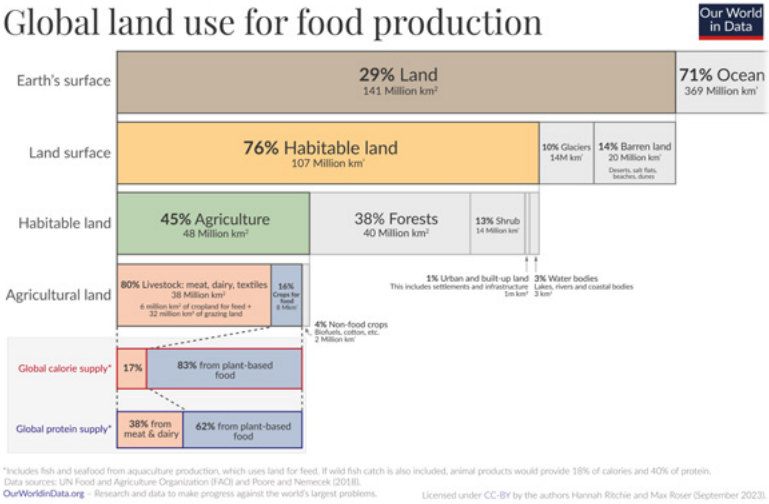
14 https://scet.berkeley.edu/wp-content/uploads/CopyofFINALSavingThePlanetSustainableMeatAlternatives.pdf

faulty pricing, we need to reflect on what would happen if such market failures are corrected. That type of analysis is also a good guide for long term strategic thinking. While we of course cannot define the exact moment in time when our specific product or service will live in a world of true pricing – if ever – it is a good start to see if we produce true value or if we only live on leased time.

A proper insight into the world we live in is therefore a good starting point.

WHAT IT LOOKS LIKE WHERE WE LIVE



Earth is a water world. 71 percent of the surface of Earth consists of oceans, the other 29 percent is land. Of that land 76 percent is habitable (the rest is barren or glaciers). Of that habitable land agriculture takes 45 percent, forests 38 percent, shrub 13 percent. Water bodies such as fresh water lakes and rivers represent three percent and built up areas only one percent. Of the agricultural land 80 percent is used for livestock (meat and dairy) and 16 percent for crops[15].

Consider that we only live *on* one percent of 76 percent of 29 percent of Earth, which translates to 0.2 percent of Earth's surface. But we live *off* all the rest, mostly from land-based plants and animals. Of all the calories humans eat we get 83 percent from plant-based food and 17 percent from meat and

15 All numbers from Our World in Data: Global land use for food production

dairy. The relationship between land-use and calories produced differs, to say the least.

Only two percent of our calories and 15 percent of our protein today come from our oceans, perhaps mostly because there is so little left in them. That stands to change, however, and ocean farming will be one of the more central parts of the transformation of food, hopefully also contributing to more knowledge of the hidden world of our oceans and humanity's relationship with them.

This means that what we associate with nature is in reality a production site for food. Nature has been lost. Think about that the next time you marvel at a field of wheat glowing in a golden sunset – it is nothing other than a giant monoculture, devoid of most of the life we associate with nature. But forests? Nah, mostly tree plantations.

Let us be absolutely clear; there is nothing natural about farming. For as long as humans have engaged in food production rather than picking what nature had to offer, we have been manipulating nature through enlarging and intensifying our food production area and by selectively breeding plants and animals. It is a dual equation, however, since it is also our 12,000-year farming history that has made us into what we are. By producing food more efficiently we could have more children. By moving our diets to grain, that are suitable for drying and storing in larger quantities, we could populate areas that are less bountiful during parts of the year. By deploying innovative thinking, we have been able to massively increase food production over the years. The biggest step we took in the 1960's and 70's through the Green Revolution that gave us the large scale food production system that we have today – and its ensuing problems.

THE MIRACLE OF FOOD – AND ITS CURSE

It is important that we see the food system we have today, and the Green Revolution we just mentioned, in the historic context in which it was created, because no system exists in a vacuum. In the 1960's we were three billion people on the planet, but the numbers grew rapidly, and many went to bed hungry. In order to solve the massive global problem of feeding humanity we came together around the Green Revolution.

The Green Revolution used new technologies such as high-yielding varieties of cereals, chemical fertilizers, pesticides and irrigation. Mechanization and finance were also put to use in order to rapidly scale up the production of cheap and safe calories. In short, we industrialized food production really, really massively. And we succeeded! Global levels of undernourishment fell fast and the father of the Green Revolution, the agricultural scientist Norman Borlaug, received a well-deserved Nobel peace prize in 1970 for his efforts – after all, he is credited with saving one billion people from starvation.

Today, with eight billion people on Earth, we produce food for at least ten billion[16] and could easily produce for more, though we make a mockery out of distributing food evenly. But the population curve is leveling out and about ten billion might be where we top out. While it seems that we have solved the issue of how to feed the planet (though there is talk about a need to produce vastly more food than today due to increased demand for certain diets), it is important to understand that our food system – our way of producing and consuming food – has

16 https://www.unep.org/news-and-stories/story/how-feed-10-billion-people

proven to be absolutely detrimental to our environment and human health, problems fully on par with the one that we once solved. It is a classic example of unintended consequences, and the main reason why we need a new food paradigm.

What did we then do during the Green Revolution? We put ourselves on a grain and meat diet. During the past 60 years our grain production quadrupled[17] while the population "only" doubled. We eat more grains, not the least by feeding it to livestock.

The Rockefeller Foundation, once one of the key players in the Green Revolution, has calculated that every dollar that goes towards food in the US also brings along one dollar in environmental harm and one dollar in health costs[18]. Food, in our time, is thus three times as expensive as we think. We have a new context that requires new solutions, and we need a new revolution, but from where will it come? If our need today is less to produce more food, but rather to produce more health for man and environment, then we need to completely rethink food.

The world is changing constantly and it is by no means certain that the world of food will look the same when today's youth are adults. After all, many of today's food giants were created thanks to the Green Revolution and a similar shift can be foreseen this time around. The Green Revolution was a miracle. Now, half a century later, we need another one.

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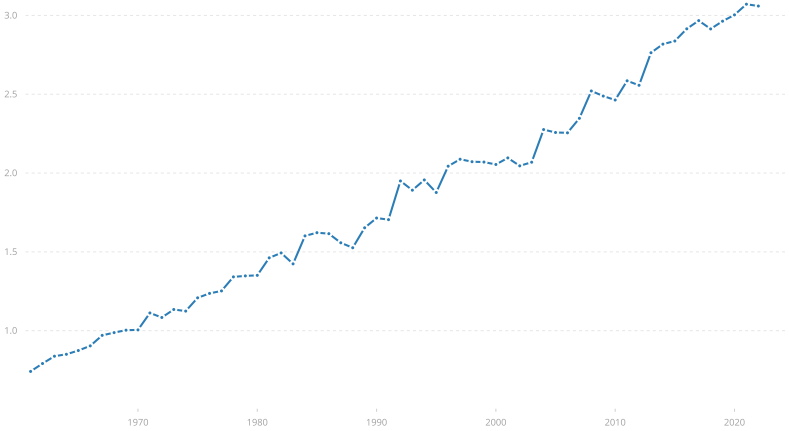
17 https://data.worldbank.org/indicator/AG.PRD.CREL.MT

18 https://www.rockefellerfoundation.org/report/true-cost-of-food-measuring-what-matters-to-transform-the-u-s-food-system/

Global cereal production (Billion metric tons)



Source: The World Bank, Creative Commons Attribution 4.0 (CC-BY 4.0)

FOOD AND POLITICS

Food is, however, not so much about economics as it is about policy. The current players in the food value chain are not evil as much as they are rational. If you make money by selling junk food with the help of massive marketing, people want it (because it contains stuff that enhances your cravings) and it is not forbidden – what is stopping you? If you get massive subsidies for producing specific types of crops or livestock, you do that. If the buyers want standardized wheat instead of heritage grains, farmers grow standardized wheat. After all, they need to provide for their families.

The political framework around food is of course tightly connected to economics and it is a rather complex issue, but it has become very visible. A United Nations report from 2021[19] stated that global subsidies to farmers amounted to $540 billion and, if the current trends continued, they could rise to $1.8 trillion in 2030. Over two-thirds of this support was considered price-distorting and harmful to the environment. Unhealthy products (like sugar) and commodities that emit much of the greenhouse gases from food production (like beef, milk and rice) received the most support. Subsidies amount to 15 percent of the combined food production value.

The UN is not an outlier. According to the 2023 World Bank report "Detox Development: Repurposing Environmentally Harmful Subsidies"[20] we likely have over $1trillion in direct subsidies to agriculture and fishing globally, with 60 percent of that being detrimental.

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19 https://www.fao.org/3/CB6683EN/CB6683EN.pdf

20 https://openknowledge.worldbank.org/server/api/core/bitstreams/61d04aca-1b95-4c06-8199-3c4a423cb7fe/content

In addition, the negative environmental externalities could top $3 trillion.

It is not "the others" that are misbehaving. Here in Europe over 80 percent of the Common Agricultural Policy favors animal-based foods[21], i.e. the foods that represent the majority of greenhouse gas emissions. It is hard for new alternatives to compete in such a rigged game. The flip side is that we have ample resources to work with in re-defining our food systems.

On top of these numbers, we have the indirect subsidies in the form of healthcare, briefly mentioned above. In food system terms it is interesting to note that foods with low nutritional quality are mostly treated in the same way as high quality, nutritious food, at least from a regulation and VAT-perspective. That is changing, however, and many countries are nowadays embracing various sugar taxes, simply because they work. This trend is likely to both grow and embrace other dimensions of the types of "food" that we really need to start calling something else.

That said, the road to the future is not smoothly paved. Food has become an intrinsic part of the ongoing political culture wars where the radical right has done its utmost to align with the worries of farmers[22]. And farmers, though there are relatively few of them these days, have an immense political clout, not the least witnessed in the farmer protests in the EU in the early months of 2024.

Does this mean that today's policies will stay? Absolutely not, but they cannot move unless we create a compelling vision of where we want to go with food and where key players

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21 https://www.nature.com/articles/s43016-024-00949-4.epdf

22 https://www.ojp.gov/ncjrs/virtual-library/abstracts/rural-radical-right-politics-fear-and-hatred-amidst-farm-crisis

such as farmers are provided with better alternatives for their livelihoods than the ones stemming from today's system. Innovations that improve the situation for farmers at the same time as saving the environment will probably stand to get a lot of political support.

As we saw, there is a lot of money in subsidies. We must note that while subsidies might seem to distort the market, the market is not always right. If subsidies can correct market failures such as the lack of accounting for health and sustainability, it is perfectly logic to use them.

The current lack of political leadership in food transformation is probably not evil either. Keeping the status quo is not something that people necessarily want – they just do not see the alternative.

We must remember that before we see alternatives, policy will not change, and the big shifts will not arrive. And before policy starts to move there most often needs to be a big crisis. We have already spoken about environment and health. A third crisis has also arrived; geopolitics, and that might be the most potent for political shifts.

GEOPOLITICS

The Russian full-scale invasion of Ukraine in 2022 has led the world to see the end of the era of globalization. We cannot anymore rely on global flows of food, and Russia provides the world with both immense amounts of grain and the fertilizer needed to grow them. That readily converts to massive risk for countries relying on either. Russia uses food as much as a strategic weapon as energy, and weaning itself of that influence (or helping strategic allies to) will be a critical task for the West.

The vast interconnectedness of our global food system has brought efficiencies of scale according to classical effects of specialization, known to and analyzed by economists for ages. In an ideal world where the natural preconditions vary, smart specialization will take precedence. But, as we all know, we do not live in an ideal world. Apparently, food is not just about specialization and global markets, it is also about national security and basic sustenance even in wealthy nations. The events and rising insights of the early 2020s prove that we need to think about food in more dimensions than just large-scale industrial efficiencies. On a systemic level the word "resilience" begs for attention.

Is resilience maybe even the Great Lever in the world of food?

If you do not have food, price is not the issue – availability is everything. That is why Singapore has embraced their 30 by 30 strategy[23] with the ambition to produce 30 percent of their needed nutrition within their own boarders by 2030. Singapore is a city state, so no large swaths of lands to drive tractors over. That is also why seemingly every month a new "largest-in-the-world" indoor growing facility is opened somewhere in the Gulf

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23 https://www.ourfoodfuture.gov.sg/30by30/

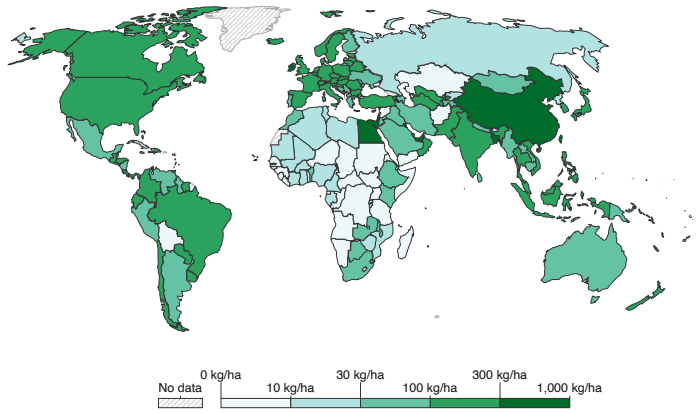
states. If you cannot trust global markets you need to do what you can to secure your access to food, especially if you cannot produce much on the land you have.

