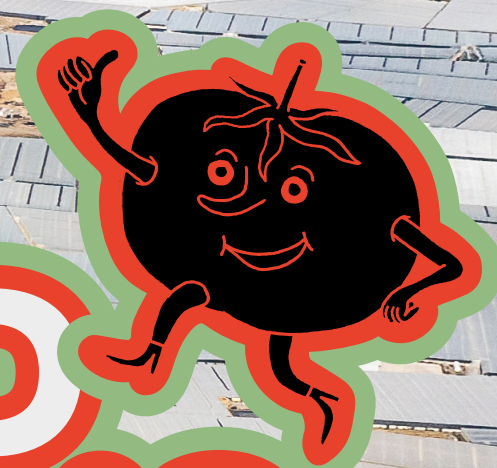


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VIVIVUM



FOOD
SYSTEMS
AT
THE LIMIT



Food Systems at the Limit

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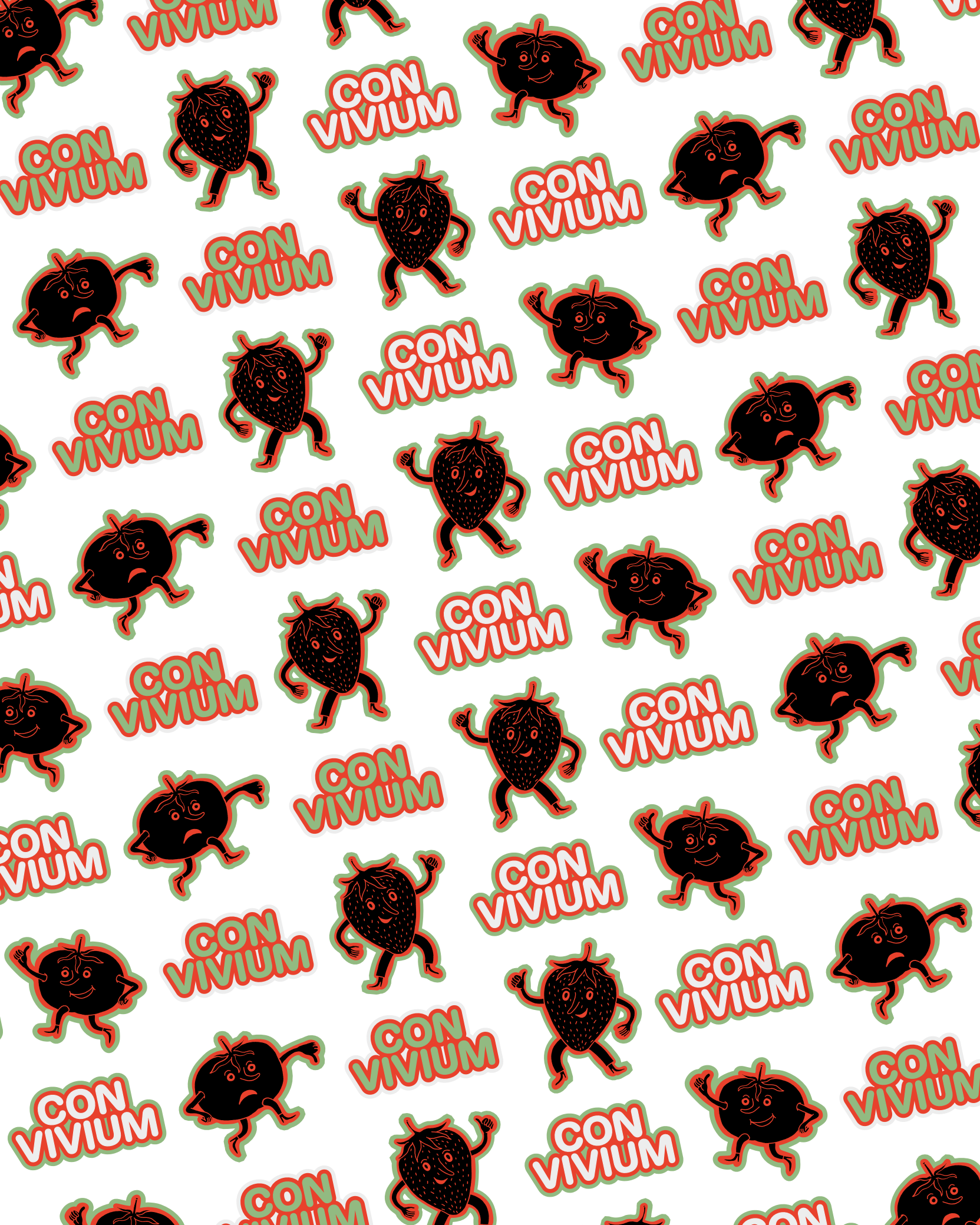
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Prologue

A cow outside the exhibition hall in Leeuwarden after transport and washing, set to compete at the Holland Holstein Show, a professional dairy cattle competition, 2025



It is unlikely that anyone reading these lines will need to worry about their next meal—not today, not this week, nor even in the months to come. Our refrigerators are well stocked, and should we notice a gap, we can easily fill it from the abundant offerings of the nearest supermarket—or simply visit one of the many restaurants close by. In industrialized societies, the majority of the population—though by no means everyone—lives with a sense of absolute food security. When we think about food at all, it is usually only to decide what we feel like eating at a given moment: salad or sushi, pizza or a burger, or perhaps chicken tikka masala?

