CHAPTER 7

Food and Agriculture

Food provides energy for humans to pursue lives of work, service, and play with family, friends, and co-workers. Food consumption is rather predictable, because food energy intake (measured in food calories) scales linearly with population. Each healthy individual consumes about 2000 food calories per day, more for teens and active people, slightly less for women than men.

But food doesn't appear on plates magically, out of nowhere. Food arrives on plates through a network of natural and human-created transformation processes that convert solar energy into available, ingestible energy. This network is often called "agriculture." The economic value added of the agriculture, forestry, and fishing industry is only 1 % of GDP for the U.S. and about 3.5 % of GDP worldwide [20]. But its importance goes far beyond its economic value. Without agriculture, none of us would be here today! This chapter presents key information about the food system and explores its sustainability challenges.

7.1 FEATURES OF THE FOOD AND AGRICULTURE SYSTEM

Figure 7.1 shows a Sankey diagram of material flows in the U.S. agriculture system [21, Fig. 1]. Several observations can be made.

First, the mass efficiency of the agriculture system is low. Consumed food (259,610 million pounds) is a very small fraction of the total input to the system (1,636,360 million pounds), yielding a mass-based efficiency of 15.9 %.

Second, animal-based food production comprises a large and important intermediate processing stage. Animal-based food production is less efficient than the overall food system with 9.64×10^5 million pounds as input and only 10.3 % efficiency on a mass basis.

Third, losses (wastage) at the final stages reduce the efficiency of the entire food system. In fact, final stage mass-based efficiency is only 72.9 %.

Fourth, imports are relatively small compared to domestic production and consumption. Thus, the U.S. is reasonably self-sufficient regarding food supply. However, exports of crops (355,560 million pounds) are a significant source of demand for the U.S. agriculture system.

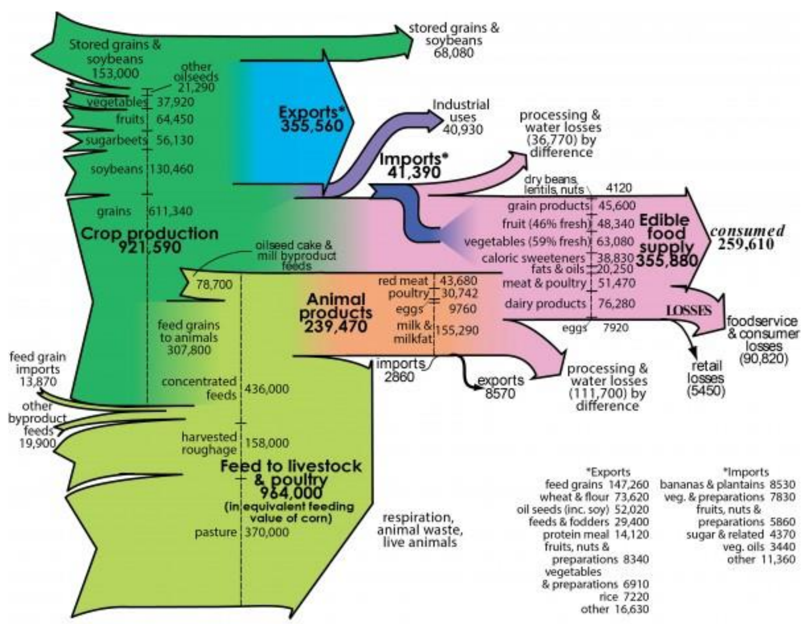

Figure 7.1: Material flow in the U.S. food system (1995, flows in million pounds) [21, Fig. 1].

