ST.GALLEN SYMPOSIUM

Global Essay Competition 2023

Title: All We Need Is Food – A Way Forward To Secure Food Availability

Essay:

Introduction

If things turn out well for me, I have around another 60 years to live. According to the FAO, this is how long we have until we render our soil useless for growing food (FAO, 2015). Even though the exact figure is controversial[1], the message is clear: As we continue to exploit our soil, we are running out of time. However, not only our land management, but also the allocation of food is unsatisfactory: there are regions in the world where milk and honey flow and others where civil populations suffer from rising shares of hunger, culminating in between 702 and 828 million affected people (FAO, 2022a).

With this in mind, I seek to communicate two aspects that are paramount when redesigning an efficient and sustainable food production system:

- First, hunger is not a symptom of insufficient food supply – the 'not enough' narrative is an illusion. Theoretically, we have sustainable sources of food in abundance, they are simply not harnessed efficiently.
- Second, healthy soil is our most valuable asset. Despite this, modern agricultural practices deprive us of the ground we stand on and contaminate the environment.

Classifying these aspects in terms of food security (see World Bank, n.d.), they fall under (global) food availability which is the focus of my essay. Therefore, topics like access to and distribution of food which are essential for eradicating hunger are not discussed.

The Defects of Our Food Production System

Inefficiencies

Projections that assume a 'business as usual' scenario shed a gloomy light on the future of food security: to sustain 10 billion people by 2050, we need to close a food gap (in terms of crop calories) of 56 percent (Ranganathan et al., 2018). Sustainability gives the impression of getting in the way: if the agricultural system shifted in a way that it maintained planetary boundaries[2], it could feed only 3.4 billion people (Gerten et al., 2020).

However, despite this, the trade-off between food availability and sustainability is not irrevocable. When accounting for a transition to a sustainable food production system, net food production could sustain the expected world population by 2050 (Gerten et al., 2020). These transitions must tackle inefficiencies regarding the way we currently produce and consume food. Two of them are:

- Excessive amounts of food end up in trash bins.
- Too much food is fed to animals instead of directly sustaining humans.

---

[1] Alternative research concedes up to 100 years. Others think that both figures are exaggerated. In general, it is hard to determine one single figure (Ritchie, 2021a).
[2] By for example abandoning agricultural land, preserving forests, reducing water withdrawal and decreasing fertilization (Gerten et al., 2020).

Food waste

On a global scale, food loss and waste amount to 21 percent of all food (UN, n.d.). One fourth of this would be sufficient to feed all of the world's hungry people (SDG2 Advocacy Hub, 2018). If no food was lost or wasted, 28 percent of the world's agricultural area would be freed up (FAO, n.d.).

Animal feed

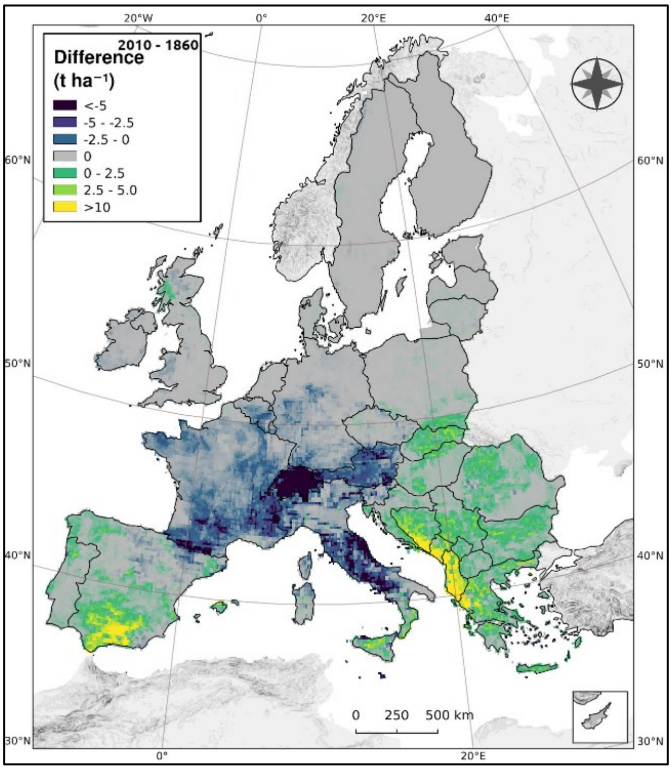
The world is hungry for meat: in 2019 on average, around 40 percent of human protein intake stemmed from animals (Roser et al., 2013). The loss in conversion is noteworthy: It takes 4 kcal of crop products to generate 1 kcal of animal products[3] (Pradhan et al., 2013). Consequently, we could feed significantly more people if crop harvests ended up on their plates instead of in feeding throughs. Despite livestock providing less than 20 percent of the world's supply of calories, its rearing takes up nearly 80 percent of global agricultural land (Ritchie, 2017).