Food has thus come to resemble almost all other products that surround us in capitalist systems, where most people can satisfy nearly any desire, at least relative to their income. Only once—during the first Covid-19 lockdown in March 2020—did an unexpected situation arise for us: supermarket shelves were briefly stripped of pasta, and yeast was nowhere to be found. Yet this brief shortage was quickly overcome and soon forgotten.

Some people among us, particularly those born into the baby-boomer generation, still heard from their parents about periods of extreme food insecurity and hunger during the Second World War. As children, we were encouraged at the family table to put only as much food on our plates as we could actually eat. Many people today are far removed from this conscious and respectful relationship to food. Awareness is often lacking as to where food comes from, how it is produced, processed, and distributed—and by whom. The pinnacle of thoughtlessness (or should one call it outright decadence?) is reached when a football star orders a steak adorned with gold leaf for €1,200 and proudly shares the feast on social media.

While the global economy continues to grow steadily and worldwide food production has reached an unprecedented level, food insecurity is nevertheless once again on the rise and has currently reached its highest global level since 2017.¹ At present, around 28 percent of the world's population lives in conditions of food insecurity—that is, in the stage preceding hunger. This includes people who lack reliable access to sufficient food, as well as those who, due to food shortages, have been forced to go without eating for an entire day.² In Germany alone, more than a million people are currently affected by food insecurity and depend on support from food banks (*Tafeln*) or other charitable organizations.³

Oversupply and undernourishment are two symptoms of a social system that appears no longer capable of organizing a just distribution of available food. This discrepancy is further exacerbated by the fact that global food consumption continues to rise, as does the volume of food waste. Altogether, food production accounts for nearly one-third of global CO₂ emissions, placing it close to the estimated emissions of the construction industry. Additional ecological factors include land-use change, water consumption, energy demand, and phosphorus depletion.

Even now, the land available for agriculture in Germany is insufficient to supply the agricultural products required. In fact, imports of products cultivated outside of Germany—known as virtual land imports—currently amount to roughly one-third of the country’s cultivated area.⁴

With the exhibition *Convivium: Food Systems at the Limit* and this accompanying book, we examine selected aspects of the complex network that constitutes contemporary food systems. The production, processing, and distribution of food depend on land, spatial configurations, and infrastructures—one of the main reasons why this topic is addressed by the Architekturmuseum der Technischen Universität München (TUM). The focus of what follows is therefore less on the buildings themselves (even though greenhouses, farms, cowsheds, and similar structures are discussed) than on an analysis of the underlying conditions, interdependencies, and constraints that connect them to the food systems.

Our aim is to render visible the key challenges facing food systems—challenges that repeatedly find expression in the built environment—while at the same time highlighting the potential of new technologies and fostering broader awareness of the structural foundations of our food supply. The following section presents a set of figures intended to introduce the topic and to delineate the broader analytical framework of the discussion, before readers move on to the contributions by experts from different disciplines, which examine and elucidate the specific aspects and questions addressed in this book.

675 Kilograms: Our Annual Intake

On a global average, an adult consumes approximately 675 kilograms of food per year, corresponding to around 1.85 kilograms per day.⁵ The composition of food consumption varies considerably across world regions and is strongly shaped by economic conditions and cultural factors. In the United States, for example, average meat consumption amounts to 123 kilograms per capita each year, whereas in India it is only 6.6 kilograms.⁶ Remarkably, the largest share of animal-based protein consumed worldwide still derives from fish and seafood rather than from terrestrial livestock.⁷ Germany lies close to the global average in terms of the total quantity of food consumed per capita, at roughly 680 kilograms annually.⁸ This overall amount is composed of approximately 52 kilograms of meat, 200 kilograms of fruit (including citrus) and vegetables, 175 kilograms of milk and dairy products (including cheese), 82 kilograms of grain (such as bread), and around 33 kilograms of sugar.