In terms of dynamics, this makes for interesting developments. Suddenly there is a massive inflow of investments, novel thinking and policy-development into new ways to produce nutrition, based on new production factors (such as money and energy). That effort results in more than food, namely new knowledge, technology, business models and strategic insights. Those learnings will go on global export and contribute to new ways of thinking about food. Food is no longer about national primary production – it is about understanding and implementing the best learnings from around the planet in order to achieve all that we can achieve through food; on the plate or beyond. Including resilience.

Additionally, if we are to achieve resilience, shouldn't we build it into the fabric of everyday life? Can we produce all the nutrition we need in the urban areas where we live based on the resources we have there even before we run into trouble? Can we re-organize cooking to make sure that everyone can have tasty, sustainable and nutritious food? Can we use our precious natural resources in a smarter way than today?

Fertilizer use per hectare of cropland, 2021

Application of all fertilizer products (including nitrogenous, potash, and phosphate fertilizers), measured in kilograms of total nutrient per hectare of cropland.



Data source: Food and Agriculture Organization of the United Nations (2023)

OurWorldInData.org/fertilizers | CC BY

Source: "Fertilizer use per hectare of cropland", part of the following publication: Hannah Ritchie and Pablo Rosado (2023) – "Agricultural Production". Data adapted from Food and Agriculture Organization of the United Nations. Retrieved from https://ourworldindata.org/grapher/fertilizer-use-per-hectare-of-cropland

ARE WE TALKING ABOUT TRANSFORMATION OR INNOVATION?

Both, actually. While the major happening in food will be about transformation, innovation will lead the way to new thinking and thus fuel the transformation. But what is the difference between the two?

Transformation means to move from one state to another and involves mental images, common understanding, policy, society, international collaboration, etc. In economic and strategic terms, we could broadly translate transformation with “macro” or “direction”. In the specific case of food transformation, we will be guided by the underlying issues (as described above) and the yet-unrealized opportunities surrounding food (we will get back to those later).

Innovation, on the other hand, provides solutions to specific problems or opportunities. Innovation is often associated with new products but can also be about new business models or processes, including how you reach your customers. If transformation is “macro”, then innovation is “micro”.

When a sector transforms there is a lot of both new value creation, value re-distribution and old value destruction. This means that there exists a natural tension between the incumbents (at least those who are not as fast-moving) and the innovators. In the world of food, the stakes are enormous; the fate of entire nations, societies and even cultural primacy are up in the air. That is how central food is to humanity.

That a transformation of our global food systems needs to happen is, we would say, undisputed from a scientific perspective; without solving food we cannot solve our climate challenge

and without mitigating the ongoing climate challenge, food production will be severely affected. And then we have health. And geopolitics.

However, the sheer size of the food industry poses a problem since the bigger a sector is, the harder it is to move, and the more entrenched the incumbents are. Food is the biggest sector there is and it is thus hardwired into every society and culture. Changing the course of a tanker takes time, but once the shift has started it is very hard to stop. We would argue that the shift has started and now the only question is how fast it will go, which brings us to the question of speed of innovation.

In the world of food, we have so far seen little transformation compared to what lies in the cards, but we have seen plenty of innovation. In our daily lives new delivery apps and meatless hamburgers have probably grabbed most of the attention. Perhaps the newborn players will be gone tomorrow, perhaps they will become the new giants of the future. But if one disappears, we can be sure that there will be ten new ones standing in line. In all big transformations there will be a jockeying for positions that will be vastly valuable once the transformation is under way for real. To be blunt, it all boils down to where you think we are in the big shift – timing is everything.

Your view on the transformation timing gives the foundation for your attitude towards innovation. If you have an ongoing operation and think nothing much will change in the short term you will be better off focusing on streamlining your operations. If you, however, think that a shift is coming soon you need to focus on innovation. If you're good at innovation and the shift is coming you have much to gain. If you have mistimed, you might lose your innovation investments.

Analogously, if you think that the shift will not come and therefore down-prioritize innovation you will likely be a loser if the shift does come. Innovation is not just something you add

overnight, it is hard and arduous work and the best innovators have their entire organizations set up around innovation; owners, boards, the C-suite and the entire staff will be focused on cranking out novelties, based on the realization that innovators over time provide a superior result compared to laggards – there are many studies stating that the rate of innovation is a predictor of future profitability[24]. At least in companies that know how to commercialize innovation[25].

Please note that it is not about one or the other. You obviously need to be good at ongoing operations if you want to have a business in the future. But you also need to be good at innovation. Balancing these needs is the artistry that separates the stars from the mediocre, and what in management is called "ambidexterity"[26].

Transformation is the by far the greatest force of the two and one that individual innovators have a hard time to control. To take an example: we most likely need to drastically reduce our intake of red meat. The most efficient way of achieving that would be to slap a heavy tax on meat, instantly moving consumption to other alternatives. Replacing meat with alternative products, such as vegan meat-analogues (products that look and behave similarly to the one you want to replace, like vegan burger patties) will inevitably take far longer. But the day that we see a meat tax, innovation will literally explode amongst the replacement alternatives.

Innovation informs the policymakers and strategists controlling much of the transformation. Unless you see and

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24 https://academic.oup.com/rfs/article-abstract/31/7/2553/4104436

25 https://hbr.org/2003/09/innovating-for-cash

26 Tushman, Michael L., and Charles A. O'Reilly III. "Ambidextrous organizations: Managing evolutionary and revolutionary change." California management review 38.4 (1996): 8–29.

understand what the alternatives could look like, it is very hard to think in new directions. Thus, innovation and transformation work in tandem and those who see the value in big shifts happening do best to pay proper attention to science and novelties, and engage with them in order to internalize novel thinking.

Let us furthermore reflect upon the fact that food affects so much more than just the food value chain. If food costs as much in negative health effects as we pay for food, does that mean that food is something for healthcare to engage with? And if our food consumption suddenly is defined by the healthcare system rather than the current food value chain, what will happen then? This increasing grey-zone between food and other sectors will invite innovations and value transfer between industries. Or, as Albert Einstein so famously put it: “We cannot solve our problems with the same thinking we used when we created them.”

INSIGHTS, IMMUNE SYSTEMS AND THE FOOD VALUE CHAIN

Transformations and innovations are preceded by insights. One of the most famous insights we have arrived at throughout history is the realization that the Earth is neither flat nor the center of the universe. What those early-day thinkers (now regarded as pillars of science) then met was the immune response of a challenged system, where power and privileges no longer were certain. We talk today of corporate immune systems or even societal immune systems that react to unwelcome insights that challenge the status quo and try their very best to eliminate the threats. It is not much different from how your body reacts to a virus.

It is indeed very hard to see outside the system in which you exist. Perhaps you lived within it your entire life. Perhaps your entire family has as well, and all preceding generations for as long as you can imagine. Furthermore, even though the system might have changed compared to a generation ago it might have done so slowly enough to virtually erase the sensation of things moving. Take a look in a cookbook of your parents or grandparents: would you really want to cook and eat what is those books? Our food habits have definitely evolved quite a bit over the years. Such seemingly stable systems are, however, as vulnerable to transformation and new thinking as any system out there. Perhaps even more so because they are not used to change.

One of the more fundamental insights you can have when it comes to food is that the current concept of a value chain "from farm to fork" is essentially flawed thinking. As we have discussed, it simply excludes two core factors; the impact of food on nature and the impact of food on man. If we can exclude

those two factors the current food system seems very efficient. But of course we cannot. And of course it isn't.

But what would happen if we saw these two factors as integral parts of the food value chain? Would we start thinking about food in new ways? Sometimes innovation is about putting on new glasses and seeing the world in new ways. That enables you to start to rethink the value chain and how value-creation is organized.

FOOD, WORDS AND MENTAL IMAGES

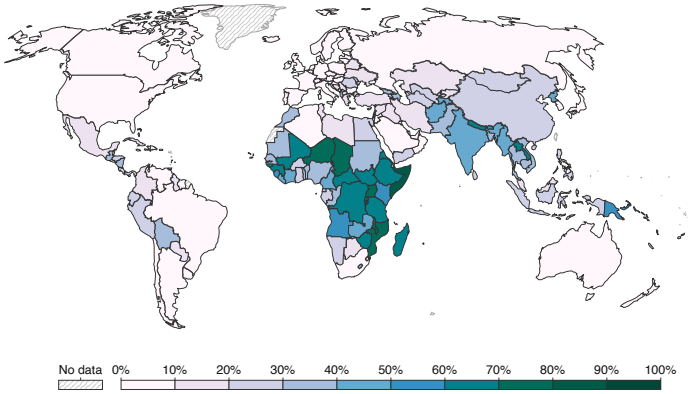
The origin of food, to most, is a mystery, vaguely defined as "farmers" or "the supermarket". Most of us know what a supermarket is, but increasingly few have any idea of what a farmer does. This is because precious few hold that occupation these days and the chances that you are related to one are getting slimmer and slimmer. In Sweden the share of agriculture in total employment has gone from 70 percent in 1850 to a notch above 2 percent in 2010[27]. Without a clear relationship with food production it might be easy to fall for various images surrounding food, fueled by clever marketing.

27 https://ourworldindata.org/grapher/share-of-agriculture-in-total-employment?country=~SWE

Share of the labor force employed in agriculture, 2019

Our World in Data

Agriculture includes the cultivation of crops and livestock production, as well as forestry, hunting, and fishing. Employment includes anyone engaged in any activity to produce goods or services for pay or profit.



Data source: Our World in Data based on International Labor Organization (via the World Bank) and historical sources
OurWorldInData.org/employment-in-agriculture | CC BY

Source: Hannah Ritchie (2022) – "Employment in agriculture: data sources and definitions" Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/agri-employment-sources

WHO DECIDES WHAT YOU EAT?

Answer: not you, at least not to the extent you think. The notion of a free will in food is nothing but an illusion. We are all caught up in a complex web of culture, family habits, the place where you work, your cooking skills, your family situation, the time of the year, what your local supermarket carries (if you have one close), clever marketeers, your economy and other people's ideas of what is for dinner, to mention but a few factors impacting what you eat.

Your local food shop is an excellent example of how your food decisions can be impacted. The next time around try and understand why certain products are placed where they are, what the guided path through the store leads you too, how brands "ping" you through packaging design, if it smells of newly baked bread, if music is being played (and what they in such case play) etc. A store is a highly designed experience that really smart scientists have been involved in creating.

Yet, this pales compared to the era of digital platforms and algorithms. Probably most people these days understand the fact that our digital environments manipulate us, but most people probably have no idea of how powerful these algorithms already are. With a continuous feed of more personal data, they only stand to get more powerful and can really only be reigned-in by legislation.

But where are we heading in terms of digital? A study by the consultancy company McKinsey[28] found that leading countries in Europe (UK, France, Netherlands and Sweden) could see as much as an 18–30 percent market share for food e-commerce

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28 https://www.mckinsey.com/industries/retail/our-insights/the-next-s-curve-of-growth-online-grocery-to-2030#

in 2030. If food goes online – who will provide the shopping experience that consumers prefer? How will the e-tailers use algorithms to nudge us to make certain choices? What will be behind the nudging – our personal needs or the margins on the sold product? Or will other factors influence, such as your personal data and your health goals? And if it is the latter, who will you trust with that data?

This brings a somewhat uncomfortable question to the agenda for parts of the current value chain. For years the retail giants have sold you food that arguably is better for their margins than for your health. In an era of measuring yourself, will you trust them with your personal data? And in an era of personal data – is the retailers much vaunted historic purchasing data of as much use as is the case today?

Those are some profound questions. But, in our era of digital platforms, let us agree on one thing – food decisions will move online and that means that a lot of value will climb up into the digital layers. In the travel industry, so-called OTAs (Online Travel Aggregators) such as Booking.com or Expedia typically charge 15–30 percent in commission. While such margins do not exist in food, the new and potentially changing roles between the various parts of the value chain will mean that value and power will move much in the same way.

In the world of telecom we have the value-added companies, providing all sorts of fancy services, and then we have the pure bit-pipes, those who just shovel around ones and zeroes. There is of course a difference between information and atoms when it comes to business models, but how great is that difference? Are we facing a shift where our retailers and e-tailers stand to become the "food pipes" that only deliver what others have helped the customers decide upon?

And who does influence people's decisions these days? Less ads and more influencers, is the answer. The next wave are not the

celebrity influencers but the digital creators. Will they exist at all or will they themselves be digitally created, perhaps completely targeted towards you and your individual TikTok feed? Virtual influencers are not something new, what is new is the powerful tools that lets you create them in vast numbers at a very low cost.

What we have been talking about here are various aspects of the so-called "food environment", the physical, digital, economic, political and socio-cultural contexts in which people engage with the food system. And there are more aspects to it than what we have discussed above.

Who decides on the food environment is not a given, however. If, say, a city, who often owns or in other ways controls a lot of the outdoor advertising space, would say no to certain types of advertising on the pragmatic basis that encouraging specific types of behavior will cost the city or society more than they can rake in through ad revenues, that could dramatically change the food environment. In the UK, both Brighton[29] and Sheffield[30] have made such a move at the end of 2023 and beginning of 2024, respectively.

The University of Connecticut Rudd Center for Food Policy and Health did a study in 2017[31] stating that of the (then) close to $14 billion in food ads in the USA more than 80 percent went towards fast food, sugar-sweetened beverages, unhealthy snacks and candy. A lot of the advertising was targeted to children, teens and communities of color. Why do you target children? To get them hooked on your products, hopefully for a long time.

No country or public health agency can stand against such

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29 https://www.brightonandhovenews.org/2023/12/10/junk-food-ads-to-be-banned-from-bus-shelters/

30 https://www.bbc.com/news/uk-england-south-yorkshire-68605935

31 https://uconnruddcenter.org/research/food-marketing/

a tidal way of advertising money. But they can ban the use of public space for such advertising and otherwise engage with the food environment. Things can thus change at the stroke of a pen and for those interested in the dynamics of transformation we would recommend keeping an eye on the development of our food environments and how policymakers relate to them. After all, you do not see as much advertising for tobacco as you used to.