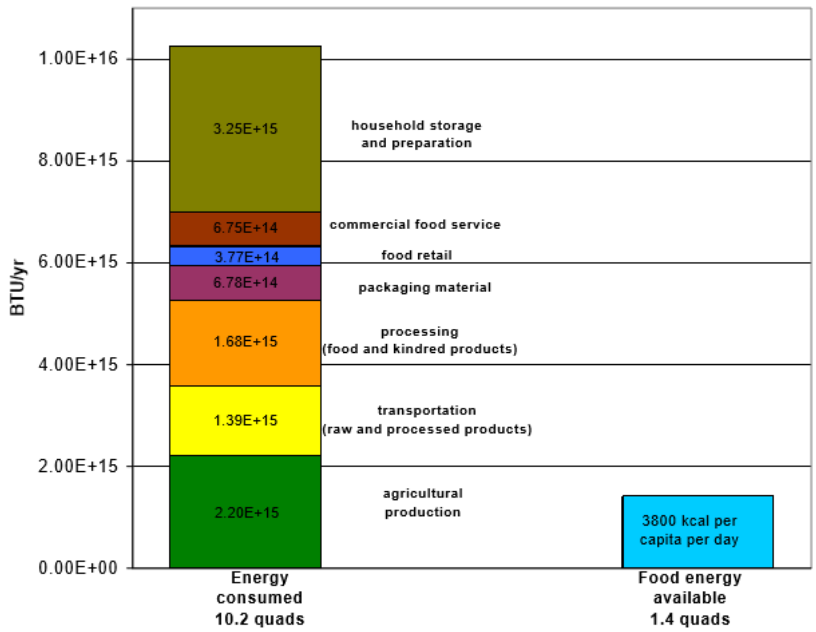

Figure 7.2: Percentages of energy consumed in different aspects of food delivery [21, Fig. 2]. **** Larisa: what year is this for? what country is this for? Can we make a ggplot version of this graph?

Finally, relative to annual worldwide consumption, there is little storage of food beyond what is needed to compensate for expected seasonal weather variations. In other words, the agriculture system produces what is needed now (or at least this year). Given that food demand scales with population, weather- and climate-related supply-side disruptions are more significant than demand-side disruptions for determining food prices.

7.2 FOOD AND AGRICULTURE SUSTAINABILITY CHALLENGES

The food system faces many sustainability challenges, including energy return ratios, CO_2 emissions, and justice issues.

7.2.1 ENERGY RETURN RATIOS

Because food is energy, the overall energy efficiency of the food delivery system can be calculated. Figure 7.2 shows the energy consumed and supplied by various aspects of the food delivery system [21, Fig. 2]. The energy efficiency of the food delivery system is 13.7 %. A good rule of thumb is that it takes roughly 7 calories of energy to provide 1 calorie of food energy. Thus, the energy return on investment (EROI) for the food system is only 1/7. The fact that the energy efficiency of the food delivery system is less than 1 means that the food delivery system is not a *source* of energy for society. Rather it is a *sink* of energy for society. Thus, today's food system is unsustainable from an energy point of view.

To put it another way, society spends more energy to *get* food than it *obtains* from food. Animals that spend more energy to obtain food than they gain from eating food ultimately die from lack of energy. Agrarian societies that spend more energy to obtain food than they gain from eating food ultimately cease to exist. But modern society remains viable because its food delivery system is supported by energy inputs from an external source: fossil fuels. Fossil fuels supply the energy for machines in agriculture, food transportation, food processing, food packaging, retail, food storage, and food preparation.

> A pithy way to summarize the sustainability challenge posed by today's food energy return ratios is: "We don't eat food; we eat oil."

7.2.2 CO_2 EMISSIONS

A second sustainabiilty challenge that arises in food and agriculture is the greenhouse gas emissions whose origin is the food delivery system. Figure 7.3 shows the amount of CO_2 released from the production and distribution of one serving of several types of food [22, Fig. 2]. Figure 7.3 leads to two important observations: (a) animal-based foods have much more environmental impact than plant-based foods and (b) consuming food that is closer to the base of the food chain has environmental benefits.

> Convenient calculators for greenhouse emissions from food production can be found online [23]. Factors such as transport distance and wastage percentages are important for determining GHG emissions from food.

7.2.3 JUSTICE

Many justice issues arise when considering the sustainability of the food and agriculture system. One issue is the spatial distribution of food availability. "Food deserts" are places where fresh food is unavailable to people without access to transportation. Figure 7.4 shows, on a county-by-country basis in the U.S., the proportion of people who lack access to fresh food.