In recent years, beef consumption in particular has been subject to growing critical scrutiny, because the production of beef carries a disproportionately high carbon footprint compared to other food products.⁹ In response to this awareness, some individuals consciously abstain from beef or meat altogether, or deliberately reduce their consumption, which is often described as flexitarian dietary practices. In Germany, approximately 8 percent of the population identifies as

vegetarian, and about 2 percent as vegan.¹⁰ In industrialized regions, per capita meat consumption tends to decline with higher levels of education and income. In countries of the Global South, however, meat consumption is expected to increase significantly in the coming years, as the consumption of meat is widely perceived in these regions as a symbol of elevated social and economic status.¹¹

14,876 Products: Our Supermarket Offering

Although the invention of the supermarket dates back to 1916 in the United States, its global rise did not begin until after the Second World War, driven by economic growth, new forms of logistics, and technological innovation. The ability to choose from a broad—and increasingly de-seasonalized—range of products in a single location fundamentally transformed shopping habits, consumption patterns, and consumer expectations. Since then, people have no longer purchased only what they actually need; instead, their consumption behavior has increasingly been shaped by how products are presented through sophisticated retail and marketing strategies, for instance arranged at eye level. At the same time, many consumers have turned away from specialized neighborhood shops such as butcheries, bakeries, greengrocers, and daily or weekly markets. As these local offerings gradually disappear, supermarkets gain ever greater power over our purchasing decisions and consumption habits.

In Germany, the total retail floor space of large supermarkets—stores with more than 2,500 square meters of sales floor—amounted to 4.16 million square meters in 2022, generating total revenues of €82.6 billion.¹² On average, large supermarkets achieved annual revenues of €16.7 million, employed around sixty-three staff members, and served approximately 810,000 customers per year. The markets analyzed in a 2022 study offered an average assortment of 14,876 individual products.¹³ Within this range, the “fresh food” category—bread, fruit, and vegetables—has gained importance and by 2022 already comprised twice as many items as it had thirteen years earlier.

This growing concentration of (food) purchasing in a single location creates a strong temptation for customers to buy more than they actually require, with excess consumption ultimately ending up as waste. Moreover, the obligation to keep all products—including fresh foods—continuously available until closing time forces supermarkets to replenish shelves on an ongoing basis. As a result, many products must be discarded after closing, as they can no longer be sold (or are no longer permitted to be sold) the following day.

132 Kilograms: Our Food Waste

In 2022 alone, an estimated 1.05 billion metric tons of food waste was generated worldwide¹⁴—equivalent to 132 kilograms per person

Tomatoes and peppers are discarded outside of greenhouses in Almería due to minor imperfections, 2025





and nearly one-fifth of all food available to consumers.¹⁵ In Germany, the absolute figure amounts to approximately 10.8 million metric tons per year. The largest share—58 percent, or 6.3 million metric tons—originates from private households, while only 7 percent (0.8 million metric tons) is attributable to the retail sector.¹⁶ However, significant quantities of food waste already arise during processing, amounting to 1.6 million metric tons (15 percent), with a further 2 million metric tons (18 percent) generated by restaurants. On average, each consumer in Germany discards around 74 kilograms of food each year. This massive waste of food not only contributes substantially to climate change but also exacerbates biodiversity loss and environmental pollution while generating considerable economic costs for society as a whole. The recycling of these enormous quantities of food waste is possible only to a limited extent—and itself entails additional CO₂ emissions through transport and processing. This is due, on the one hand, to the fact that large volumes of food waste still do not enter organic waste streams and, on the other, to the strict regulations governing the disposal of catering waste containing animal products, which may only be handled by specialized waste management companies. The situation becomes particularly paradoxical in light of the fact that “dumpster diving”—the recovery of edible food from supermarket waste containers—continues to be legally classified in Germany as theft and is therefore punishable by law. By contrast, France has had legislation in place since 2016 (Loi Garot) requiring supermarkets with sales areas exceeding 400 square meters to donate unsold food to food banks and other charitable organizations, or to recycle it as compost or animal feed.¹⁷ Even if some of the over-produced goods are ultimately converted into biogas or compost—or, in the best case scenario, redistributed directly to those in need—the systematic nature of food waste inevitably carries with it a profound ethical dimension.

673 Million People Go Hungry Worldwide

While food supply in many countries is not only secure but increasingly characterized by overconsumption, rising health problems, and widespread waste, the number of people suffering from hunger worldwide has at the same time stagnated. Over a long period, hunger was successfully reduced through a range of international aid programs; according to the most recent *State of Food Security and Nutrition in the World* report, however, 673 million people still do not have enough food on a daily basis.¹⁸ In light of growing global economic prosperity on average, this figure is deeply disturbing. The drastic cuts to international development assistance by the governments of the United States, Germany, and numerous other countries raise serious concerns that the number of people affected by hunger will increase again in the near future. The universally recognized human right to adequate, sufficient, and healthy food, as enshrined in Article 11 of the United Nations

International Covenant on Economic, Social and Cultural Rights, is currently neither adequately protected nor effectively guaranteed. In principle, existing global food production resources would be entirely sufficient to end hunger. What is lacking, however, is the political will to organize a just and equitable distribution.