SOFTWARE EATS THE WORLD

In 2011, Marc Andreessen, co-founder of venture capital firm Andreessen Horowitz and of the 90's Internet behemoth Netscape, wrote a now famous essay entitled "Software Is Eating The World". In it, he described how emerging companies built on software were disrupting industries and replacing dominant household names. Today virtually every company is a software company. Those that did not manage the transition to digital make up a steadily growing graveyard and they provide clear lectures on what happens if you fail to embrace innovation and new thinking in order to make yourself relevant in a re-modelled value chain.

The next generation computers are built with the help of today's best knowledge and today's best computers. Tomorrow's computers and knowledge will be able to construct even better computers, etc. In perpetuum. "Exponential development" is a good phrase to get accustomed to.

And it is not just the computers – it is the speed of change that these steadily more capable machines give rise to, making life even more complicated for company owners, boards and leaders. We see it as completely out of the question for anyone with an ambition in the future of food to downplay the digital revolution that has transformed every other sector it has touched. Food is, however, one of the by far least digitized sectors and one of the major threats to incumbents is a fundamental lack of understanding of digital. And this was before AI came along…

The increasing amount of data we have about food, from where it comes, how it was grown, what it contains, how it was transported, what you should eat according to your own personal data etc. will shape the future of food, not the least

because the access to data enables completely new innovations and business models. AI will fuel this revolution due to its capabilities to make sense of vast amounts of data points, previously all but impossible to connect and analyze.

Without data it is impossible to think about food in the future. Unless you have hard data – are you even sure it is food (food forgery is achieving new heights on a daily basis)? We thus move from a food system where we believe in certain things to one where we know. In the future you will not be able to just state that you believe something about food and get away with it.

A case in point regarding the use of tech in the world of food is the US company Inari that uses a combination of genomics, AI and gene editing technologies such as CRISPR to radically improve plants. They have put out a whitepaper on what they hope to achieve[32] and it is radical; increase yields with 10–20 percent, reduce the amount of nitrogen needed with 40 percent and reduce water usage with 40 percent. If they will achieve their stated goals is hard to speculate on, but it seems entirely reasonable.

Facing such potential, can lawmakers resist cutting red tape, for instance in the form of restrictions on the use of gene editing and gene modification, so-called GMO? And do these types of technologies mean that we are headed in the direction of more biodiversity because we can understand more of nature through technology, or will sudden efficiency gains for the staple crops Inari will start with: corn, soybeans and wheat, lock in their chokehold on our food production? We will get back to biodiversity later on.

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32 https://inari.com/wp-content/uploads/2023/01/INARI-Multiplex-Gene-Editing-Whitepaper_1122.pdf

Furthermore, with our increasing computational powers we have a new tool to mess with our brains. When the digital and physical realms increasingly mix through new XR headsets it is possible to create entirely new food experiences. In the future everyone can get the best table at the best restaurants by digitally mixing realities. And if you thought that taste sits on the tongue, think again; it sits in the brain. This fact is not entirely new – restaurants have since long known that food tastes differently depending on the color of the plate, or the music being played. What is new is the extent to which we can use digital tools to manipulate our food experiences. This has for instance meant that the amazing Danish restaurant Alchemist nowadays has digital developers amongst their kitchen staff. It will not stop at high-end restaurants; if you can have the experience of lobster tail and truffle risotto while eating tofu and porridge, why not go for it? Perhaps digital will become a method to democratize food experiences.

It seems, after all, that software is not only eating the world – but that we will be the ones eating software.

ROBOTS AND OTHER MACHINES

When you have data and algorithms you can use those to train or steer robots. Get used to seeing many of those in the kitchens. Robots are amazing workers; quick, accurate, flexible and do not mind getting burned at the frying station. They are also, and perhaps most importantly, cheap. Food that can be easily prepared by robots – including 3D-printers – will thus be cheaper to cook, which, through price-dynamics, will lead us to consume what robots are good at cooking.

It might not be so bad – robots can after all prepare individually adapted meals with the same ease as they prepare a standardized one, which means that we can get the right amounts of food with the right nutrition for each individual eater. You do not anymore need to be a good boy and struggle to eat everything on the plate – it will be exactly what you need.

In order to make the best use of robots you need a surrounding infrastructure in which you can effectively use them. Start looking for them in professional kitchens in the urban areas where they will make for good investments for those professionals who increasingly cook our meals.

AI AND FOOD

Any talk about software and robots would be incomplete without a mentioning of AI. This topic is of such a vast nature that it is impossible to wrap your head around it but let us consider the fact that we suddenly have the power to analyze and understand the nature we have around us to an extent never before imaginable. Or to figure out how individuals react to the food they eat. Or to manipulate plants and animals by combining AI with gene-editing technologies such as Crispr. Or to figure out what customers want, optimize your logistics, build more efficient marketing campaigns or God knows what. The arrival of AI is a game-changer for every sector, but there is a slight twist when it comes to food: if AI reduces the need for mundane competencies such as economics, we can always go back to the land and sustain ourselves through the methods of our ancestors.

We said before that in the future every company is a food company, well, they will also be AI companies and the intersection of the two promises a lot of interesting developments.

WHO COOKS OUR FOOD?

Increasingly not we, the people. The food sector is usually divided into "food at home" (FAH) and "food away from home" (FAFH) and the trend only goes in one direction. In 2010, US food expenditures on FAFH surpassed FAH for the first time[33] and between 1978 and 2012, FAFH's share of energy intake doubled, from 17 to 34 percent. Most of that growth is attributable to increasingly available fast-food. By eating more food away from home our nutritional intake has worsened.

It is easy to take this trend as proof that the only "right" way to eat is food cooked at home. We would definitively argue in the other direction. The amount of time we use to prepare food in our homes is falling. The number of ready-made meals we serve at home is going up. Take the Swedish classic, meatballs with mashed potatoes – in many homes that dish amounts to no more than whipping up instant mashed potato powder and frying some ready-made meatballs. In Sweden a normal family cooks no more than eleven different meals in any given month[34]. That does not make for the diverse type of eating that we need to embrace.

In order to cook healthy and well-tasting meals at home you need to have time, the interest and be able to afford it. And let us be frank, many people hate to cook and even more cook badly.

The answer instead lies in better food, and much of that will need the tender care of food professionals – proper chefs – and their future army of robots and 3D-printers. These are also the ones who can take proper care of new food products and cook

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33 https://www.ers.usda.gov/webdocs/publications/90228/eib-196.pdf?v=6911.2

34 Food & Friends: Matrapporten 2019

them with a good result. The world is filled with people who have tried vegan burger alternatives at home but have failed to cook them to the perfection that a professional can. Repeat purchases are rare when something tastes bad – even if you are the culprit yourself. A budding food entrepreneur with a new product should therefore aim for the professional sector that can take proper care of it instead of going straight to retailers.

This "better food" also needs to come at a price-point that is attractive. People love to eat good food and if they can have good food at a good price that is a winning combination for both consumers and society.

A special note needs to go to public meals; the ones served at e.g. schools and hospitals. This type of food has been much maligned over the years, but it faces a renaissance. In Sweden, every third meal served outside the home is a public meal and these meals are some of the best people in general get. They are designed by nutritionists, cooked by professionals, using the latest hardware and benefit from economies of scale. True, the public meal can absolutely improve further, but there is no arguing about the amazing bang-for-the-buck these kitchens deliver. For a measly four percent of the food sector turnover[35] they deliver three million meals a day in a nation of ten million people.

Public food (and the private version: canteens) is a key potential future growth area. If food is seen as a tool to achieve better school results, improved productivity or lower use of medication, then these types, of meal situations become strategic. We should see them as such, value them as such and start working with them as the indispensable tools they are. And their share of the food sector turnover will probably rise.

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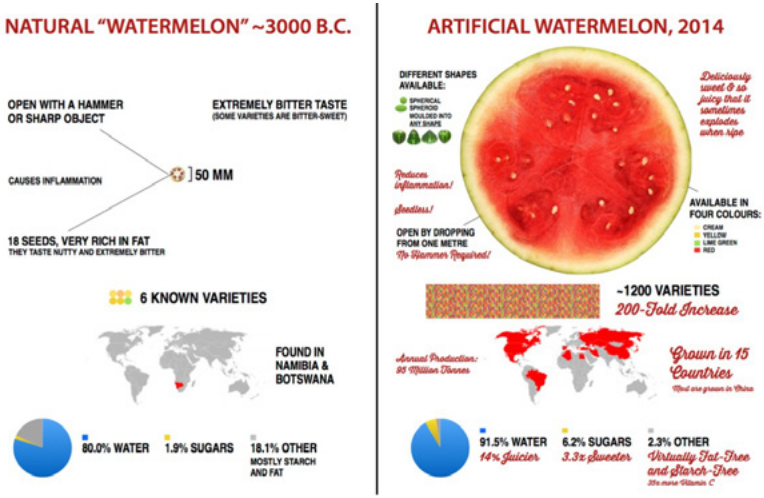
35 https://www.vinnova.se/m/hallbara-matsystem/offentliga-maltider/

WHAT IS NATURAL?

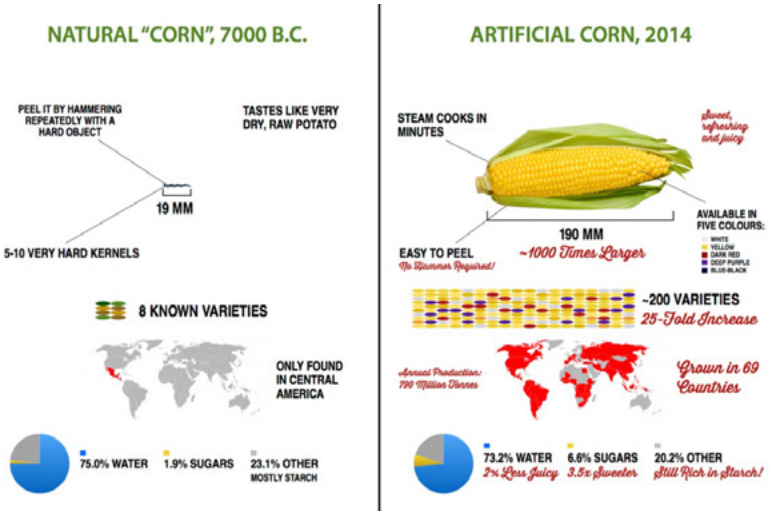
A philosophical question in the context of food production is what is natural and what is not?



Source: James Kennedy Monash

The Australian science teacher James Kennedy has done some great infographics on the development of various food items from their natural state until today[36]. It seems the watermelon is probably the least natural of all. 5,000 years of selective breeding has taken it from a diameter of 50 mm to more than 12 times as much. The volume and weight have of course increased way more than that. (As has its shape – you have

36 https://jameskennedymonash.wordpress.com/2014/07/14/artificial-vs-natural-watermelon-sweetcorn/



Source: James Kennedy Monash

probably all seen pictures of square Japanese watermelons[37].) Maize is not far behind, increasing a thousand-fold in size since man started to farm. And today's succulent peaches used to look more like cherries and tasted, well, not like peaches.

The list of man-assisted evolution of edible plants goes on and on and on. But we have not stopped at fruits and berries. While your modern-day apple tree can live without much attention, much of the food we eat today would not survive in nature. Hard-bred seeds are matched with artificial fertilizers and chemicals that keep pests away and improve yields. Now we are not talking about evolution anymore, but a co-existence between nature and chemistry.

A key to understanding the transformation is seeing food for what it is; an enormous system that has transformed nature to "culture". Is the next step to transform culture to "science" and

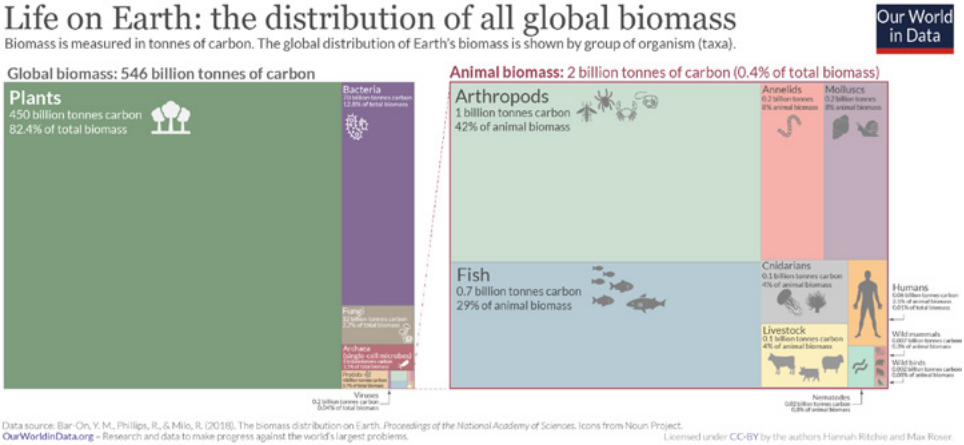
37 https://en.wikipedia.org/wiki/Square_watermelon

produce our food with other forms of industrial methods more in line with the structure of the rest of society? Or should we go back towards nature and adapt our way of living to what Mother Earth can bring forward, perhaps with some assistance from man, but without imposing our very limited knowledge on her with the help of brutal industrial methods?

It is absolutely fair to be worried about these developments, but let us be honest and realize that food is something we have always tinkered with and nature does it too. Gene editing, for instance (when you cut out a gene from the DNA of an organism), happens every day due to natural causes such as solar radiation. Evolution itself is constantly at play, man-made or natural.