Soil Health and Modern Agriculture

Even though soil is our 'natural capital', we find it in a desolate condition: in the last 40 years, nearly a third of arable land has been lost to soil erosion or pollution (Cameron et al., 2015). Every year, the size of Germany's arable land is rendered useless (Rickson et al., 2015; World Bank, n.d.). In 2019, Central America, Southern Brazil, parts of East Africa and East Asia showed the highest estimated soil erosion rates (predicted through Global Soil Erosion Modelling 1.3) (Borrelli et al., 2022). In Europe, between 1860 and 2010 soil degradation rates have increased in France, Belgium, Germany, Austria, Switzerland and Italy (see Figure 1). Therefore, the soil mismanagement of past generations has been particularly pronounced in West Europe.

[3] This an average figure and varies depending on parameters like the type of crop, type of animal and location.

Figure 1) European soil erosion rate variation between 1860 and 2010
Source: Fendrich et al., 2022, p. 7847



However, even positive changes in soil erosion rates over time like in Central Europe are concerning: also in this case soil erodes – just at a decreasing pace. Currently, on average soil erodes up to 100 times quicker than it is built (Cameron et al., 2015; Sulaeman and Westhoff, 2020) – and rehabilitating soil is challenging: it takes at least a century to form 2.5 centimeters of topsoil[4] (Cho, 2012; Cameron et al., 2015). How could it get that far?

Healthy soil retains nutrients and makes them available to plants, creates structure and holds water close to plants' roots (Bot and Benites, 2005). However, 'modern' practices like repetitive harvesting, deep tillage, overuse of synthetic fertilizers, vegetation burning and an overall insufficient effort to keep nutrients and carbon in balance disturb the soil's ecosystem. Researchers compare out treatment of soil to a hydroponic system, "a physical substrate to support plants, [but] providing little else" (Cameron et al., 2015). As a result, many farmers are left with soil susceptible to nutrient and water runoff and erosion (Bot and Benites, 2005).

Particularly synthetic fertilizers have sparked debates, since on the one hand they often harm the environment, but on the other hand their use has facilitated feeding a growing population since the 1960s (Ritchie et al., 2022). The latter, however, might come to an end soon: in high-income countries yield growth is limited (OECD/FAO, 2022), which can explain why since the beginning of this millennium, yields of several major crops have stagnated (Cameron et al., 2015). After a point of maximum efficiency has been surpassed, an increase in fertilizer application results in stagnant or even declining yields (Noor et al., 2020).

---

[4] Topsoil is the upper most productive 30 centimeters of soil, with 30 centimetres being a generalized approximation (Ritchie, 2021a).