15 Million Pigs: Pig City

When the Dutch architecture firm MVRDV published its study *Pig City* in 2000,¹⁹ the figures presented pointed to a problem at a scale that has since become ever more apparent. At the time, the Netherlands was home to 15.2 million pigs and 15.5 million inhabitants. MVRDV's argument was based on a simple but far-reaching question: How much land would be required in the Netherlands to keep all pigs in accordance with the standards of organic farming and to supply them with organically produced feed? Under this scenario, pigs alone would have occupied approximately 75 percent of the country's total land area. The architects' provocative proposal was to organize this required space vertically, in the form of high-rise structures, in order to preserve sufficient land for human settlement. What was conceived as an architectural provocation has since been overtaken by reality.

If we place this twenty-five-year-old example in a contemporary context, the magnitude of the issue becomes even more clear. In Germany, approximately 21.5 million pigs were kept in 2025²⁰—99 percent of them under conventional livestock rearing conditions and only about 1 percent under organic standards.²¹ As in the Netherlands, the land required for a complete conversion to higher-welfare production systems is currently not available.

MVRDV's architectural provocation has since been overtaken by reality: for several years now, pig high-rises have become a built reality in China.²² In the city of Ezhou, in Hubei Province, a twenty-six-story building with 390,000 square meters of usable floor area was completed in 2022, dedicated exclusively to the rearing of approximately 1.2 million pigs per year.²³ This dystopian structure forms part of a long-term strategy pursued by the Chinese government to secure a stable supply of inexpensive pork for its population. If MVRDV's idea were consistently pursued under these conditions, Germany alone would require no fewer than 127 such high-rise facilities—each comparable to the one in Ezhou—to house all pigs under organic livestock rearing systems.

Another Helping?

The current state of global food supply is shaped by extreme inequalities of opportunity, unjust distribution, unacceptable levels of waste, and severe forms of resource exploitation. Today, most industrialized countries are no longer able to adequately supply their populations with food from domestic production alone. The provision of animal feed for

livestock—for the animals that are subsequently consumed—already requires ever-expanding areas of land that are unavailable within national borders. And the associated imports of agricultural commodities, such as soy, are widely regarded as one of the key drivers of rainforest deforestation.

Comprehensive food sovereignty—understood as the capacity of a country or society to shape its food system autonomously, sustainably, and largely from its own production—is currently achieved by almost no nation.²⁴ Ensuring food security is therefore increasingly emerging as a central political issue, particularly for countries with growing populations seeking improved levels of food supply. This is because overfishing of the oceans, the escalating impacts of climate change, increasing water scarcity and soil erosion, and the loss of biological diversity, as well as the consequences of war, geopolitical tensions, and unstable global markets, already make visible the multiple forces pushing systems of food production and distribution ever closer to the limit.