It is probably about time that you get ready for the next leap – the so-called second domestication, when we start to see microorganisms for what they are – amazing little bio factories that can produce basically anything we need in huge volumes. We will get back to that a little later on, but for now it suffices to ask yourself the basic question: is a cow more natural than a microbe?

Mother Nature is quite savvy. Perhaps we do not know all about her? Perhaps we are so early in our history as a species that we need to treat novelties as logical next steps instead of as abominations.



BIODIVERSITY AND THE NEW AGE OF DISCOVERY

Planet Earth is a rich creation and Mother Nature has been hard at work over the years. About 60,000 vertebrates, close to 400,000 plants, five million fungi, millions upon millions of invertebrates and unmeasurable amounts of microbes populate our planet. Yet we get 75 percent of our calories from 12 plants and five animals. Of all the plants out there, we grow some 200 at scale[38]. How come we have streamlined food production in this way?

Because these plants can be easily plugged into the industrial paradigm governing our global food systems. Over the last 100 years we have lost a staggering amount of diversity – 75 percent– on the altar of industrial efficiency. The banana has basically been reduced to a single variety, the Cavendish. If a

38 https://www.fao.org/3/y5956e/Y5956E03.htm

Cavendish disease rips through the global banana sector we can say goodbye to that treat.

Mind you, such events occur regularly. The banana already had such an event in the 1950s when the Panama disease basically extinguished the then dominant variety, the Gros Michel[39] which was subsequently replaced by the Cavendish. But, the orderly mind would then say, if it had happened already and we replaced the Gros Michel with the Cavendish, certainly there is another variety out there waiting in line? For sure, but it is the Cavendish that is mostly being exported and that export is dependent on an industrial system where the bananas are picked green and matured during a finely tuned transport and warehousing system. It is far from certain that we can plug another banana variety into the Cavendish system.

Two other famous incidents are the phylloxera epidemic that destroyed most of the vineyards in Europe in the late 19th century and the potato blight in Ireland in the mid 1800's, that killed a million and had another two million emigrate to the USA. And this is even before we have started to think about the potent threat of agrobioterrorism, that, as you intuitively understand, aims at our food systems.

It would appear that a continuous and multidimensional match has been set up between biodiversity and industrial efficiency.

Biodiversity (all living things) and its more food production-oriented sibling "agrobiodiversity" (the biodiversity that is used directly or indirectly for food and agriculture) are vital concepts to care about and work with. Food does not come from soil but from a plethora of systems and functionalities that live in symbiosis. Soil is in fact created by plants, through

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39 https://en.wikipedia.org/wiki/Gros_Michel_banana

the decomposition of organic matter, and is therefore a result of a well-functioning, biodiverse ecosystem. Yes, you can push soil to deliver yields by pouring chemistry onto it, but there is a finite limit to that practice. If you want to sink your teeth into the topic of biodiversity we recommend the 500-something page report *The State of the World's Biodiversity for Food and Agriculture*[40] from the FAO.

But we mentioned the new age of discovery above, what is that? Well, we might not use much of the biodiversity around us simply because we do not know particularly much about it. That stands to change, however, with the rise of powerful computers and technologies letting us understand nature from a scientific perspective. Today, sequencing a DNA sets you back $100, rather than a few million dollars. Powerful new research facilities such as MAXIV[41] and ESS[42] in the South of Sweden can identify properties of materials (or food) on a level previously not seen. Google's AlphaFold[43] uses AI in order to predict how proteins fold – and how they fold is key to how they function.

This type of structured approach to understanding properties of various plants have already reached the market in the form of scrambled "eggs" and "mayo" from Eat Just[44]. The scrambled eggs are in fact mung beans and the mayo is made from peas – it happens that in those plants you find proteins that operate much like those found in eggs. But you need to look for them, find them, and be able to scale them, which Eat Just did.

In the world of medicine, we have long turned to plants for

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40 https://www.fao.org/3/ca3129en/CA3129EN.pdf

41 https://maxiv.lu.se

42 https://europeanspallationsource.se

43 https://alphafold.ebi.ac.uk

44 https://www.ju.st

inspiration and still do. In fact, 40 percent of the medicines we use still derive from plants[45]. A question starts to form; have we at all questioned the decisions our Neolithic ancestors made regarding what plants to grow and breed? Or could science play a role in shifting the perspective?

The global South for sure seems to think so. Sitting on the world's biodiversity reserves and therefore an amazing future wealth, they have decided that their precious resources will not be plundered by the global North this time around and in 2022 this resulted in the Kunming-Montreal Global Biodiversity Framework[46], which is the global framework for how to interact with and preserve biodiversity. One of the key points is the progressive closing of the $700 billion biodiversity annual finance gap. As stated time and again, a problem for someone is an opportunity for another.

One of the great realizations you can have when looking at the future of food is the effects of biodiversity in action. Synecoculture[47] is a farming method coming out of Sony Computer Science Laboratories in Tokyo and deals with so-called augmented ecosystems, more complex ones than nature can make on her own. In short, Synecoculture is about having loads of things grow together in a rather chaotic way. Plants love it and grow like crazy. In fact, the productivity on such fields have proven to yield 40–150 times (not percent) higher than conventional farming on the same acreage and has rendered some absurd gains for people farming in that way[48].

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45 https://www.fs.usda.gov/wildflowers/ethnobotany/medicinal/index.shtml

46 https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

47 https://synecoculture.org

48 https://www.fao.org/fileadmin/user_upload/GSP/GSOBI-21/DAY2/Plenary/Sony_Masatoshi_Funabashi.pdf

Taking a barren and deserted land to edible rainforest takes a year, with the soil improving rapidly. The method works best in the tropics, but it can be deployed in all climate zones. The problem from today's economic perspective is that you cannot run a harvesting combine over a Synecoculture field at a given time of the year and send huge amounts of standardized produce to a food factory. But if we re-thought the system around farming, we could reap the benefits of such an amazing natural productivity. The Tropics could then become the new breadbasket of mankind. And if you can turn barren land fertile, is that not property development? Ah, it seems we have a new business model around food production!

Innovation from and around biodiversity will be one of the planets most profound business opportunities for decades to come, if not centuries.

DEFINING WHAT FOOD IS

Now that we talk about biodiversity, let us go one step deeper. Defining food is slightly trickier than you might think. No one really gets their nutrition directly from food but rather from a complex system of activities performed by various parts of the body, such as enzymes, bacteria, digestive juices and movements in the bowel. Food is broken down into nutrients in several steps and are then transported out to where they are needed for such things as energy, growth or cell repair. While man has always had a vague notion around what happens to food in the gut we barely have started to know about the processes from a scientific perspective.

The interest for this space has really only boomed over the last decade[49] and today there are plenty of new findings regarding both the microbiota (all those microorganisms that live inside of you) and the gut-brain connection (what you eat also affects your mind). How has the level of scientific engagement with food and nutrients transformed in this exponential way? It is simply down to other technological advances, such as massively more powerful computers, AI and sensor technology. We have mentioned the steadily lower cost to sequence a DNA. Other costs are going down too, enabling not only the studying, but also the manipulation of biology, reflected in the fact that you on Amazon.com can buy a "DIY Bacterial Genome Engineering CRISPR Kit" for $169. And that was just the first one that popped up when we searched.

Since it is hard to see the speed of technological advancement slowing down it is as hard to see the end of scientific progress in a field that until now has been enormously hard to penetrate:

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49 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9786924/

biology. No wonder that computational biology is a red-hot area for some of the smartest scientific minds on the planet.

No need to say, there is an immense difference between the knowledge we have picked up by trial and error over millennia and hard facts coming out of deep science. While we absolutely must not in any way diminish those hard-earned insights, especially not those still existing with indigenous populations, we must at the same time realize that science is advancing at a tremendous speed in an area not used to it. Will our new and shiny tools and scientific methods make new discoveries? Absolutely! Will we suddenly know more about ourselves and the nature from which we come and in which we live? Certainly. Will they change our relationship to food? Without a doubt.

One of the more interesting scientific developments we see out there is novel methods to remove anti-nutrients from food. Anti-nutrients[50] are compounds in food that hinder the uptake of certain nutrients. The most well-known is probably phytic acid that can be found in whole grains, seeds and legumes and that can block the absorption of iron, zinc, magnesium, and calcium. If you can get all your necessary minerals from whole grains by removing the phytic acid from them, a great argument for eating beef (a great provider of bio-available minerals) falls. This development is called the mineral shift and holds a great promise.

Does all this mean that food will go in the same direction as biotechnology and be artificially manufactured? To some extent it already has. We already produce a lot of food ingredients in giant factories with the help of technologies such as extraction, chemical synthesis or even nano technology.

But should we not be more traditional when it comes to food?

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50 https://www.hsph.harvard.edu/nutritionsource/anti-nutrients/

Why? And in which traditional sense?

Studies on Ötzi, the 5,000 year old iceman that was found in a glacier in Italy 1991, has showed he ate a far more diverse diet than today[51] and probably most times in history. And Hippocrates, the "Father of Medicine", saw nutrition as a key medical tool. You probably have come across the quote "Let food be thy medicine and medicine be thy food" attributed to him.

It is easy to see how more knowledge and less belief will fuel a next generation of food companies providing you with the nutrition you need, coming from far more sources than today, embracing both new and re-discovered truths and, not the least, be based on data, all the way down to your individual needs. After all, you do want to know that the medicine you take is verifiably good for you. The same holds for food.

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51 https://www.alimentarium.org/en/magazine/history/ötzi-and-his-diet

HEALTH

When it comes to health and food there is an endless amount of literature and studies connecting the two. While everyone absolutely knows about this connection we do a really bad job turning knowledge into practice. In the US half the population suffers from a chronic disease, such as "The Big Four" (cancer, diabetes, cardiovascular and respiratory diseases), and 86 percent of the health care costs go toward treating them[52]. This pattern is repeated across the world and now we are only talking about the health care costs. In addition, we have human suffering and huge losses in productivity. The issues even stretch into national security policy. In the USA, 77 percent of young Americans do not qualify for military service, the leading singular reason being obesity[53].

But it is not just about the suffering from these diseases. Eventually we die from them, in droves. Chronic diseases kill over 40 million people every year, which is three quarters of all deaths. Almost half of those are considered premature, i.e. before age 70[54]. Tobacco still plays a major role, but the growth belongs to our unhealthy lifestyles.

Are our health care systems doing anything about it? A study of various medical educations[55] stated that the mean time a student spent on nutrition during his or her many years of education was a grand total of 11 (eleven) hours.

Yet, healthcare systems all around the world has recently

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52 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7077778/

53 https://www.military.com/daily-news/2022/09/28/new-pentagon-study-shows-77-of-young-americans-are-ineligible-military-service.html

54 https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

55 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9546301/

gotten a new tool in the box in the form of GLP-1 drugs such as Wegovy/Ozempic, Zepbound and Saxenda. The drugs help users lose weight fast by decreasing appetite and helping control blood sugar levels. The idea is that you will lose weight and meanwhile you can work on acquiring new habits, such as eating less junk food and exercising.

The drugs are still expensive, but new varieties are in the pipeline and prices will come down. These types of drugs are forecasted to become once-in-a-lifetime blockbusters and it is easy to understand why – the demand is massive in spite of monthly costs of $300 and above. Is obesity even an epidemic that needs to be treated in the same way as Covid, i.e. with massive, global campaigns and ample public funding? We are not there yet, but it is perfectly logical to put such a question and reason around the consequences.

The arrival of GLP-1 drugs sets up an epic match between food and pharma. What if you spend your money on medicine instead of junk food? What is a cookie factory worth in the future if everyone is on these drugs?

We should in this context reflect on "death over the balance sheet", which arrives when your assets no longer bring in the cash-flow on which they are valued. A cookie factory that suddenly sells far less cookies is worth less and you might have to take a big write-down. If you are unlucky those write-downs can threaten your equity. Death from write-downs can happen far faster than death from ongoing business and perhaps it is time that we start talking about the potential to have stranded assets also in the food sector.

Sitting still in front of a computer all day is not good, but you might wonder if it is better to venture out into our urban food environment where an endless amount of advertising and offerings are dragging us towards fast food and snacks.

A meta study[56] published in the BMJ (British Medical Journal) evaluated the association of exposure to ultra-processed foods and adverse health outcomes. Spoiler: strong correlation.

Ultra-processed foods are industrial formulations composed of chemically modified substances that to a high degree are extracted *from* real foods and then paired with additives to enhance taste, texture, appearance, and durability. Precious little whole foods to be found within.

While processing is not necessary an evil per se, ultra-processing for sure is bad and linked to a plethora of negative health outcomes; mortality, obesity, diabetes, cancer, mental issues, etc.

In places such as the US and the UK ultra-processed foods can represent more than half the energy intake. In Italy the number is around ten percent. It is always tricky to provide your personal observations in a scientific context, but people do seem slimmer in Italy than in the USA.

What can we do about this? Quite a lot, actually. A study from 2018[57] stated that a tax that raised the price of alcohol with some 50 percent would help avert 21 million deaths and generate nearly $17 trillion in additional revenues, over the course of 50 years. And the effects can come fast. Lithuania increased its alcohol tax revenues from €234 million in 2016 to €323 million in 2018 (approximately 50 percent) and the results were stunning. Alcohol-related deaths dropped from 23.4 per 100,000 people in 2016 to 18.1 per 100,000 people in

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56 https://www.bmj.com/content/384/bmj-2023-077310

57 Summan and Laxminarayan 2018, quoted in the report Health and Taxes Save Lives, https://www.drugsandalcohol.ie/30450/1/Health-Taxes-to-Save-Lives-Report.pdf

2018[58]. It would seem that raising taxes on alcohol is a smart thing to do, not only in theory.