Environmental Impact

Modern agriculture has repercussions beyond its own boundaries. Some detrimental environmental impacts are:

- Pollution due to nutrient runoff and pesticides leading to the growth of algae, oxygen depletion, and surface and groundwater contamination, which often surpasses what is considered the 'safe limit' (Cameron et al., 2015; FAO, 2022b).
- A loss of biodiversity and habitat of wild animals (Sánchez-Bayo and Wyckhuys, 2019).
- The depletion of surface and groundwater resources due to extensive irrigation (Bierkens and Wada, 2019).
- The emission of greenhouse gases like CO2 and the 300 times more potent N2O due to practices like ploughing, which releases carbon stored in the soil, and the use of fertilizers (FAO, 2022b). Overall, an estimated 21 to 37 percent of all emissions are caused by the agricultural sector (IPCC, 2019), of which three-quarters are linked to the livestock sector (Springmann et al., 2018; Zattara and Aizen, 2021).
- Deforestation especially in South America (Fraanje and Garnett, 2020). A sixth of the Amazon rainforest has already been lost (Irfan, 2019). Large parts of this area is used for the cultivation of soy, a popular animal feed (Fraanje and Garnett, 2020).
- A higher likelihood of zoonoses: an increasing exposure of humans to wildlife and adverse husbandry conditions in factory farming favour the emergence of new viruses (Tollefson, 2020; Marchese and Hovorka, 2022).
- An increased human antimicrobial resistance due to the consumption of extensively antibiotics-fed livestock animals (O'Neill, 2016).

Who Is to Blame?

Inefficiencies

In U.S.-American food supply chains, it is estimated that the consumption side accounts for 45 percent, pre-harvest losses for 29 percent and processing for 11 percent of total food loss and waste (CEC, 2017). These figures differ significantly across countries, but a global commonality is that consumers in particular in the US and Europe are among the main culprits.

Consumers do not necessarily agree with the way food is produced – particularly as there are deficiencies when it comes to transparency and awareness (Astill et al., 2019). Nonetheless, with every purchasing decision like buying animal-based products, a signal is sent to the agricultural markets which influences managerial and investment decisions.

Soil Health And Agriculture

Subsidies

Global subsidies have reached 700 billion USD a year (The Food and Land Use Coalition, 2019). They cannot only determine how, but also what farmers grow and rear: farmers that cultivate fruits and vegetables tend to receive less subsidies than for example meat-producing farmers (FAO, 2022a). According to the Food and Land Use Coalition, on a global scale only one percent of farm subsidies end up benefitting the environment (The Food and Land Use Coalition, 2019).

Big Ag

Apart from farmers, there are stakeholders in the upstream and downstream supply chain that played a key role in establishing the current food production system. They are commonly referred to as 'Big Ag', a term that encompasses companies and conglomerates that supply the inputs that most farms have become dependent on (e.g. fertilizers, seeds, machinery and technologies). Segment- and country-specific studies show that few companies concentrate a large share of the respective market, making it challenging for smaller actors to assert themselves (see e.g. Ashwood et al., 2022).

How can we ensure food availability in the future?

In the past, persons in charge in the agricultural sector have turned a blind eye on the finiteness of natural resources. This now falls back on us. Awareness is growing – now we need to take collective action and initiate a large-scale turnaround.

We must align global food production with the principles of sustainability and efficiency. My suggestions are:

- A focus on sustainability
    - A shift towards regenerative agricultural practices that harness and safeguard ecological processes. 'Conservation agriculture' encompasses practices like no or minimum tillage, protective crop cover that fixes nutrients in the soil, crop rotations and the preservation of biodiversity and soil organic matter (Bot and Benites, 2005; Cameron et al., 2015). The resulting healthy soil sequesters emissions (Melillo and Gribkoff, 2021). Currently, in the EU organic farming makes up only 9.1 percent of the total utilized agricultural area (Eurostat, 2022), giving leeway for expansion.
    - A prevention of the overuse of polluting fertilizers.
    - A rehabilitation of already damaged land (Sulaeman and Westhoff, 2020; Bot and Benites, 2005).
    - A turn towards husbandry that preserves soil health and increases the share of soil organic matter and microbes, e.g. by means of grassland rotation, dung, and grazing of grass (Powell, 2018).
- An increase in efficiency
    - A reduction of food loss and waste, e.g. by means of optimised technologies in supply chain management (UN Environment Programme, 2020).
    - A turn towards more efficient and natural sources of livestock feed.
    - A maximization of fertilizer efficiency, e.g. by means of precision farming (Ritchie, 2021b).
    - An efficient use of three-dimensional space, e.g. by means of vertical farming.
    - A change of consumer behaviour, e.g. by means of a shift to a plant-heavy or plant-based diet in particular in emerging 'meat-hungry' countries (see Foley, n.d.).
    - An increase of productivity, e.g. by means of sustainably exploiting yield growth potentials in medium- and low-income countries (OECD/FAO, 2022), and by considering growing GMOs.
- Further suggestions
    - A strategy to cope with potentially higher temporal yield variability of sustainable systems (see Knapp and van der Heijden, 2018).
    - A potential expansion of arable land (if sustainable), e.g. due to a possible shift of agricultural climate zone (see King et al., 2018).
    - An alignment of global and regional policies and subsidies that foster the transition.
    - A promotion of transparency and awareness of the mentioned problems.
    - A diversion of money towards innovations like cultured meat and hydroponics.