- 1 See OECD, "Food Systems, Food Security and Nutrition," <https://www.oecd.org/en/topics/food-systems-food-security-and-nutrition.html>.
- 2 Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development (IFAD), UNICEF World Food Programme (WFP), and World Health Organization (WHO), *The State of Food Security and Nutrition in the World 2024* (Rome: FAO, 2024).
- 3 According to Eurostat, in 2024 about 11.2 percent of the German population could not afford a proper meal at least every second day. For more on this, see Eurostat, "Inability to Afford a Meal with Meat, Chicken, Fish (or Vegetarian Equivalent) Every Second Day," last updated November 14, 2025, https://ec.europa.eu/eurostat/databrowser/view/ilc_mdcs03/default/table?lang=en.
- 4 As of 2015, according to Tanja Dräger de Teran, *Das Grosse Fressen: Wie unsere Ernährungsgewohnheiten den Planeten gefährden*, WWF Deutschland, March 2015, www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF_Studie_Das_grosse_Fressen_Zusammenfassung.pdf.
- 5 Anca Monica Brata and Anisoara Olimpia Waldhutter, "Food Consumption Typologies: A Comparison between the Large Regions of the World," in *Annals of the University of Oradea, Fascicle: Ecotoxicology, Animal Science and Food Science and Technology* (2023), https://protmed.utoradea.ro/nou/images/Publicatii/Ecotox/2023B/Food_science/03_Brata.pdf.
- 6 See German Federal Statistical Office, "Globale Tierhaltung, Fleischproduktion und Fleischkonsum," 2004, https://www.destatis.de/DE/Themen/Laender-Regionen/Internationales/Thema/landwirtschaft-fischerei/tierhaltung-fleischkonsum/_inhalt.html.
- 7 Brata and Waldhutter, "Food Consumption Typologies."
- 8 According to statistics from the German Federal Ministry of Agriculture, Food and Regional Identity. The following figures refer to data from 2023: <https://www.bmel-statistik.de/ernaehrung/tabellen-zu-ernaehrung#c7876>.
- 9 See Guido Reinhardt, Sven Gärtner, and Tobias Wagner, *Ökologische Fußabdrücke von Lebensmitteln und Gerichten in Deutschland*, Institute für Energie- und Umweltforschung, Heidelberg, 2020, https://www.umweltbundesamt.de/sites/default/files/medien/6232/dokumente/ifeu_2020_oekologische-fussabdruecke-von-lebensmitteln.pdf.
- 10 See German Federal Ministry of Agriculture, Food and Regional Identity, *Nutrition Report 2024*, cited in Carolina Kyllmann, "Share of Vegans and Vegetarians Largely Unchanged in Germany – Govt Report," *Clean Energy Wire*, September 24, 2024, <https://www.cleanenergywire.org/news/share-vegans-and-vegetarians-largely-unchanged-germany-govt-report>.
- 11 See Lisa Tostado, "Fleischkonsum weltweit: Alltagessen und Luxusgut," Heinrich Böll Stiftung, January 6, 2021, <https://www.boell.de/de/2021/01/06/fleischkonsum-weltweit-alltagessen-und-luxusgut>.
- 12 In comparison, the food service industry in Germany generates about €50 billion, according to the German Federal Statistical Office, "Beschäftigung und Umsätze in der Gastronomie noch unter Vor-Corona-Niveau," press release no. N061, November 23, 2023, https://www.destatis.de/DE/Presse/Pressemitteilungen/2023/11/PD23_N061_45.html.
- 13 The following figures and text are based on EHI Retail Institute, "Supermärkte," <https://www.handelsdaten.de/branchen/supermarkt/C3%A4rkte>.
- 14 See United Nations Environment Programme, *Food Waste Index Report 2024*, March 27, 2024, <https://www.unep.org/resources/publication/food-waste-index-report-2024>.
- 15 Europe is roughly in line with the global average here, but individual countries show significant differences; see "Eurostat, Food Waste and Food Waste Prevention – Estimates," data extracted in September 2025, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Food_waste_and_food_waste_prevention_-_estimates.
- 16 See German Federal Ministry of Agriculture, Food and Regional Identity, "Lebensmittelabfälle in Deutschland: Aktuelle Zahlen nach Sektoren," June 6, 2025, <https://www.bmel.de/DE/themen/ernaehrung/lebensmittel/verschwendung/studie-lebensmittel-abfaelle-deutschland.html>.
- 17 Zero Waste Europe, *France's Law for Fighting Food Waste*, factsheet (Brussels: Zero Waste Europe, 2020), p. 1.
- 18 Aktion gegen den Hunger, "Welternährungsbericht," press release, July 28, 2025, <https://www.aktiongegenhunger.de/presse/welternahrungsbericht-2025>; see also Food and Agriculture Organization of the United Nations (FAO), *The State of Food Security and Nutrition in the World (SOFI) 2025*, <https://doi.org/10.4060/cd6008en>.
- 19 The project *Pig City* was presented as an exhibition in 2001 at Stroom Den Haag – Centre for Visual Arts, Netherlands; <https://www.mrvd.com/projects/134/pig-city>.
- 20 See German Federal Statistical Office, "Schweinebestand 2025 leicht gewachsen, Zahl der Betriebe weiterhin rückläufig," <https://www.destatis.de/DE/Themen/Branchen-Unternehmen/Landwirtschaft-Forstwirtschaft-Fischerei/Tiere-Tierische-Erzeugung/schweine.html>.
- 21 Germany distinguishes between five systems of livestock rearing, with organic farming corresponding to system 5. In this category, each pig weighing more than 110 kilograms is allocated at least 1.5 square meters of indoor space and 1.2 square meters of outdoor access. By contrast, the same animal in system 1 is provided with only 1.0 square meters in total; see <https://haltungsform.de/kriterien-5stufig/>.
- 22 Daisuke Wakabayashi and Claire Fu, "China's Bid to Improve Food Production? Giant Towers of Pigs," *The New York Times*, February 8, 2023, <https://www.nytimes.com/2023/02/08/business/china-pork-farms.html>.
- 23 Yating Yang, "High on the Hog: Skyscraping Hi-Tech China Swine Farm Produces 1.2 Million Pigs a Year," *myNEWS*, July 2, 2024, <https://www.scmp.com/news/people-culture/article/3268839/high-hog-skyscraping-hi-tech-china-swine-farm-produces-12-million-pigs-year>. We have not verified which livestock rearing system is currently used for the pigs in these high-rise buildings.
- 24 See Jonas Stehl et al., "Gap between National Food Production and Food-Based Dietary Guidance Highlights Lack of National Self-Sufficiency," *Nature Food* 6 (2025), <https://www.nature.com/articles/s43016-025-01173-4>. According to this study, Guyana is currently the only country in the world that can still feed itself.

