Agriculture and Food Production by the Numbers

Land Area[1]: [Units in Mha = 10^6 ha]

Agricultural land (≈50% of habitable land area)........5000
 Pasture and animal feed (≈80% of agri.)............4000
 Crops (≈20% of agri.) 1000
Human infrastructure (≈1% of habitable).................100

Food Production[2, 3, 4]:

≈15×10^{15} Calories are produced from human-edible crops globally each year, of which ≈50% is allocated for human consumption, ≈15% for non-food uses, and ≈35% for livestock consumption. This does not include Calories derived from non-edible plant material fed to livestock (≈10×10^{15} Calories per year).

Estimated increase in total yield required to feed the global population in 2050[5]: +60-100%.

Top Crops by Calories produced

Crop	Calories (10^{15})	Proteins (g) (10^{13})	Area (Mha)
Sugar Cane	3 - 7	0	30
Maize	2 - 4	10	200
Rice, paddy	2 - 3	5	200
Wheat	2 - 3	10	200
Oil Palm Fruit	1 - 2	0.6	20
Soybean	1 - 2	10	100
Rapeseed	0.4 - 0.5	2	30
Barley	0.4 - 0.5	2	50
Top crops total	**≈ 12 - 20**	**40**	**830**
Next 50 sum	**4**	**10**	**400**

Values in the table represent total production, including what is allocated for livestock consumption and for non-food uses. Calories are presented as a range, with an upper-limit.

Feed to Food conversion efficiencies[6]:

(% Calories | % Protein)
Beef...3 | 3
Pork...9 | 9
Poultry...13 | 21
Dairy..17 | 14
Eggs...17 | 31

GHG emissions[7, 8]: [Units in 10^9 tonnes of CO_2eq] (global/annual)

Total...52
Food Production (≈25% of total)..................................13
 Livestock and fisheries (≈30%).............................4
 Crop production (≈30%)......................................4
 Land use (≈25%)..3
 Supply chain (≈15%)...2

Water Usage[9]: [Units in km^3] (global/annual)

Blue Water withdrawn (≈10% of available)...............4000
 Agriculture (≈70%)...2800
 Industry (≈20%)...800
 Municipalities (≈10%).......................................400
Blue Water consumption (≈50% of withdrawn)........2000
 Agriculture (≈90% of consumption)................ 1800

Number of farms worldwide and their breakdown by size[10]: 500-600 million

Very small (<1 ha)...72%
Small (1-2 ha) 12%
Medium (2-5 ha) 10%
Large (>5 ha)...6%

Percentage of agricultural land area implementing sustainable intensification (SI) practices by type[11]:
[Total ≈ 10% of land area, or ≈ 450 Mha; 30% of farms worldwide]

Conservation Agriculture...3.6%
Pasture/Forage Redesign...1.6%
Integrated Crop/Biodiv. Redesign..............................1.3%
Trees in Agro-systems..1.0%
Irrigation/water management...................................0.7%
Integrated Pest Management....................................0.4%
Intensive small/patch systems..................................0.3%

Nitrogen input to crop production[12]:
[Total ≈ 170 Mt N $year^{-1}$]

Synthetic fertilizer (Haber-Bosch)...............................50%
Biological Nitrogen Fixation (legumes).......................20%
Manure (input and left on field)................................10%
Crop residue...10%
Atmospheric deposition + Irrigation...........................10%

Change in global food productivity 1960 to 2010[13]:
+150-200%

Supplementary Info and Definitions

Land area[1]

"In the visualization we see the breakdown of global land area today. 10% of the world is covered by glaciers, and a further 19% is barren land – deserts, dry salt flats, beaches, sand dunes, and exposed rocks. This leaves what we call 'habitable land'. Half of all habitable land is used for agriculture. This leaves only 37% for forests; 11% as shrubs and grasslands; 1% as freshwater coverage; and the remaining 1% – a much smaller share than many suspect – is built-up urban area which includes cities, towns, villages, roads and other human infrastructure. There is also a highly unequal distribution of land use between livestock and crops for human consumption. If we combine pastures used for grazing with land used to grow crops for animal feed, livestock accounts for 77% of global farming land."

Food Production[3]

"5935 kcal/p/d of crops directly edible by humans are grown alongside 3812 kcal/p/d of vegetable matter eaten by other animals but not directly digestible by humans (i.e. GP&S). This total of 9747 kcal/p/d is more than four times the average dietary energy requirement for healthy life (ADER) of 2353 kcal/p/d."

"Of the 5935 kcal/p/d directly edible by humans, 338 kcal/p/d are left in the ground or lost during harvest and 332 kcal/p/d are lost post-harvest. Of the remaining 5265 kcal/p/d, 30% are exported internationally but only 29% are received as imports (the difference being a trading loss of 73 kcal/p/d)... A further 126 kcal/p/d are invested for re-planting."

"Globally, 808 kcal/p/d are directed to 'non-food uses', mainly biofuels, particularly liquid hydrocarbons (Serrano-Ruiz et al., 2012). Other uses include cosmetics, pharmaceuticals, paints etc."

Estimated increase in total yield required to feed the global population in 2050[5]

"...approximately 800 million people are still chronically undernourished, most of them living in Asia and Africa (FAO 2017). Over the next few decades, the demand for food will increase further due to population and income growth. In addition, plant-based products are increasingly being used as renewable resources. To keep up with this rising demand, it is estimated that global agricultural production will have to increase by at least 60% and possibly up to 100% until 2050 (Godfray et al. 2010, Hertel 2015)."