What will people drink then? Non-alcoholic drinks, of course, which opens up for the innovators. The non-alcoholic trend has been strong for quite some time and seems only to grow in force. What if it was supercharged with policy? If a country can build a strong new sector based on political understanding and support, there is a global market out there in want of solutions. And this is just a very banal example.

The flip side of getting a chronic disease from food is to enhance your performance by eating right. This is something that elite athletes have known and worked with for ages. If you put the right nutrients into your body and hydrate yourself at the right moment you can get ahead of the competition. This is not just a question for top athletes – everyone who performs a task that relates to body or mind is affected, which means everyone. Generalizing productivity from food is of course impossible and varies from person to person, but likely a lunch-induced food coma will cost the employer way more than the lunch costed the employee. What does this mean? Perhaps it would be good for an employer to offer staff free lunch, but to help shape what is being served.

A further question we could ask (though it is rather politically charged) is since we pay for food anyway through our health-care budgets, why not give good food straight to the ones that need it? That would also tap into the issue of food justice.

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58 https://www.who.int/news/item/05-12-2023-who-calls-on-countries-to-increase-taxes-on-alcohol-and-sugary-sweetened-beverages

HUNGER

Until the event of everyone having the food they need we unfortunately need to deal with hunger, one of humanities greatest and recurring sorrows. Thanks to accelerating climate havoc, Covid, and geopolitical events, hunger is on the rise again[59]. As this is written over 800 million people suffer from hunger, but that is just the tip of the iceberg. Almost a third of the global population, 2.3 billion, are moderately or severely food insecure. And over three billion cannot afford a healthy diet. We have more than enough food for everyone on the planet, but we fail to get it to where it is needed. It is a disgrace of epic proportions.

In this context we need to accustom ourselves with the notion of "hidden hunger"; when you suffer from micronutrient deficiency due to a nutrient-poor diet. It is estimated that over two billion people suffer from hidden hunger, especially in low- and middle-income countries.

Hidden hunger can lead to overeating (the body is desperate for nutrition so craves more food) and the extra calories you consume beyond what you can burn then turn into fat and further down the road into various nasty diseases. Scientific developments such as the mineral shift and food system developments such as taxes and food subsidies are ways to solve a problem that exists thanks to an industrial streamlining of food staples.

There is a special case of nutrition deficiency that we need to give special attention: the first thousand days. From conception to a child's second birthday, it is extra vital that they get proper

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59 https://www.who.int/news/item/06-07-2022-un-report--global-hunger-numbers-rose-to-as-many-as-828-million-in-2021

nutrition because that is when much of their future development is set. During this period the brain develops at peak speed and lack of proper nutrition affects it for life. The child's future physical health is also at risk. You cannot recuperate later in life from deficiencies during this critical phase – once the window has closed it remains closed.

In the world there are some 200 million children under the age of five who suffer from the experience of chronic or acute malnutrition during their first thousand days[60,61] which amounts to almost 30 percent of all children under five, globally. The staggering difference between the cost of providing proper nutrition to children and the life-long returns from such an investment are eye-watering to any economist, be it from moral or economic or both perspectives. Making sure that such a massive human waste does not happen should be top of every agenda.

According to Article 25 of the Universal Declaration of Humans Rights[62] all humans have the right to food "adequate for the health and well-being of himself and of his family". While the declaration is frequently trampled upon, it is still a shining castle on a hill and something to strive for, for all of humanity, always.

But it is not just about morale. Food justice is always a good investment, also later in life, and making sure that everyone gets good food – and not just cheap and empty calories – brings loads of benefits for individuals and society alike. When we transform our food systems we should therefore think about the dimension of justice – that everyone can have access to

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60 https://thousanddays.org/issues/the-global-picture/

61 https://data.unicef.org/resources/jme-report-2023/

62 https://www.un.org/en/about-us/universal-declaration-of-human-rights

good food. The task of creating the models for that to happen will likely fall on the shoulders of the social sciences, such as economics. The one who succeeds in delivering that is sure to receive a Nobel Prize.

SOIL

Earth to earth, ashes to ashes, dust to dust. The phrase from the burial service in the Book of Common Prayer says it all. We live in an eternal cycle in the closed-loop system of planet Earth and the atoms in your body have likely once upon a time been part of a dinosaur or a fungi. Atoms exist virtually forever; it is how we organize them that matters. One way we organize them is through soil-based food production, i.e. farming, done in that very thin layer of organic matter that covers the planet and that we literally live from. And that is basically gone.

We, as humans, have already transformed over 70 percent of Earth's landmass from its natural state. While doing that we have achieved the staggering result of degrading between 20–40 percent[63] of it. Of the total landmass, not the parts that we have transformed.

The culprit is easy to find: modern agriculture. Giant monocultures, heavy tractors compacting the soil, insufficient crop rotation, chemical fertilizers. Flipping agriculture from a destroyer to a regenerator of planetary health is key to the future of humanity and we can start by respecting soil, this wonder over all wonders. This is not to say that farmers do not respect soil, most do, but the economic system in which they operate make it hard for them to practice farming in the way we need them to.

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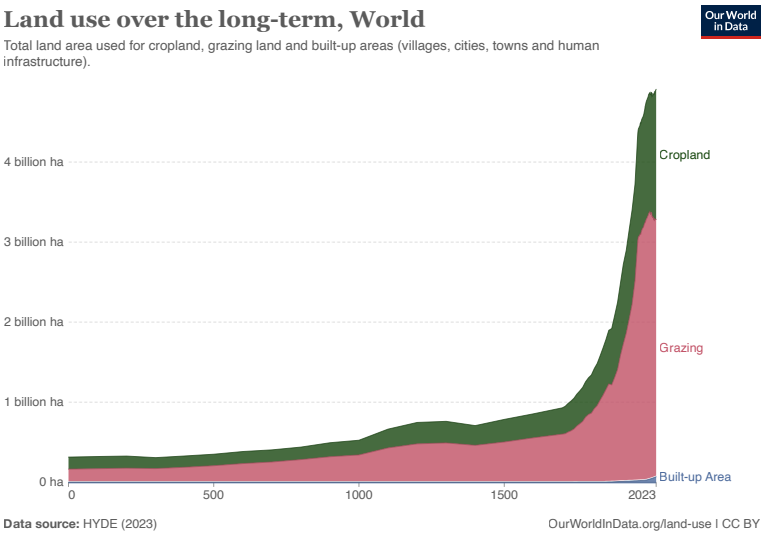
63 https://www.unccd.int/sites/default/files/2022-04/UNCCD_GLO2_low-res_2.pdf



Source: Hannah Ritchie and Max Roser (2019) – "Half of the world's habitable land is used for agriculture" Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/global-land-for-agriculture

FERTILIZER

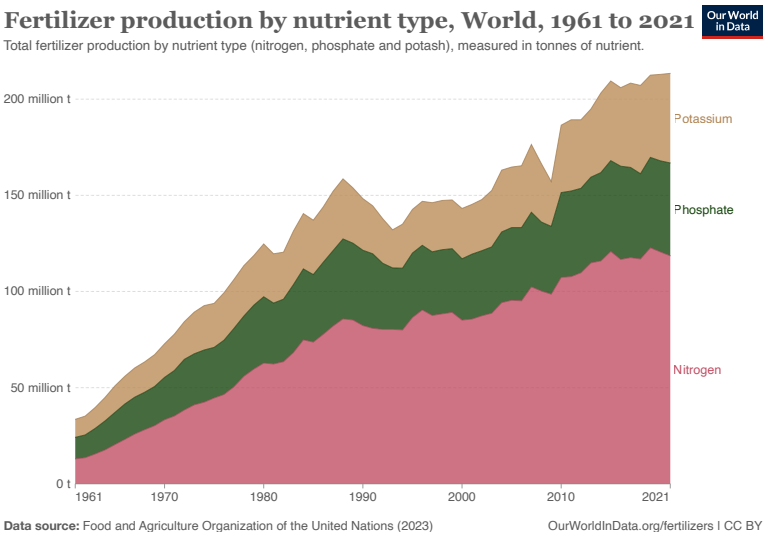
It is impossible to talk about soil without going into the delicate topic of fertilizer. In nature, plants and animals are part of a very intelligent cycle that together provide for each other. But if you want to get more out of nature than nature can produce on her own, for instance if you want to grow just one crop on a large swath of land, made possible to operate efficiently with the help of big machinery, you need fertilizer. Before we learned how to produce artificial fertilizer this basically meant finding and mining islands filled with guano (bird poo) or caves where bats had produced it in a similar way. Mind you, countries have had strategies for geographic expansion and have gone to war over bird poo. But since the beginning of the 20th century, we have known how to produce artificial fertilizer.

The transition to an industrial food production system has meant an enormous focus on the industrial production of fertilizer, which is very energy-intensive. Today it is estimated that roughly half of the world's food is produced using industrial fertilizers[64]. We need them because we must get more out of the soil than it can produce itself, at least given the types of crops and growing methods we rely upon today.

Fertilizers basically come in three types; nitrogen, phosphorus and potassium. All must be present in the soil to make plants happy.

Nitrogen fertilizer is produced from natural gas through a multi-step chemical process whereas potash and phosphorus are mined, most notably in Russia and Belarus (as you might intuitively understand we have geopolitical issue here). And we might have an even bigger issue in the form of "peak

64 https://ourworldindata.org/how-many-people-does-synthetic-fertilizer-feed



Source: Hannah Ritchie, Max Roser and Pablo Rosado (2022) – "Fertilizers".
Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/fertilizers

phosphorus", the notion that there is only a limited availability of phosphorus and that we might run out of it, according to some estimates within a few decades[65]. If the supply of phosphorus starts to run out, prices will rise and food costs will go up.

But that is because we are really, really bad at recycling it. Our current practices basically involve pouring phosphorus on agricultural land, the plants take what they need and the remainder is washed away, ending up in lakes or seas, leading to eutrophication. Rightly handled, however, phosphorus could be recycled up to 46 times[66]. Phosphorus management will therefore become an area of increased attention and innovation.

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65 https://en.wikipedia.org/wiki/Peak_phosphorus

66 http://web.mit.edu/12.000/www/m2016/finalwebsite/solutions/phosphorus.html

As will completely new forms of minerals that can be used as fertilizers. One that has gained a lot of attention is “struvite”, a mineral compound composed of magnesium, ammonium, and phosphate and that forms naturally in wastewater treatment facilities. Wastewater may not be just “waste” as we probably could take the next step in fertilizer developmen in the urban areas where humanity now lives and start to valorise side streams from that new habitat of man.

We should also note that other forms of food production, such as agroecological practices, that tries to mimic nature’s own processes, do not rely on industrial fertilizers. We can produce food without industrial fertilizers, but not within our current food paradigm.

The cost of fertilizer is tightly connected to the price of energy, this means that if our use of energy goes up, the cost of fertilizer can also be expected to rise and food prices with that.

FOOD IS IN THE AIR

It is impossible to talk about food without digging into greenhouse gases, the unintended consequences of much of our food production practices of today. Producing food without producing greenhouse gases is something we quite simply need to fix if we are to solve our climate challenges. It might therefore be useful to get a bit nerdy about greenhouse gases. There are three that we need to bother with; carbon dioxide (CO_2), which is the greenhouse gas that most people by now have heard of, methane (CH_4), and nitrogen (N_2O), the latter absolutely necessary for today's food production[67]. Together they represent 96 percent of all the greenhouse gases.

Greenhouse gases share the common feature that they trap heat in the atmosphere rather than letting it radiate out into the vastness of space, slowly making planet Earth hotter and hotter. A lot of the excess heat produced by the greenhouse gases have so far been stored in our oceans, but not even they can suck up all the energy. How much energy are we talking about, you might ask? Loads.

Between 1971 and 2020 scientists have estimated that we added around 380 zettajoules, 380,000,000,000,000,000,000,000 joules to the atmosphere thanks to global warming[68]. To get it to something we can compare: it is the equivalent of 25 billion Hiroshima bombs worth of heat. So far, our oceans have sucked up close to 90 percent of this energy – the rest has gone into heating land and melting ice. Steadily warmer oceans lead to more water in the sky and worse storms, which leads to

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67 https://research.noaa.gov/2022/05/23/greenhouse-gas-pollution-trapped-49-more-heat-in-2021-than-in-1990-noaa-finds/

68 https://essd.copernicus.org/articles/15/1675/2023/

devastation. With temperatures rising, less of that water will be stored as snow and ice, which leads to more flooding, etc. Greenhouse gases are serious stuff and food is involved in the production of all three, representing roughly a third, depending on how you define the value chain.

If you have seen figures stating that agriculture's share of greenhouse gas production has gone down, do not be fooled. They have gone down *relatively* speaking because the other sources have gone up. However, greenhouse gases come from different sources and break down according to different time-scales and thus need to be addressed in different ways. This makes it possible to target innovation strategies. Let us start from the top.

CARBON DIOXIDE (CO_2)

This is the motherload of all greenhouse gases and the source of the commonly used term CO_2 equivalents, the "gas currency" that enables us to compare various emissions (and potentially price them). They emanate primarily from the burning of fossil fuels for transportation, energy, cement manufacturing and to some extent from agriculture. CO_2 can stay in the atmosphere up to a thousand years. When we feed CO_2 into the atmosphere it stays with us.

In the world of food the prevalence of CO_2 is, however, to some extent an opportunity. Since plants love CO_2 they actually get more food through our emissions (CO_2 is actually injected into greenhouses), but they do not eat it all and eventually a worsening climate will make them less happy. Furthermore, if we need to use land to capture CO_2, for instance by planting trees, a rather interesting question arises for those who sit on land – should I use it to capture carbon or to grow food?