A greenhouse in Tüßling, Germany, 2024, where controlled climatic conditions enable continuous, year-round tomato production



Convivium or Embracing the Mainstream

In the book *Tools for Conviviality*, published in 1973, the Austrian social critic Ivan Illich introduced the term “convivial” against the backdrop of his criticism of industrial overproduction and the limits of modern society. The notion helped to show how industrial growth could be balanced and alternatives to mass production offered, yet without signifying a return to the past or utopian designs for “noble savages.” Arguing that it was not possible to solve the crisis by additional escalation—by more production, management, or science—Illich saw hope in prescribing limits. In fact, the limits within which machines are allowed to replace human labor—with industry able to flourish and a future society to grow—can be properly modern without being dominated by industry. Illich called such balance through self-limitation “convivial”—“a technical term to designate a modern society of responsibly limited tools.” In his view, it is “a society in which modern technologies serve politically interrelated individuals rather than managers.”

In early historiography, the term actually meant public eating and often abundance. The Latin *convivium* refers to lavish banquets held after periods of fasting, where social gathering around food meant discussing politics and living together. Romans modeled these events based on the Greek notion of “symposium,” that is, public dining for discussing politics primarily, with only men present. The Roman version introduced a more family-based character to the gathering, emphasizing habitation, social status, and the involvement of women. Through the religious phrase *sacrum convivium* (sacred banquet), the term was modified over time in its derivatives, such as the Italian *convivia* (to coexist) or the French *convive* (signifying a guest sharing food in a friendly setting).

Illich’s original interpretation of conviviality, a term that generally designates the ritual of a joint meal, as an optimistic vision for post-industrial society can serve to frame the problem of food production today. To illustrate it briefly, current calculations say that each human should theoretically have at their disposal around 2 square meters of arable land for feeding themselves, in a decreasing trend toward the targeted 1.5 square meters in 2050. Pessimistic scenarios about the effects of climate change on food production point out that half of Asia depends on water from (melting) Himalayan glaciers to maintain its agriculture. Or that with every degree we heat the planet, the yields of cereal crops will drop by 10 percent. Research clearly shows that the expansion of arable land must stop to protect climate and biodiversity, that meat consumption needs to decline in favor of plant-based proteins, and that food waste must be reduced. Two competing paradigms offer solutions.

On the one hand, there are high-tech systems based on the technological progress run by “positivism” in Jürgen Habermas’s sense of the term. Here, “research, technology, production, and administration have coalesced into a system which cannot be surveyed as a whole,” one which lost its center while becoming the basis of Western values. Through positivist model institutions that promote research, it is possible to secure economic growth and civic loyalty—provided that citizens do not critically question the ultimate goals of these endeavors. In the context of food production today, high-tech systems, such as indoor automated agriculture, serve as positivist promises mostly suited to wealthy and relatively self-sufficient states, such as the Netherlands, Germany, Israel, or Singapore. They appear to be linked to the organizational apparatus of governments, universities, and companies that aim to transfer knowledge, a business known since the period after the First World War, when the idea of social development was exported from the Global North to the Global South as a substitute for colonization. Food production in highly automated environments goes hand in hand with export politics and corporate policy, where the primary goal is profit. However, these developments are not without benefits, as some of their achievements are stunning. Dutch food technology, for example, is an apparent miracle of efficiency, squeezing 50 kilograms of tomatoes out of a single square meter crop area (six times more than Spain, which ranks second at 8.5 kilograms). Additionally, Spanish tomatoes have a water footprint roughly twenty times higher than Dutch tomatoes. Yet, to grow a single kilogram of Dutch tomatoes requires ten times more energy. The benefits of indoor farming include the use of water within a closed loop and the lack of pesticides due to the replacement of soil with a hydroponic system. However, the soilless cultivation of vegetables lacks bacteria from the earth and might thus affect the human gut microbiome. Moreover, indoor food production helps cities adapt to climate change and can sometimes mitigate heat. However, as a highly controlled system with patents concentrated in the hands of a minority, it is still far from providing a solution for global food security.

The second paradigm, on the other hand, involves low-tech practices which increasingly focus on nature-as-a-process, rather than nature-as-a universe. As Bruno Latour puts it, the seventeenth-century development of economy took nature into account as a factor-in-production, indifferent to our actions and grasped from afar. This long-held view of nature-as-a-universe spawned systems of production: workers, capitalists, machines, cities, factories, and agribusinesses. Nature-as-a-process instead treats the Earth as a living organism of its own, with nonhumans being active participants in biochemical and geochemical phenomena. Furthermore, Indigenous knowledge that has been preserved is illustrative of food production practices that are opposed to synthetic biology and intelligent robots. In Mexico City, for example, Indigenous forms of farming such as chinampa floating gardens still operate under the influence of the Aztec division of urban land. Revision

Workers, mostly migrants, remove plastic sheeting from the roof of a greenhouse in Almería—a dangerous job with little protective equipment, 2025



of legacies, such as Mexican agronomy school, which was built on this heritage in the 1920s, becomes not only attributed to alternative scientists but also enters the mainstream food policies of organizations like the Food and Agriculture Organization (FAO) of the United Nations. Adopting this knowledge, intragovernmental organizations are integrating agroecology, which imitates the form and function of natural systems, as a pathway to heal the global food system. Some of these organizations—such as La Vía Campesina, operating since 1996, or the Landworkers' Alliance—offer a more hopeful vision of food production, where agroecosystems are maintained by traditional societies, managed at low intensities and in strong connection to the landscape in which they are placed. Yet in terms of numbers, their outreach into the global food system is limited, with indoor agriculture producing far more yields per square meter. With the constant increase in population and food demand, and decrease in reproductive capacity, with human labor being the scarcest resource, agroecology practices are often left to activists and grassroots unions. As twentieth-century modernists recognized some time ago, spatial solutions for large numbers of people are needed, as is the possibility of interfering in mainstream spaces of capitalist production.