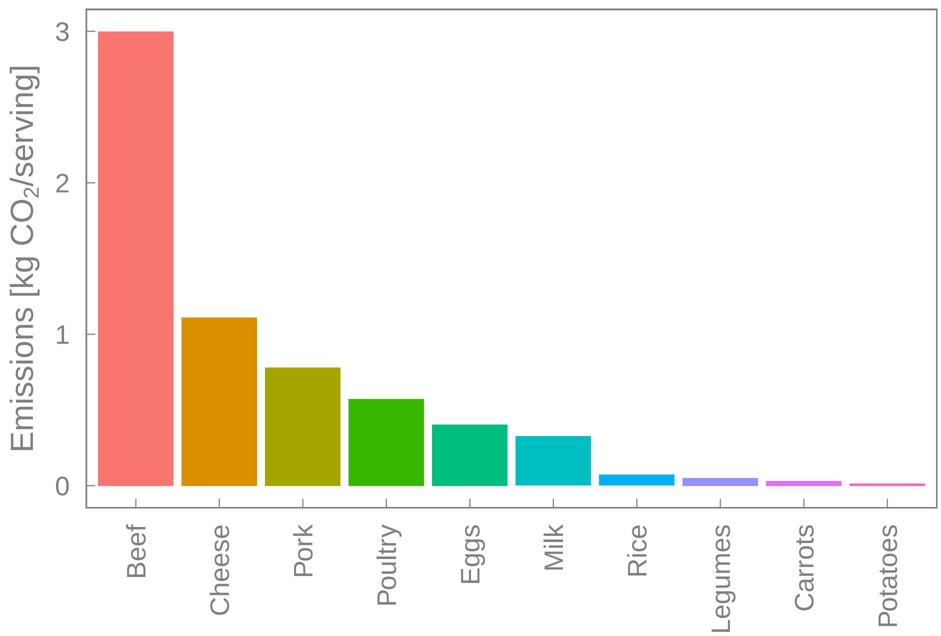

Figure 7.3: Carbon dioxide (CO_2) equivalent emissions per serving of various foods [22, Fig. 2].