That will be decided based on the price we put on carbon. In Europe, that price currently hovers around $100/ton of CO_2 equivalent[69].

A hectare of trees can sequester as much as 11 tons of CO_2 per year (in the tropics)[70]. And since that income is rather passive it would mean that each hectare could provide its owner with a yearly revenue of approximately $1,000, and the only effort needed is watching trees grow. That is more than the average income in the world's poorest countries. If the price would quadruple to $400/ton, which some analysts think will be the case if Europe is to reach its target to eliminate 90 percent of its CO_2 emissions, that is three times the yearly GDP/capita in sub-Saharan Africa[71].

Not every country currently embraces carbon pricing schemes, but most probably will one day. CO_2 will be part of the business model of food, one way or another.

But we also want to point you to the two other greenhouse gases on the podium, because they belong solidly to the food sector and are absolutely addressable within it. Agriculture accounts for about 40 percent of all methane emissions and 75 percent of all nitrous oxide emissions[72]. The emissions of course vary depending where in the world you are, but nevertheless they end up in the same atmosphere.

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69 https://carbonpricingdashboard.worldbank.org/compliance/price

70 https://www.elibrary.imf.org/downloadpdf/book/9781616353933/ch05.pdf

71 https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=ZG&most_recent_value_desc=false

72 https://www.fao.org/3/ca8389en/CA8389EN.pdf

METHANE (CH_4)

Methane is the main component of natural gas (70–90 percent of it)[73] and while we pump huge amounts from the ground it is also a food side stream. There are two main sources of food methane: livestock and rice. When ruminants (like cattle, sheep and goats) process food through their various stomachs a natural by-product of the digestive process is methane (the technical term for this is enteric fermentation), which they duly burp up and thus contribute to global heating, representing approximately 27 percent of global methane emissions. Rice adds another seven percent to global methane emissions and manure a few percent more.

Methane is less frequent than CO_2, but about 30 times more powerful. It is also more short-lived. Each unit of methane lives in the atmosphere for about ten years, which means that if we can attack methane emissions, we can put a quick band-aid on global warming. It is a fair guess that such a potential quick fix will be supported by policymakers irrespective of the fact that CO_2 stays in the atmosphere for far longer.

How could we go about it? It will vary. Enteric fermentation (cow burps) can be addressed with various feed supplements that inhibit the methane production, resulting in methane-free burps. Another positive side effect of such treatment is that more of the animal's energy can go towards laying on fat and muscle or to produce milk. The choice to use it or not will be down to the price of the supplement. Since these supplements are just beginning to hit the market, this is an area to follow closely.

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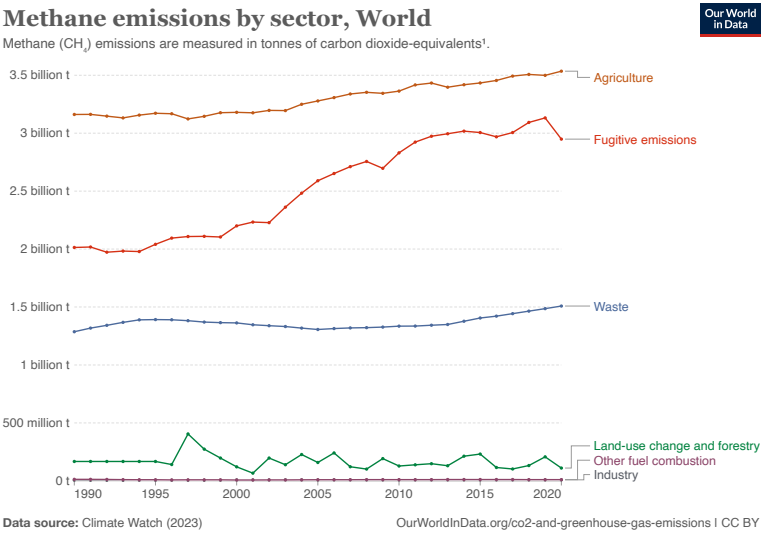
73 https://climatecommunication.yale.edu/publications/should-it-be-called-natural-gas-or-methane



1. Carbon dioxide equivalents (CO_2eq): Carbon dioxide is the most important greenhouse gas, but not the only one. To capture all greenhouse gas emissions, researchers express them in "carbon dioxide equivalents" (CO_2eq). This takes all greenhouse gases into account, not just CO_2. To express all greenhouse gases in carbon dioxide equivalents (CO_2eq), each one is weighted by its global warming potential (GWP) value. GWP measures the amount of warming a gas creates compared to CO_2. CO_2 is given a GWP value of one. If a gas had a GWP of 10 then one kilogram of that gas would generate ten times the warming effect as one kilogram of CO_2. Carbon dioxide equivalents are calculated for each gas by multiplying the mass of emissions of a specific greenhouse gas by its GWP factor. This warming can be stated over different timescales. To calculate CO_2eq over 100 years, we'd multiply each gas by its GWP over a 100-year timescale (GWP100). Total greenhouse gas emissions – measured in CO_2eq – are then calculated by summing each gas' CO_2eq value.

Source: Hannah Ritchie, Pablo Rosado and Max Roser (2020) – "Breakdown of carbon dioxide, methane and nitrous oxide emissions by sector" Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/emissions-by-sector [Online Resource]

But there are other methods for methane reduction from livestock as well. In certain parts of the world, for instance in very dry climates, dairy cattle spend most of their lives in barns since there is nothing to graze on in nature. In those cases, you can capture methane through the ventilation system. Or you use a combination. Ponds of manure can be covered, and the methane can be captured as biogas. Another alternative is of course to eat less meat, which, however, seems a lot harder to achieve.

When it comes to methane from rice[74], there are both new varieties like SUSIBA2[75] that emit less methane, and new methods to turn the remaining straw, post-harvest, into paper or bedding, instead of burning it (more on this later). For methane reduction the technical solutions are out there, it is the scaling that is missing.

The disgrace of waste is for another chapter, but a lot of methane leaks from landfills and one of the main things we throw on landfills is food. By reducing food waste, especially in places where it is not collected and turned into biogas, we can achieve great reductions of methane emissions.

We should of course capture as much methane as we can – it is after all basically the same as natural gas and has a rather substantial value.

NITROUS OXIDE (N_2O)

If you thought that methane seemed like a potent greenhouse gas, meet cousin Nitrous Oxide. It is 300 times as powerful as CO_2, ten times as powerful as methane and lasts for a little more than a hundred years. Too bad we literally eat it (or inhale it – N_2O is also called "laughing gas" and is widely used for anesthetic purposes).

The main source of N_2O as a greenhouse gas is our massive use of fertilizers for food production. When we decarbonize our economies, for instance by moving over to electric vehicles, this is a greenhouse gas that provides a tougher challenge. N_2O is a natural result of the so-called nitrogen cycle where nitrogen circulates everywhere in nature in various chemical forms (78 percent of the atmosphere consists of nitrogen).

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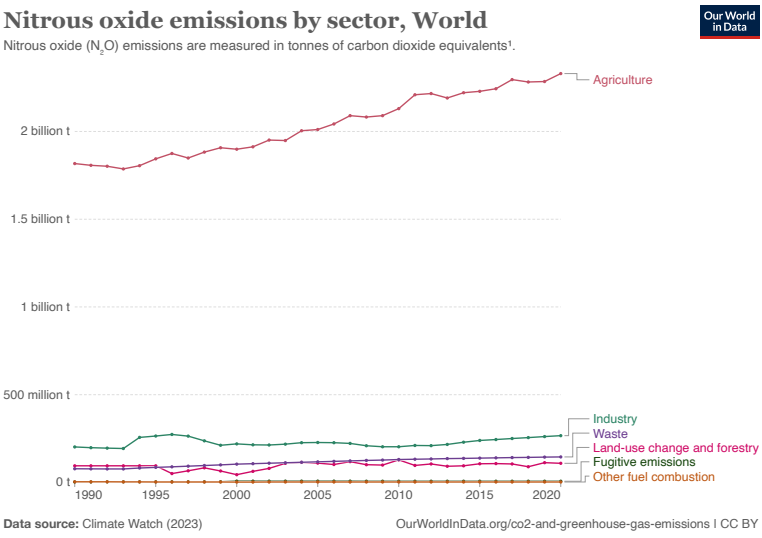
74 http://www.ciesin.org/docs/004-032/004-032.html

75 https://www.slu.se/en/Collaborative-Centres-and-Projects/trees-and-crops-for-the-future/c4f/forskarportratt/chuanxin-sun/



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Source: Hannah Ritchie, Pablo Rosado and Max Roser (2020) – "Breakdown of carbon dioxide, methane and nitrous oxide emissions by sector" Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/emissions-by-sector

But since we humans are smart, we have learned how to hack the cycle, most notably through the Haber-Bosch process, through which nitrogen gas is combined with hydrogen to form ammonia, a powerful fertilizer. When ammonia oxidizes, N_2O is created.

Without a massive use of industrial fertilizer the Green Revolution would never have happened. The negative side effects of industrial fertilizers are that they require vast amounts of energy; up to two percent of global energy consumption and as much as five percent of all natural gas goes toward ammonia

production[76]. The production largely sits on the wrong hands (from a Western perspective), with Russia as the clear leader in global fertilizer exports and with China in the third spot[77].

Oh, did we mention that N_2O is a main source of respiratory diseases? Now we have.

Given the above, it is actually very strange that precision agriculture is not mandatory.

But there are two more issues with greenhouse gases and food that we need to discuss. A lot of our farmland lies on what once was wetlands such as marshes, swamps, bogs, and flood-plains. Through extensive ditching we have been able to farm previously unavailable land or to start vast tree plantations (the latter especially in places such as Sweden and Finland). When covered by water these lands were carbon sinks. When laid bare they start to leak carbon, including significant amounts of methane. It is the same process that is happening in Siberia where the thawing of the tundra due to climate change leads to vast amounts of methane emissions.

Let us add a little innovative twist. When you buy a salad from your supermarket and it sits in a little pot, that pot will likely be filled with peat, coming from such dried-out wetlands. Peat is also a fossil fuel but has a lower energy density than coal or oil due to its higher water content. An alternative to peat in horticultural applications like the salad pot is to use sphagnum moss, that can be grown on a flooded field (re-creating that carbon sink), harvested with a special machine and giving a far higher economic yield than, say, wheat. In this case, horticulture and farming are perfectly complementary.

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76 https://en.wikipedia.org/wiki/Haber_process

77 https://oec.world/en/profile/hs/fertilizers

We have mostly spoken about gases emanating from food production, but the entire cycle is problematic. The burning of rice fields post-harvest (to prepare for the next crop) regularly engulfs much of Asia in a thick smog and, together with other emissions, affects over 90 percent of the populations in Asia and the Pacific region. Four million people die annually and prematurely due to this food habit[78].

Food is in the air. And kills from a distance.

78 https://www.adb.org/sites/default/files/publication/780921/air-quality-asia.pdf

WHAT ABOUT WATER? DRILL, BABY, DRILL!

Drilling for water is the only thing we have drilled for to an even greater extent than for oil. We extract water at a tremendous rate from underground reserves because we need it. Herein lies a problem that is rapidly gaining attention. Of all the water on the planet 97 percent is salt. Of the three percent that remain, two thirds are locked away as snow, glaciers and polar ice caps. And about all the remaining freshwater lives underground. Just 1 percent of our fresh water can be found in lakes and rivers, i.e. close to nothing[79].

It is estimated that between 1993 and 2010 we pumped a total of two trillion tons of water from underground reservoirs, which has led the Earth's axis to shift![80]

Globally we pump approximately 1,000 cubic kilometers of water per year[81]. That is almost two full bathtubs per day for every person on the planet, enough to cover the entire area of the UK in four meters of water. Water is replenished in an eternal cycle by precipitation finding its way into rivers or underground aquifers and layers of rock from where we get it. But water is not replenished at the same speed as we are using it. Not only are we depleting our own future reserves, but it

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79 https://www.weforum.org/agenda/2023/07/global-distribution-fresh-water-withdrawals/

80 https://www.scientificamerican.com/article/rampant-groundwater-pumping-has-changed-the-tilt-of-earths-axis/

81 https://theconversation.com/we-rely-heavily-on-groundwater-but-pumping-too-much-threatens-thousands-of-underground-species-218919#:~:text=Globally%2C%20we%20pump%20almost%20-1%2C000,meaning%20levels%20are%20continuously%20declining

also means that entire ecosystems can be wiped out when the underwater reserves get depleted.

The depletion of our ground water reserves is a major challenge for humanity, leading to endemic water scarcity and becoming a threat to food. Of all the water we pump, 70 percent goes towards farming[82]. Some foods are extra thirsty, beef is one of them. And when you export food, you actually export water, which is something that water-scare nations have become all-too aware of.

Yes, we can desalinate water, but it is expensive and it leaves behind enormous amounts of salty slush. This makes for a strategic question: If the price of water will go up in a radical way, how will that affect you?

Speaking about salt water, that immediately pushes us towards our much-manhandled oceans.

A study[83] by WWF states that between 1970 and 2012 we lost 49 percent of all marine populations. At the same time the farming of fish and other forms of seafood has gone from virtually nothing to representing half of all fish we consume[84]. The fish farming trend seems unstoppable and is now moving onshore – where it is easier to control water quality and where proximity to markets can provide additional benefits.