When it comes to food production, such approaches won't likely happen by completely breaking with the legacies and practices of the neoliberal model. Instead, we need both competing paradigms in equal measure—biodiversity and technodiversity—paired with emerging geodiversity—returning to Indigenous farming and creating new food cultures based on conviviality, because our food systems have reached their limits.

With reference to Illich's interpretation of conviviality as a designation for limited and collectively shared industrial production, this book and the accompanying exhibition advocate a shift. How can extractive food industries become more convivial, and therefore be reconstructed and familiarized in public? This is not to say that a dominant agrifood regime may not work due to the energy needed for the massive scale of production, a fact that, even if correct, no one would be able to verify or calculate. Instead, it might not work because places of food production are not transparent, publicly seen, and beautiful enough. The political precedes the environmental, and that is why this compilation of essays seeks to point out, from an architectural point of view, the anatomies, urbanism, and functions of buildings where food production happens now, in our immediate surroundings, in Europe. By learning about production spaces, we can understand the actors who operate them, their colonial background, and finally also the propaganda and irrationality of consumerism that stands behind these spaces.

Greenhouses, Farms, and Related Lands

The narrative of the book at hand follows twelve cases of food production, which face the consequences of various twentieth-century crises:

nitrogen pollution and a lack of necessary workers to run controlled environments in the Netherlands, the desertification of Italian soils, the overfishing of European and African seas, the dissolution of the Ukrainian breadbasket region, and the migrant crisis around manual labor linking Spain and Africa, among other pressing issues. Despite the differences in scenario, this is the story of a single organizational space that increasingly became a non-place of indoor agriculture—represented by a greenhouse and a farm. This abstract space, when it comes to greenhouses, has been called Cartesian by Rem Koolhaas, meaning that based on René Descartes’s logic of making ourselves “masters and possessors of nature” such spaces were of aesthetic and public interest. Although the Dutch greenhouses emerging in the seventeenth century, following the rise of the Dutch Republic, relied on a brand-new gridded system and were geared to regularity in order to enable the investigation of plants brought from colonies, these spaces were built in prominent places, such as botanical gardens, public parks, or private properties of the ruling classes and wealthy merchants. At that time, the term *automatons* (related to today’s automation) referred to mechanically moving mythical figures or animals that decorated spectacular fountains in the gardens surrounding the greenhouses. Greenhouses applied systematization to transmit exotic environments of jungles, to imitate goods from faraway lands, and, finally, to become an integral part of numerous nineteenth-century utopias. Serving as vitrines for European empires, early greenhouses, being novel and beautiful environments, were noticed, and publicly admired. Their iconic representative, the Crystal Palace, as a self-contained environment to protect against London’s foul air, stayed a seminal visual reference and spatial manifestation of climate-controlled architecture based on the development of science, such as *physica experimentalis*. As scientific experiments spread throughout European gardens, the use of glass became a standard horticultural practice. Denis Diderot and Jean-Baptiste le Rond d’Alembert’s *Encyclopédie* records the system’s wide adoption in the eighteenth century (see p. 57).

Although the 1920s saw the spread of large-scale greenhouses to solve food scarcity after the First World War, and then the Venlo-type greenhouse revolutionized agriculture in the 1930s, it was the mid-twentieth-century Green Revolution that turned greenhouses from public spaces into infrastructures. As most of contemporary environmental historiography underscores, the Green Revolution gave birth to monocultures, so-called plantation systems. These systems operated based on hybrid seeds, genetic engineering, modern irrigation, mechanization, chemical fertilizers, and pesticides to create food for the masses, followed by the exhaustion of soils and emission of gases, all to achieve extra harvests. Landscapes were organized as huge-scale agglomerates; whole countries were used as farmlands, such as Cuba, which exported sugar to the Soviet Union for decades, or the Congo, which exported cocoa beans to Belgium (fueling its chocolate industry). Mid-twentieth century technology enabled, first, a fast rise in yields, second, cheap

The circular milking barn at the Dairy Campus in Leeuwarden, Netherlands, where cows move through an automated carousel that exemplifies the spatial logics of high-efficiency milk production