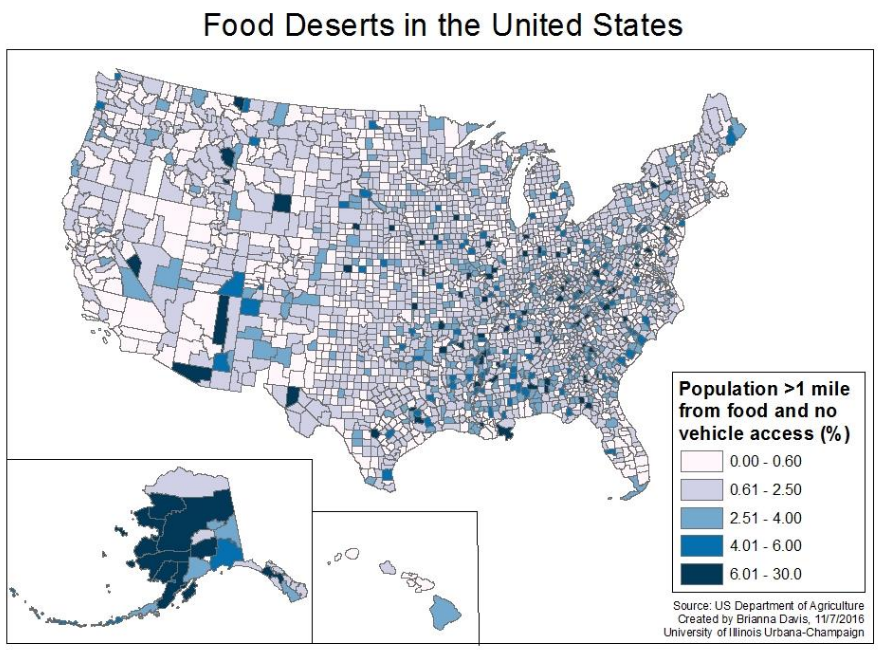

Figure 7.4: Food deserts in the U.S. **** Larisa: include reference here. ****

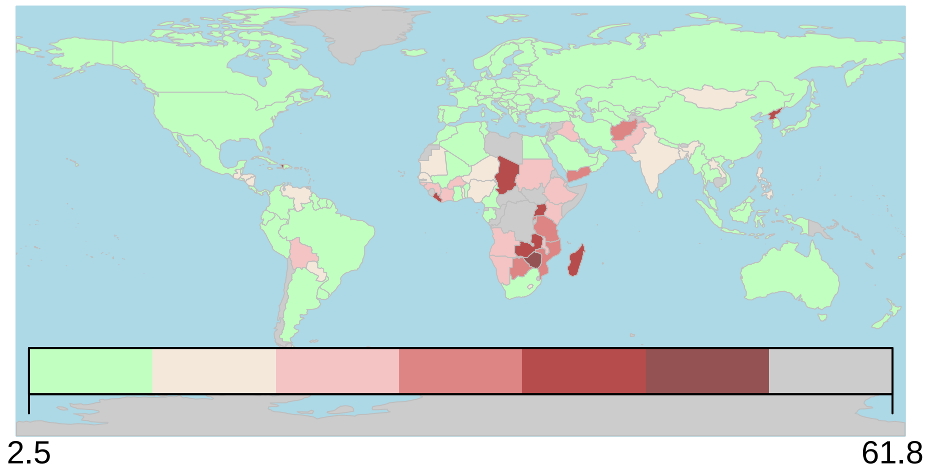

Figure 7.5: Percentages of population undernourished in all countries 2015. **** Larisa: add citation here. ****

Lack of access to food tends to correlate with lack of access to money, so malnourishment tends to mirror poverty. Figure 7.5 shows the percentage of people in each country who are undernourished.

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## 144 codes from your data successfully matched countries in the map
## 2 codes from your data failed to match with a country code in the map
## 100 codes from the map weren't represented in your data

## Warning in rwmGetClassBreaks(dataCategorised, catMethod = catMethod,
numCats = numCats, : classification method should be set to one of
:fixedWidth diverging quantiles pretty logFixedWidth categorical
## setting to fixedWidth as default
## Warning in rwmGetColours(colourPalette, numColours): 6 colours specified
and 7 required, using interpolation to calculate colours
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7.3 FOOD AND AGRICULTURE TRANSITIONS

To achieve a more-sustainable food system, changes on many levels will be needed, from the personal to the global.

On the personal level, eating closer to the base of the food chain and pursuing vegetarian or vegan diets are among the most effective ways to reduce negative environmental impacts of the food supply system. Participating in the slow food movement can promote sustainability, as it seeks to promote traditional, regional cuisine, thereby reducing the distance from farm to plate.

At the global level, organic farming seeks to limit the use of synthetic fertilizers and pesticides by promoting the use of compost, manure, and natural practices. Practices such as crop rotation and biological (as opposed to chemical) past control are encouraged.

The growing problem of food waste spans the personal and global levels. Actions and policies to minimize food waste provide benefits such as reducing inputs to the food system and strain on the biosphere.

QUESTIONS

7.1. Verify the efficiency values in Section 7.1. Use Figure 7.1 as the basis for your calculations.

7.2. Verify the efficiency values in Section 7.2.1. Then perform your own research to find the proportions of coal, oil, and natural gas consumed by the food and agriculture system. Are we eating coal? Are we eating oil? Or are we eating natural gas?

7.3. Use a food emissions calculator (such as the one suggested in this chapter [23]) to estimate the greenhouse emissions from your food choices over the course of a week. Compare to your peers. How do your food-related emissions compare to your emissions from transportation-related activities? Guided by the figures and advice in this chapter, develop an alternative diet and estimate its greenhouse gas emissions. What amount of GHG emissions reductions can you obtain by changing your diet?

7.4. Dig deeper into the problem of food deserts. Where are they most prevalent? What are their causes? What can be done to alleviate them?