Conclusion

If we transform our food production system and change consumption patterns on a global scale, there is no trade-off between food availability and sustainability. Once we drastically reduce inefficiencies like food loss and waste and feeding livestock animals instead of humans, we cannot only sustain the current, but also the projected future population. For the sake of our children and grand-children, it is paramount that we preserve and restore soil health and fertility. A range of solutions can invert inefficient and unsustainable practices that are engrained in 'modern agriculture'. However, if they are not implemented, large-scale food insecurity and consequent impacts like migration and social upheavals, and environmental disasters await us. In the end, all we need is food – securing this basic physical need must be a key priority on the global agenda.

Bibliography

Ashwood, L., Pilny, A., Canfield, J., Jamila, M., Thomson, R., 2022. From Big Ag to Big Finance: a market network approach to power in agriculture. Agric. Hum. Values 39, 1421–1434. https://doi.org/10.1007/s10460-022-10332-3

Astill, J., Dara, R.A., Campbell, M., Farber, J.M., Fraser, E.D.G., Sharif, S., Yada, R.Y., 2019. Transparency in food supply chains: A review of enabling technology solutions. Trends Food Sci. Technol. 91, 240–247. https://doi.org/10.1016/j.tifs.2019.07.024

Bierkens, M.F.P., Wada, Y., 2019. Non-renewable groundwater use and groundwater depletion: a review. Environ. Res. Lett. 14, 063002. https://doi.org/10.1088/1748-9326/ab1a5f

Borrelli, P., Ballabio, C., Yang, J.E., Robinson, D.A., Panagos, P., 2022. GloSEM: High-resolution global estimates of present and future soil displacement in croplands by water erosion. Sci. Data 9, 406. https://doi.org/10.1038/s41597-022-01489-x

Bot, A., Benites, J., 2005. The importance of soil organic matter: key to drought-resistant soil and sustained food production, FAO soils bulletin. Food and Agriculture Organization of the United Nations, Rome.

Cameron, D., Osborne, C., Horton, P., Sinclair, M., 2015. A sustainable model for intensive agriculture (Briefing Note). Graham Centre for Sustainable Futures, University of Sheffield.

CEC, 2017. Characterization and Management of Organic Waste in North America: Foundational Report. Commission for Environmental Cooperation, Montreal, QC, CA.

Cho, R., 2012. Why Soil Matters. State Planet. URL https://news.climate.columbia.edu/2012/04/12/why-soil-matters/ (accessed 1.29.23).

Eurostat, 2022. EU's organic farming area reaches 14.7 million hectares [WWW Document]. URL https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220222-1 (accessed 2.1.23).

FAO, 2022a. In Brief to The State of Food Security and Nutrition in the World 2022. FAO; IFAD; UNICEF; WFP; WHO; https://doi.org/10.4060/cc0640en

FAO, 2022b. Soils for nutrition: state of the art. FAO. https://doi.org/10.4060/cc0900en

FAO, 2015. International Year of Soil Conference [WWW Document]. Food Agric. Organ. U. N. URL http://www.fao.org/soils-2015/events/detail/en/c/338738/ (accessed 1.29.23).