Feed to Food conversion efficiencies[14]

Definition: "Feed Conversion Ratios (FCRs) measure the amount of feed/crops needed to produce a unit of meat. FCRs and related issues are generally discussed in terms of "efficiency." For example, chickens are more efficient converters crops that cows. They have a lower FCR, meaning that it takes less feed to create a pound of chicken than a pound of beef."

Top crops by Calories produced (per capita/day) versus the next 50 crops

Crop	Cal/capita/day	Protein/capita/day
Sugarcane	2600	0
Maize	1500	40
Rice, paddy	1100	20
Wheat	1100	40
Oil Palm Fruit	700	2
Soybean	700	40
Rapeseed	200	7
Barley	200	7
Top crops total	**8100**	**150**
Next 50	**1500**	**40**

Values in the table represent total production, including what is allocated for livestock consumption and for non-food uses.

GHG emissions[7, 8]

"Today's food supply chain creates ~13.7 billion metric tons of carbon dioxide equivalents (CO2eq), 26% of anthropogenic GHG emissions."

"Livestock & fisheries account for 31% of food emissions." Animals raised for food production contribute to GHG emissions in several ways. Livestock (mainly cattle) produce methane through digestive processes. Manure management produces methane and nitrous oxide, while pasture management practices can also contribute to GHG emissions (fertilizers, stocking rates, forage quality). Fuel consumption from fishing vessels also falls into this category.

"Crop production accounts for 27% of food emissions." Emissions that result directly from agricultural production, including: nitrous oxide from fertilizer and manure application, methane emissions from rice paddies and carbon dioxide produced by agricultural machinery.

"Land use accounts for 24% of food emissions." The expansion of agricultural land often comes at the cost of removing carbon sinks, such as forests and grasslands, resulting in net carbon dioxide emissions. This is often termed 'land use change'. Other land use contributors include 'savanna burning' to allow for animal grazing (mainly in Africa), and soil cultivation that releases carbon dioxide through plowing, etc.

"Supply chains account for 18% of food emissions." Contributors to supply chain emissions include food processing, transport, and packaging, among others. Food transport produces a relatively small percentage of food production emissions (6% globally), thus, eating locally grown food may not be the most effective way to reduce supply chain emissions. Alternatively, approx. 25% of food production emissions end up as food wastage, either during the supply chain or at the consumer level.

Water Usage

Definition: "Blue water - renewable surface water runoff and groundwater recharge - is the main source for human withdrawals and the traditional focus of water resource management."

Definition: "Water withdrawal describes the total amount of water withdrawn from a surface water or groundwater source." (American Geophysical Union)

"If we are withdrawing only 10% of renewable water resources, and consuming only 5%, what then is the problem? Not all renewable water resources are usable. The numbers may suggest that we are using only a small fraction of the available resources and that we should be able to increase this share fairly easily. Not so, for the following reasons:

- Of global water resources, a large fraction is available where human demands are small, such as in the Amazon basin, Canada, and Alaska.
- Rainfall and river runoffs occur in large amounts during very short periods, such as during the monsoon periods in Asia, and are not available for human use unless stored in aquifers, reservoirs, or tanks (the traditional system in the Indian subcontinent).
- The withdrawal and consumption figures do not show the much larger share of water resources "used" through degradation in quality—that is, polluted and of lower value for downstream functions.
- Water not used by humans generally does not flow to the sea unused. Instead, it is used in myriad ways by aquatic and terrestrial ecosystems—forests, lakes, wetlands, coastal lagoons—and is essential to their well being."

<u>Number of farms worldwide and their breakdown by size</u>[10]

"Estimates are available for 167 countries which represent 96% of the world's population, 97% of the population active in agriculture, and 90% of agricultural land worldwide. The resultant estimate of the total number of farms in the 167 countries comes to nearly 570 million."

"...for a sample of 111 countries and territories with a total of nearly 460 million farms. Seventy-two percent of the farms are smaller than one hectare in size; 12% are 1–2 ha in size; and 10% are between 2 and 5 ha. Only 6% of the world's farms are larger than 5 ha."

<u>Percentage of agricultural land implementing sustainable intensification (SI) practices by type</u>[11]

Definition: "Sustainable intensification (SI) is defined as an agricultural process or system where valued outcomes are maintained or increased while at least maintaining and progressing to substantial enhancement of environmental outcomes."

<u>Nitrogen input to crop production</u>[12]

"Fertilizer supplies about 50 percent of the total N required for global food production. In 1996 global fertilizer N consumption totaled 83 Tg N (Smil 1999), and consumption has increased little since then, for example, 84.1 Tg N in 2002 (FAO 2004). Therefore, Smil's estimates of the global N flows are probably still appropriate and are used here. The other annual inputs into crop production – biological N-fixation (~33 Tg; 24-41 Tg), recycling of N from crop residues (~16 Tg; 12-20 Tg) and animal manures (~18 Tg; 12-22 Tg), atmospheric deposition, and irrigation water – provide an additional 24 Tg (21-27 Tg) (Smil 1999)."

<u>Change in global food productivity 1960 to 2010</u>

Definition: "Productivity measures the quantity of output produced with a given quantity of inputs. Long term productivity growth reflects improvements in farmers' production efficiency and technological progress." (Dept. of Agriculture, Australia)

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