At the same time, we move farming into the oceans. Kelp and seaweed are high in nutrients. Humble filter feeders, such as sea squirts, grow at a tremendous rate and can be used in similar applications as beef. Algae can be grown in large ponds and provide necessary Omega3. The nascent blue economy is

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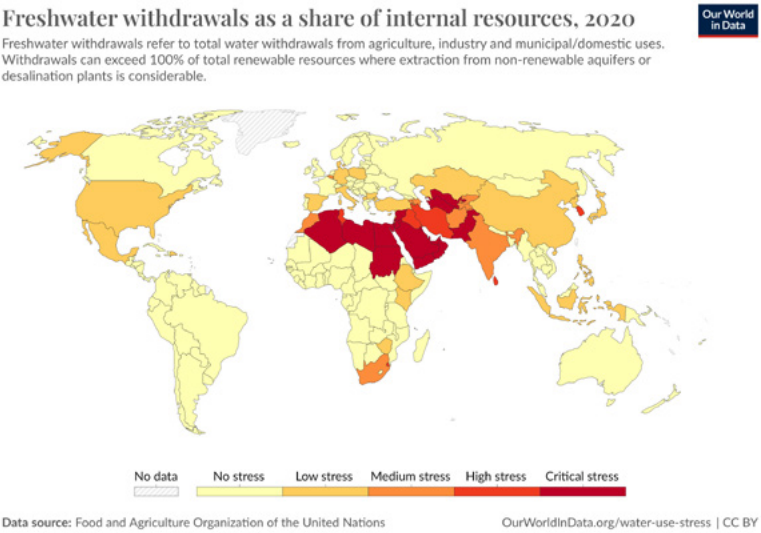
82 https://unesdoc.unesco.org/ark:/48223/pf0000384655

83 https://www.wwf.eu/?252450/Failing-fisheries-and-poor-ocean-health-starving-human-food-supply--tide-must-turn

84 https://www.fao.org/documents/card/en/c/cc0461en

actually a rather glowing light in an otherwise rather dark world of food and that is reassuring. If land becomes impossible to farm, we may be able to go back into the oceans again.



Source: Our World in Data team (2023) – "Ensure access to water and sanitation for all" Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/sdgs/clean-water-sanitation

WASTE

When you scrape the food rests on your plate into the trash bin it becomes waste and is no longer part of the food value chain. Now, it's part of the waste value chain and in many places around the world this means a one-way ticket to a landfill where it will blend with other waste and leak methane. Approximately a third of all food is wasted; in the developed world after the meals, in other parts of the world somewhere between the field and the rest of the production chain. This means that we over-tax our planet by extracting too much from it while not feeding back the wasted nutrients to the soil from where they came. If we could just minimize waste, much of the food-related issues would be solved.

In many parts of the world methane from waste is nowadays captured and can be reused as biogas, thus reducing our need for fossil gas. But you can of course mine waste far beyond that and the starting point is to separate food waste from other waste streams and then separate the different food waste streams. Taking care of waste is a fantastic business – you valorize something that other people throw away, and sometimes you even get paid for taking care of what you in any case want to lay your hands on.

Taking care of waste can happen everywhere. The fruits around the coffee bean, almond and cacao pod has only recently come to attention for their amazing nutrition. The stones in apricots, peaches and apples can become milk. Oat hulls can be turned into xylitol. It is not that we did not know that we had waste, we did not really know what to do with it or we had forgotten how to use it or had it in such abundance that we did not have to care. As science has expanded, we have acquired a better understanding of what is in the waste and how we can

get that value out (more on microorganisms below). We must be strategic about waste, because we have discovered that resources are not endless and wasting is a shameful practice that individuals and companies will want to end.

THE INCREASED COMPETITION FOR RESOURCES

Pumping fossil slush from underground reservoirs is not sustainable so we have come up with new technologies to make things out of what nature provides, instead of making it from oil, for example bio materials, such as bio-plastics or biofuel. There are few things we would need to sacrifice decarbonizing our societies, it seems. However, let us just be aware that there are certain areas where food production might collide with other interests.

Almost 22 percent of all sugarcane production and 16 percent of maize production go towards producing bioethanol. 15 percent of vegetable oil production burns as biodiesel[85]. No problem, if we have unlimited land, but we do not. If we were to replace fossil plastics with bioplastics we would need five percent of all arable land[86]. And if the ambition is to plant more trees either to produce bio-"stuff" or to draw down CO_2 from the atmosphere they need to be planted somewhere, preferably where they once were cut down to make room for plantations or livestock. Which means that plantations and livestock have to move.

Food is thus not only a matter for eating. We do not state this to encourage fever-dreams about a Mad Max world where various tribes compete for the few resources we have, but just to point out that the solution probably is to build a wider understanding of what the true value is of our various resources and their components.

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85 https://www.ifpri.org/blog/food-versus-fuel-v20-biofuel-policies-and-current-food-crisis

86 https://www.sciencedirect.com/science/article/pii/S0921344922000337

An interesting example is the increased use of rice straw to produce packaging, instead of burning it after harvest. Here we see an integration between two different industries and several business models operating at the same time. Combining business models is an excellent past-time for those who want to be part of the great food transformation.

THE ROLE OF URBANITY

While certain people dream of leaving on a spaceship, most of us will remain on Earth. And most of us will spend our days in man's new habitat – the urban areas that we have decided to call home. Urbanization might not be as much discussed in the context of food as climate change, health and geopolitics, but it for sure is a key factor in the transformation of food. From today (2023) until 2050 the World Bank expects the number of people living in urban areas to double[87] when seven out of ten are expected to be urbanites. Mind you, that has already happened in the developed world where over 80 percent now live in urban areas.

Urbanity is thus where food "happens", where we buy it, cook it, eat it, waste it and – ahem – "dispose" of it. Urban areas are also where we produce a lot of the potential inputs for food, such as heat, CO_2 and plant nutrition. If we are to fix food, we need to start to think about food in urban terms.

Urban areas are amazing in the sense that when many people come together we achieve new efficiencies. A high density of people make it possible to deliver new services, simply because you can address a critical mass of customers. You can also share infrastructure such as kitchens and you can build the infrastructure that lets you collect side streams such as waste, heat and sewage, and potentially gases as well. This means that you have a machine into which you can plug food.

Needless to say, if we are to fix sustainability we need to recirculate as much as we can, and urban areas are potentially great for that. Urban areas also provide us with advanced food and communication environments and while they so far have

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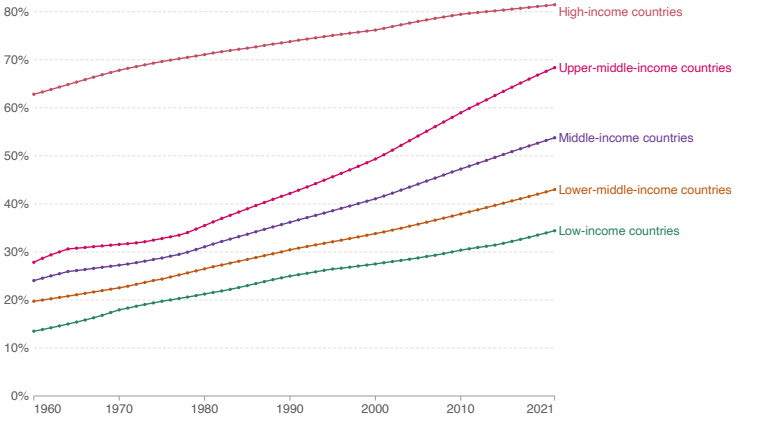
87 https://www.worldbank.org/en/topic/urbandevelopment/overview

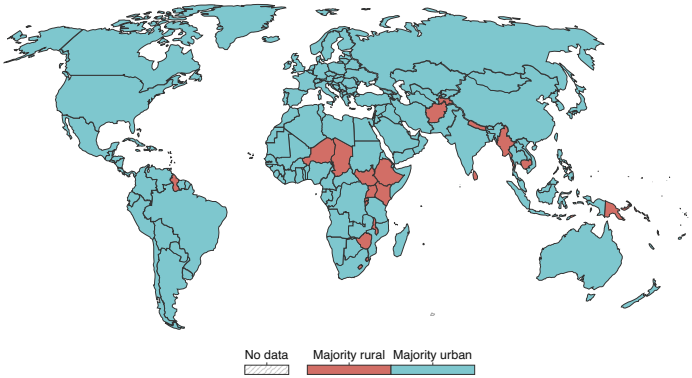
Share of the population living in urban areas, 1960 to 2021



Data source: UN Population Division (via World Bank) OurWorldInData.org/urbanization | CC BY
Note: Because the estimates of city and metropolitan areas are based on national definitions of what constitutes a city or metropolitan area, cross-country comparisons should be made with caution.

Do more people live in urban or rural areas? 2050

'Majority urban' means that over 50% of the population resides in urban areas, whereas 'majority rural' means that at most 50% live in urban locations.



Data source: United Nations, Department of Economic and Social Affairs, Population Division (2018); HYDE (2023)
Note: Because the estimates of city and metropolitan areas are based on national definitions of what constitutes a city or metropolitan area, cross-country comparisons should be made with caution.
OurWorldInData.org/urbanization | CC BY

Source: Hannah Ritchie, Veronika Samborska and Max Roser (2024) – "Urbanization" Published online at OurWorldInData.org. Retrieved from: https://ourworldindata.org/urbanization

not been used in an optimal way for health and sustainability, nothing says it cannot be the case in the future.

An urban area is a dynamic machine, and we can probably unite around the fact that the future of food will take shape in such contexts, especially if the urban infrastructure supports such dynamic development.

Urban infrastructure is one of those areas that are developing at a breakneck speed so let us use a few sentences on a specific part of it – logistics.

Food is one of the most transported items on the planet, which means that food and logistics are tightly connected. And logistics have developed enormously since the first online food retailers emerged (and died) in the 1990s. You can sell food online these days without owning your own last-mile delivery network – logistics can be bought on tap. Together with the previous discussions on the rise of digital platforms and personal data we thus see a new urban food world emerging.

If food can be had as easily online as in a store, with logistics handled by pros instead of yourself and where the building in which you live enables the logistics, will we still go to the supermarket, carry home our bags and cook for ourselves? Or has food itself become infrastructure, available 24/7 and not just in the form of bad fast food? And how do new forms of logistics affect the urban or peri-urban service-levels?

It is always beneficial to consider history when looking into the crystal ball. The first pizza drone delivery was made in late 2016. In April 2024 the drone delivery company Zipline announced its one millionth delivery and a combined flying distance of over 100 million kilometers or 2,500 times around the planet. And they are not the only company out there. Autonomous drones are coming to sidewalks and landing spots all around the world and forget about range anxiety – these drones can re-charge on their way.

Where will this development take us, say, ten years from now?

When you get new forms of transportation, that changes how we build infrastructure and how we engage with it. Will the arrival of cheap, clean and fast transportation lead to structural changes in the food sector? Most likely. According to McKinsey & Co, drone transportation can approach $1.5–$2 per delivery, provided some technical and legal developments that still are lacking[88]. With such delivery prices and an infrastructure supporting it, convenience will reach new levels. Ultra-fast delivery might have gotten a bad rap and been seen as the ultimate form of laziness, but in reality, this sector is governed by the trade-off between price, time and effort. The potential to have a drone whisk your hot meal to you in a few minutes at a really low cost instead of having a gig-worker bring it to you in 30-45 minutes, at a higher cost, will make a difference, especially if combined with "Prime"-like business models where you can get unlimited deliveries at a fixed monthly price.

Since the delivery radius increases radically with aerial drone delivery, you can reach far more customers and convenience can stretch to places currently outside delivery areas. There are thus certainly reasons for food sector players to consider what is happening in infrastructure and logistics.

Changing urban environments takes time, but ongoing discussions amongst architects, urban planners and entrepreneurs promise novel solutions, much in the same way that the establishment of out-of-town malls for car-carried shoppers once was a novel solution for our time and led us to shift our food purchasing patterns.

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88 https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/future-air-mobility-blog/drones-take-to-the-sky-potentially-disrupting-last-mile-delivery

When we build these new urban environments there is a growing realization that we need to get them right for food – after all, we are talking about multiple tens of trillions of dollars in investment and constructions we are to live with for decades. How these new urban areas are designed will affect how food is distributed into it (unless food is produced in the city itself) and how the side streams from urban food (sewage and waste) are utilized in (hopefully) circular food systems. An extra challenge is the fact that urbanization processes in many cases are not structured but more informal, i.e. shanty towns.

It is thus imperative for all builders, planners, infrastructure operators, technical consultants and other actors dealing with our physical environment to start to understand food, because getting our urban areas right for food is a major part of the food equation. Did we say that a doubling of the world's urbanity represents a giant opportunity? Now we have.

We mentioned leaving on a spaceship. Perhaps we live on one?

SPACESHIP EARTH

In 1969 the legendary futurist R. Buckminster Fuller published his book "Operating Manual for Spaceship Earth[89]. He likened Earth with a spaceship, flying through the void with a finite amount of resources. No place to dock and resupply. The term stuck.

What has happened lately is that there is a growing realization that extreme environments such as space is a great place to develop technology for Earth, also in relation to food. All-in-all, everything is about recycling on Spaceship Earth, though the processes are longer than on a rocket heading for another planet.

Economics is our construct and we have imposed its limited functionality on ecology and our one-of-a-kind spaceship. A well-functioning economic system should be based on the rules of ecology and planetary limits, not try to model nature to its liking. It is important to understand and embrace this distinction and let that lead us to the construction of better functioning systems. Nothing is set in stone, not even immense systems such as food. The only thing we are certain of is that Spaceship Earth moves through the great void and that there is no Planet B.