FAO, n.d. Food wastage: Key facts and figures [WWW Document]. URL https://www.fao.org/news/story/en/item/196402/icode/ (accessed 1.28.23).

Fendrich, A.N., Ciais, P., Lugato, E., Carozzi, M., Guenet, B., Borrelli, P., Naipal, V., McGrath, M., Martin, P., Panagos, P., 2022. Matrix representation of lateral soil movements: scaling and calibrating CE-DYNAM (v2) at a continental level. Geosci. Model Dev. 15, 7835–7857. https://doi.org/10.5194/gmd-15-7835-2022

Foley, J., n.d. A Five-Step Plan to Feed the World [WWW Document]. Natl. Geogr. Mag. URL http://www.nationalgeographic.com/foodfeatures/feeding-9-billion/ (accessed 1.29.23).

Fraanje, W., Garnett, T., 2020. Soy: Food, Feed, and Land Use Change, Foodsource Building Block. Food Climate Research Network, University of Oxford.

Gerten, D., Heck, V., Jägermeyr, J., Bodirsky, B.L., Fetzer, I., Jalava, M., Kummu, M., Lucht, W., Rockström, J., Schaphoff, S., Schellnhuber, H.J., 2020. Feeding ten billion people is possible within four terrestrial planetary boundaries. Nat. Sustain. 3, 200–208. https://doi.org/10.1038/s41893-019-0465-1

IPCC, 2019. Special Report on Climate Change and Land. URL https://www.ipcc.ch/srccl/ (accessed 1.29.23).

Irfan, U., 2019. Brazil's Amazon rainforest destruction is at its highest rate in more than a decade [WWW Document]. Vox. URL https://www.vox.com/science-and-health/2019/11/18/20970604/amazon-rainforest-2019-brazil-burning-deforestation-bolsonaro (accessed 1.29.23).

King, M., Altdorff, D., Li, P., Galagedara, L., Holden, J., Unc, A., 2018. Northward shift of the agricultural climate zone under 21st-century global climate change. Sci. Rep. 8, 7904. https://doi.org/10.1038/s41598-018-26321-8

Knapp, S., van der Heijden, M.G.A., 2018. A global meta-analysis of yield stability in organic and conservation agriculture. Nat. Commun. 9, 3632. https://doi.org/10.1038/s41467-018-05956-1

Marchese, A., Hovorka, A., 2022. Zoonoses Transfer, Factory Farms and Unsustainable Human–Animal Relations. Sustainability 14, 12806. https://doi.org/10.3390/su141912806

Melillo, J., Gribkoff, E., 2021. Soil-Based Carbon Sequestration [WWW Document]. MIT Clim. Portal. URL https://climate.mit.edu/explainers/soil-based-carbon-sequestration (accessed 2.1.23).

Noor, M.A., Nawaz, M.M., Hassan, M. ul, Sher, A., Shah, T., Abrar, M.M., Ashraf, U., Fiaz, S., Basahi, M.A., Ahmed, W., Ma, W., 2020. Small Farmers and Sustainable N and P Management: Implications and Potential Under Changing Climate, in: Datta, R., Meena, R.S., Pathan, S.I., Ceccherini, M.T. (Eds.), Carbon and Nitrogen Cycling in Soil. Springer Singapore, Singapore, pp. 185–219. https://doi.org/10.1007/978-981-13-7264-3_6

OECD/FAO, 2022. OECD-FAO Agricultural Outlook. https://doi.org/10.1787/agr-outl-data-en

O'Neill, J., 2016. Tackling Drug-Resistant Infections Globally. Final Report and Recommendations. The Review on Antimicrobial Resistance.

Powell, G., 2018. Sustainable grazing strategies that meet ecological demands, Nuffield Farming Scholarship Trust Report. Nuffield Farming Scholarship Trust.