Aerial view of Tascosa Feed Yard in Bushland, Texas, showing the vast, grid-like layout of one of the High Plains' large cattle feeding operations



food, and third, a decoupling of food and city. What had been tested outdoors in the Global South was transmitted back indoors in the Global North. In the European Economic Community (EEC), established in 1957, member states were intent upon not allowing the starvation experienced after the Second World War to happen again, so the Common Agricultural Policy (CAP) was brought in, which followed the idea of a common market that, in turn, kept on increasing with the expansion of the European Union. In the 1980s and 1990s, this was ruled by the model of “productionism,” which said: “Let’s just produce more. The more food we produce, the cheaper it will become.” With the mid-twentieth-century technological uprise and the political decisions that followed, the biodiversity of food production declined. It was performed by technical spaces operated not by farmers but by land managers interested in the intensification of crops. For the sake of illustration, consider that today, in the Brandenburg area around Berlin, an average farm has 242 hectares, which equates to 340 football fields, owned by a company that hires farmers to operate agribusinesses who are not always the ones who care about the soil.

The abstract space of production has been exported worldwide in the form of either greenhouse components or the capital and digital technologies that run them (see p. 45). With the adoption of efficient, standardized agriculture coming from a standardized grid, Germany introduced the Venlo model in the late twentieth century to meet or create a demand for strawberries all year round on supermarket shelves (see p. 75), among other purposes. Yet, when it comes to omnipresent foods, the tomato appears to be a plant that represents the best gentrification of food systems across space and time. In Germany alone, more than a quarter of all vegetables consumed are tomatoes—around 30 kilograms per capita each year, including processed products. Despite attempts at regionalism, so far only around 3.5 percent of tomatoes are grown domestically, while roughly 70 percent are imported from the Netherlands and Spain. Those that do not originate from high-tech Dutch greenhouses grow in their parallel reality: the Almería region in southern Spain. There, again, the same kind of non-space, spanning 32,000 hectares, produces vegetables based on the opposite labor principle. Here, plastic is used instead of glass, the level of technologization is low, and, instead of automation, manual labor is employed—carried out, among others, by migrant workers from West Africa (see p. 87). Again, the formation of the space of food production had political origins, this time not in the colonial conquest of countries, but in Francisco Franco’s project of colonization of the desert in 1939, through the Instituto Nacional de Colonización. This introduced climate-as-a-service again, aiming to resettle the population and turn the workers into peasants, making sure that huge yields would be achieved, and therefore also food security for isolated Spain. Narratives of food security for the sake of disconnection from the world, so often run by totalitarian regimes and used as a tool of populist propaganda (see p. 239), kept on

leaving their legacies in the landscape. Five decades after Franco's death, Almería became a giant plastic bubble tensed by semilegal work and water pollution—not a territory, nor architecture, but a formation without autonomous urban and architectural logic, mimicking profit value chains.

When it comes to animals, after heated discussions on the nitrogen crisis and demands for animal welfare, traditional farms are turning into glazed structures for breeding cattle. Indeed, they appear as climates of their own, and boundaries among greenhouses and farms are getting blurred. In the same way as light, air, and water are used to control plants, in the context of cattle breeding nature-as-a-process is replaced by a whole range of rubber mats and waterbeds for a comfortable position of the animals, brushes that remove dirt and make blood circulate, and robots that automate milking and cleaning routines. These spaces that function on the principle of maximization of animal comfort to produce 200 kilograms of milk per capita in Europe yearly share the same political roots as large-scale greenhouses. While the latter had its origins in the merging of the Green Revolution seed boom with the historical advancement of climate-controlled glass spaces, modern farms are rooted in railway and refrigeration technologies. Highly productive systems such as the Chicago Union Stockyards created notorious gridded spaces of disassembly lines where millions of pigs and cows were slaughtered under horrible working conditions. Nonetheless, it was precisely through the constant interplay of industry and architecture that these spaces inspired Henry Ford's car assembly lines. Moreover, this interplay eventually fostered a disconnect from the concept of cohabitation with animals, which had previously been slaughtered within historical city centers. As later history was to show, big meat processing centers kept on moving away from cities, while meat production was rising overall, with Les Halles in Paris cited as a well-known example. Pushed to the margins of public consciousness, and very often of the architects' interests, these non-places were designed through manuals and handbooks, equipped with concrete and metal fences, to optimize cows' bodies toward *the true type*, bringing maximal performance. With spaces as evidence, through these zootechnical environments we can learn about the standardization of animal life, about the separation of calves from their mothers, about artificial thermodynamic conditions to replace natural cycles, and finally about animals' resistance to enclosure (see p. 123). By observing the spaces of farms rather than slaughterhouses, an alternative story of modern architecture can be narrated, which depicts techno-Darwinism. Breeding bulls are kept separate from cows, confined throughout their entire lives and used for semen collection for global export (see p. 141). Animals are stored, packed, and transported across continents. Cities are increasingly dominated by animal metabolism, as new disease outbreaks emerge from high-density monocultures applied to animal life.