89 https://en.wikipedia.org/wiki/Operating_Manual_for_Spaceship_Earth

NEW INNOVATIONS

We are in the early days of the necessary and long overdue transformation of our food system, and this means that we have only seen the start of the innovation avalanche, be they products, services, models or policy. It is therefore dangerous to list innovations in a Guide like this because everyday something new emerges that blows your mind and renders the old obsolete, much like in the early days of the Internet. But, ok, let us mention a few on the product side, the most relatable part of the innovation universe, simply because examples are always instructive. After all, there is some truth to the saying that a picture is worth a thousand words. So here are some examples that have our attention as of May 2024:

Square Roots[90]: experimenting with growing leafy greens without photosynthesis.

Solar Foods[91]: producing protein from CO_2.

Vow[92]: the world's tastiest meat is lab-grown and consists of (rumored) a combination of quail and alligator cells. Are there more taste discoveries around the corner? Absolutely.

Mediterranean Food Labs[93]: is a new type of flavor company using fermentation to concoct magic potions. If you want to make a French onion soup you cannot just boil onions in water – that would taste horrible. Unless you take a few spoons of magic potion and add that to your onions in water.

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90 https://www.squarerootsgrow.com

91 https://solarfoods.com

92 https://www.eatvow.com

93 https://www.med-food-lab.com

Endless Food Co[94]: makes "chocolate" from spent beer grains through fermentation. Since cocoa beans are endangered due to climate change this is reassuring, because the experience of chocolate is here to stay no matter what.

Kaffe Bueno[95]: upcycles coffee grounds, separating out all the unused biochemicals in the offee grounds – those are actually more valuable than the coffee in the cup.

A special mention goes to Mycoproteins. Multiple entrepreneurs deal with this new branch on the food tree and no wonder. Mycoprotein is made by throwing fungi spores into a carbon slush that the spores can feed upon. The next day they have grown tremendously and you harvest them, squeeze them together into a shape and – voilà – you have a steak packed with nutrition. Like a breast of chicken, but cheaper. Entrepreneurs are talking about prices of no more than $1.5 per kilo.

Another mention goes towards projects where novel food production happens in symbiosis with other industries, for instance using waste heat from computer centers to produce food. Or by utilizing under-utilized resources. When plants grow indoors it really does not matter if the LEDs shine while the sun is over the horizon or during nigh-time when energy prices are a fraction of those at peak hours.

These examples are just a few – a drop in the bucket. However, one thing many of the newcomers have in common (like mycoprotein, Endless and Med. Food Labs) is the clever use of fermentation.

Fermentation is one of the original food technologies alongside drying and freezing (where nature provided you with enough cold). Famous examples include kimchi, sourdough

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94 https://endlesscph.com

95 https://www.kaffebueno.com

bread or – for the adventurous – Swedish fermented Baltic herring, often referred to as one of the most revolting food experiences you can have, or Icelandic Hákar, fermented shark with a distinct note of ammonia.

Fermentation and precision fermentation (when you have designed a microorganism to act as a bio-factory) are thus not exactly new kids on the block, but the rise of science has enabled fermentation to take a huge leap.

One of the more intriguing aspects of fermentation is that we can create edible things from raw material that is not necessarily edible in the first place, like saw-dust, straw or mown grass – microorganisms are not picky eaters. That makes for a very interesting discussion regarding what constitutes our future food. Especially so since we ourselves use the microorganisms in our gut to break down our food into the components that our cells crave.

The whole new use of microorganisms for food production is sometimes described as the "second domestication", a term popularized by a 2019 report from the think tank RethinkX[96]. The first domestication was about plants and animals and happened after the last ice age. The second one is about the use of these specially designed microorganisms for food production. The question now is if we can use that knowledge for the production of food on scale, rather than raising and killing larger, sentient, animals?

Of course we can – we can produce fermented products such as beer, wine and cheese in large quantities so we know our ways around microorganisms in food already. And if the proteins we produce through microorganisms are cheaper than

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96 https://www.rethinkx.com/press-release/2019/9/16/new-report-major-disruption-in-food-and-agriculture-in-next-decade

the large-animal proteins we use today, that is what we will use. If the pundits are correct (and they get easier to believe by the year) food will be rolled-up by microorganisms sector by sector, with the only question remaining being when the takeover will happen.

Watch the fermentation space closely. Perhaps that's where we will get our bulk food from in the future, while we save plants and animals for special occasions or just to enjoy their companionship and beauty.

ENERGY

Food is energy and energy is what produces our food. The topic of energy and food can and will fill entire libraries, in this section we therefore just want to point in a few directions.

If you can grow food indoors with the help of LEDs, the price (and availability) of electricity will guide the production. If you have free energy in the form of hydro, geothermal or fossil (if you are a petrostate) you have the potential to become a large food producer. It is thus time to consider the food producing futures of countries such as Norway, Iceland and Saudi Arabia. Please note that LED is semiconductor light and rides the same type of curve as processors, i.e. they get continuously better and cheaper. Please also note that LEDs can produce different wavelengths with which you can steer plants; their growth, colour, taste and nutritional composition.

But perhaps it is all about how we organize our planet. Net primary production (NPP)[97] is the measurement for how incoming sunlight gets converted to biomass through the photosynthesis and is the basis for every ecosystem on the planet. As you might expect it differs quite a bit depending on where you are. The Tropics are the undisputable world champs when it comes to converting sunlight to biomass – many times more efficient than the cold North – and could easily be the breadbasket for the entire planet – if we only decided to eat what grows best there, which is not wheat and maize. But what if we used microorganisms in order to convert the biomass of the tropics into food? Now, this is raw speculation around a potential development, but take that speculation as a cue to think about the relationship between food and energy.

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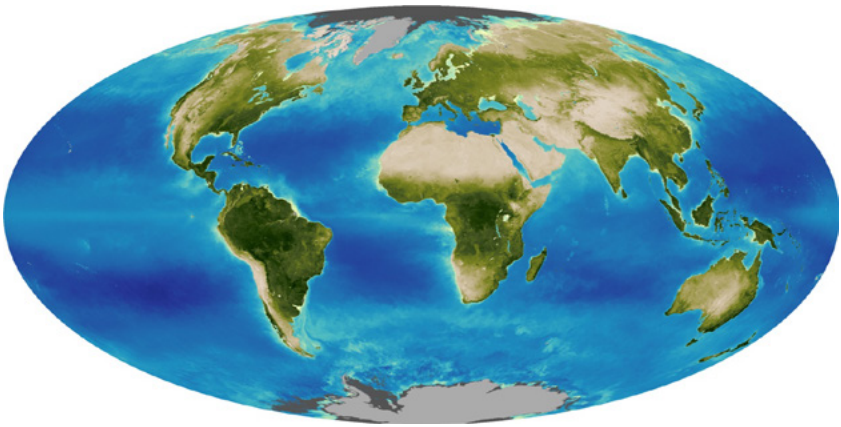
97 https://wad.jrc.ec.europa.eu/primaryproduction



The map is made from ocean chlorophyll data collected by the SEAWIFS satellite and vegetation data collected by NOAA satellites and analyzed by the global inventory modeling and mapping studies (GIMMS) project at NASA's Goddard Space Flight Center, 2008.
Source: NASA, Earth Observatory

FINANCING THE TRANSFORMATION

By now you probably have started to see a pattern emerge; by thinking outside the current food value chain new solutions can be found, not the least by combining business models from different sectors. That cross-sector thinking has the potential to unleash new, creative methods to embrace food as an intrinsic part of future business systems.

Identifying and working with such value creation will also be key to unlocking the vast sums needed for the transformation of food. But how much more financing will we need? In its 2024 report "Recipe for a Livable Planet"[98] The World Bank estimates that the annual investments in the agrifood sector need to increase 18 times to $260 billion per year, in order to halve its current emissions by 2030, and be on track for net-zero in 2050. The health, economic and environmental benefits are (according to previous estimates) expected to be as high as $4.3 trillion by 2030, or a return on investment of 16 times. There is no doubt there will be a lot of capital flowing to food.

This means that the future of food should not be thought about in terms of early stage entrepreneur and venture capital, but rather in terms of big financial elephants moving big structures: nations, sovereign funds, insurance companies, wealth managers, private equity, family offices, pension capital etc. Rightfully so, since food has an amazing property for investors and that is steady, predictable returns over long time. While a venture capital fund always will be looking for 10x over a short period of time, a long-term investor could be happy with a predictable five percent, year after year. Like a bond.

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98 https://www.worldbank.org/en/topic/agriculture/publication/recipe-for-livable-planet

CLOSING REMARKS: WHAT HAVE WE MISSED?

It is blatantly obvious that a short guide such as this will miss, omit and fail to both embrace all aspects of food and the coming transformation, as well as to synthesize them into a coherent picture. Please forgive all our shortcomings and see it as a start on your own journey to understand food and its transformation in your specific context. Food is a lens through which you can observe the world and through which you can analyze your business, existing or potential. Food is a truly fascinating and enjoyable subject and we will all personally be affected by the coming transformation. If you find what we write interesting and want to dig deeper together with us, please reach out.

REFLECTIONS ON THE UNSEEN

It is time for some final words, and they go toward the unseen. What we have done over the years is to gradually reduce food to become a matter of cost, generally speaking. We compare the price of food like any other good and we tend to pick the cheapest. No wonder, price is the only clearly visible and objective measure to base our decisions on, the rest is subjective. But if we choose to see the potential in food in order to achieve our goals, we will not only see that food can play a major role in almost every aspect of life, from storing carbon to improving productivity, we will also realize that the price of food is the small part of the equation – it is the effects of food that take precedence. If it is necessary to change what you eat or serve, or even to produce food in new ways, those decisions should be guided by the value that is created (or lost). For economists this means new areas to explore way beyond what has been done so far and includes everything from political economy and accounting to investments in human and natural capital. Understanding and putting a value on what could have been is a perennial problem, but food provides an amazing arena for research and where the gained knowledge potentially could spill over to other sectors.

THE FINAL, FINAL WORDS GO TOWARD POLICYMAKERS

The siblings transformation and innovation thrive on each other, but are fed by insights, resources and new thinking. But there will be no transformation and, hence, less innovation without a change of the policy framework within which food exists. It is the system set-up that gives us the food we eat – we cannot really blame the actors on the stage for the words of the play, or how it is directed. Until the policy framework around food shifts, we will only see incremental development. This is not to say that selling plant alternatives to meat through today's retail channels is insignificant, but the major shifts will only happen in conjunction with policy. Such systemic shifts will need to be seismic.

This should, however, be encouraging for policymakers since food could become a tool for so much more than just feeding people. Policymakers need to understand their new and wider role in the world of food, including pointing out the need for food to engage with other sectors in order to achieve overarching societal goals – food should and could, after all, be seen as an opportunity rather than a threat.

This means a need for new way of seeing food in society – and we fully understand the complexity and intellectual challenges in achieving such a change – but food system transformation is nothing new, not even radical ones. However, the really big shifts happen so seldom that we from a generational perspective might not see a single major shift over the course of an individual lifetime. In between those major shifts innovation tends to be of a more incremental nature. Food thus seems to be very stable. Until it is not anymore.

How come we ended up here? Throughout history countries

have used their capabilities to secure livelihoods and compete on international markets, and food is no exception. However, food deals not just with produce, but also with culture to a far higher degree than most other goods. Food is a source of pride and emotions, and everyone wants to push their specific addition to the global food culture pot.

National strategies around food seem to fall into this trap time and again. A conviction of the superiority of your food products only make you see them, instead of all the other things you can bring to the world of food. (We have refrained from discussing the cultural nature of food in this guide out of sheer self-preservation but rest assured that the topic exists in ample measures.)

In a global market under rapid and profound transformation a smarter strategy is to consider where the future is heading and to do some serious thinking about what your position could be in such a transformed system.

In a country such a Sweden, ripe with tech, biotech, pharma, process industries, forestry, energy, etc. we can find embryos to new global solutions. We can upgrade our current ways of food production and those upgrades can be sold on a global market with a better result than the output from our primary food production. The sooner we realize this and start to push and support innovation based on what we can achieve on a global scale by bringing the innovative powers of a modern nation to the table of food, the better off we will all be.

A special challenge is that food often is perceived as synonymous with rural areas and that gets food stuck in the perspective of today's primary production model. It is deeply unfair, not the least for the rural areas that are governed by what the current food system demands of it rather than being seen as the heroes of a prosperous planet founded on nature's riches.

Our farmers cannot anymore be seen as providers of wheat or soy – they need to be seen as caretakers and providers of nature's riches, and as such are essential parts of the transformation of life on Earth in a sustainable direction. Which, to be honest, will require a bit of a mental shift also with the farmers themselves.

In this transformation of the role of farmers we need to remember that agriculture employs one billion people globally – and 78 percent of the world's poor[99] – so food furthermore sits on the potential to lift many people out of poverty and create more equitability, by turning the farming profession more profitable, or by enhancing productivity, freeing human resources for other important tasks.

Policymakers, if they can embrace and act on the multiple realizations around food, sit on the solution. We hope they will rise to the occasion.

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99 https://openknowledge.worldbank.org/server/api/core/bitstreams/61d04aca-1b95-4c06-8199-3c4a423cb7fe/content

POST SCRIPTUM

After having read through the previous pages you are bound to shift between hope and despair – food has that effect on you. But hope will prevail. Over the next 50 years the population growth on Earth will level out. We will likely not become much more than ten billion and this means that if we over the course of the coming decades can turn our food system into a source of health and sustainability, including becoming a great carbon sink, we can hold the planet forever! We already produce ample food for everyone, now we "just" need to fix the bad parts of food and then we are done. Hey, we might even become heroes to our coming generations! Not a bad sector to devote your life to…

COMMENTS AND FUTURE DEVELOPMENT

Thank you for getting this far! You will have noted from the cover that we have given this guide a production date. Food transformation is a developing story so there will be updates. If you have input, suggestions or want to help finance the ongoing work – do get in touch.

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