Pradhan, P., Lüdeke, M.K.B., Reusser, D.E., Kropp, J.P., 2013. Embodied crop calories in animal products. Environ. Res. Lett. 8, 044044. https://doi.org/10.1088/1748-9326/8/4/044044

Ranganathan, J., Waite, R., Searchinger, T., Hanson, C., 2018. How to Sustainably Feed 10 Billion People by 2050, in 21 Charts.

Rickson, R.J., Deeks, L.K., Graves, A., Harris, J.A.H., Kibblewhite, M.G., Sakrabani, R., 2015. Input constraints to food production: the impact of soil degradation. Food Secur. 7, 351–364. https://doi.org/10.1007/s12571-015-0437-x

Ritchie, H., 2021a. Do we only have 60 harvests left? [WWW Document]. Our World Data. URL https://ourworldindata.org/soil-lifespans (accessed 1.29.23).

Ritchie, H., 2021b. Can we reduce fertilizer use without sacrificing food production? [WWW Document]. Our World Data. URL https://ourworldindata.org/reducing-fertilizer-use (accessed 1.29.23).

Ritchie, H., 2017. How much of the world's land would we need in order to feed the global population with the average diet of a given country? [WWW Document]. Our World Data. URL https://ourworldindata.org/agricultural-land-by-global-diets (accessed 1.29.23).

Ritchie, H., Roser, M., Rosado, P., 2022. Crop Yields. Our World Data.

Roser, M., Ritchie, H., Rosado, P., 2013. Food Supply. Our World Data.

Sánchez-Bayo, F., Wyckhuys, K.A.G., 2019. Worldwide decline of the entomofauna: A review of its drivers. Biol. Conserv. 232, 8–27. https://doi.org/10.1016/j.biocon.2019.01.020

SDG2 Advocacy Hub, 2018. Food waste in a food insecure world [WWW Document]. URL https://www.sdg2advocacyhub.org/news/food-waste-food-insecure-world (accessed 1.26.23).

Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B.L., Lassaletta, L., de Vries, W., Vermeulen, S.J., Herrero, M., Carlson, K.M., Jonell, M., Troell, M., DeClerck, F., Gordon, L.J., Zurayk, R., Scarborough, P., Rayner, M., Loken, B., Fanzo, J., Godfray, H.C.J., Tilman, D., Rockström, J., Willett, W., 2018. Options for keeping the food system within environmental limits. Nature 562, 519–525. https://doi.org/10.1038/s41586-018-0594-0

Sulaeman, D., Westhoff, T., 2020. The Causes and Effects of Soil Erosion, and How to Prevent It.

The Food and Land Use Coalition, 2019. Growing Better: Ten Critical Transitions to Transform Food and Land Use, Global Consultation Report. The Food and Land Use Coalition.

Tollefson, J., 2020. Why deforestation and extinctions make pandemics more likely. Nature 584, 175–176. https://doi.org/10.1038/d41586-020-02341-1

UN, n.d. Stop Food Loss and waste, for the people, for the planet [WWW Document]. URL https://www.un.org/en/observances/end-food-waste-day (accessed 1.28.23).

UN Environment Programme, 2020. Food loss and waste must be reduced for greater food security and environmental sustainability [WWW Document]. UN Environ. URL http://www.unep.org/news-and-stories/press-release/food-loss-and-waste-must-be-reduced-greater-food-security-and (accessed 1.26.23).

World Bank, n.d. What is Food Security? There are Four Dimensions [WWW Document]. URL https://www.worldbank.org/en/topic/agriculture/brief/food-security-update/what-is-food-security (accessed 1.29.23a).

World Bank, n.d. Arable land (hectares) - Germany [WWW Document]. URL https://data.worldbank.org/indicator/AG.LND.ARBL.HA?locations=DE (accessed 1.29.23b).

Zattara, E.E., Aizen, M.A., 2021. Worldwide occurrence records suggest a global decline in bee species richness. One Earth 4, 114–123. https://doi.org/10.1016/j.oneear.2020.12.005

Word Count (essay text only, excluding the caption of the figure): (2099/2100)