



Fact sheet

Sustainability of alternative proteins: environmental, social, and economic impacts



The Good Food Institute is a non-profit organization working globally to accelerate innovation in the alternative protein market. We believe that transitioning to a more sustainable food system is fundamental to addressing the climate crisis, reducing the risk of zoonotic diseases, and feeding more people with fewer resources. Therefore, we collaborate with scientists, investors, entrepreneurs, and government agencies to develop plant-based, cultivated, or fermented food analogs.





Our work focuses on three main areas:

In **Corporate Engagement**, we support companies of all sizes in developing, launching, and commercializing alternative protein products. We offer tools to support startups and entrepreneurs in their business strategies. We provide market intelligence to help companies make decisions. We conduct research to identify and overcome challenges.

In **Science and Technology**, we fund cutting-edge research on alternative proteins, promote collaborations between scientists, companies, and governments, publish data and findings to drive scientific progress, and design educational programs to train the next generation of leaders in alternative protein.

In **Public Policy**, we advocate for public policies that support the development and commercialization of alternative proteins, work with governments to create a favorable regulatory environment, educate the public about the benefits of alternative proteins, monitor the political landscape, and defend the sector’s interests.

Through this work, we seek solutions to:

-  Feed nearly ten billion people safely, fairly, and sustainably by 2050;
-  Contain climate change caused by the current food production system;
-  Create a food production chain that does not depend on animals;
-  Reduce the food sector’s contribution to the emergence of new infectious diseases, some with pandemic potential.

In just over 6 years of operations in Brazil, GFI has already helped the country become a leading player in the global plant-based protein market. The intention is to continue developing this work to transform the future of food, promoting new protein sources and offering analog alternatives to animal proteins.

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1. Environmental performance of animal meat

Due to low conversion rates, conventional meat requires more resources to deliver the final product, resulting in higher water consumption and land use, as well as production inputs, exerting significant pressure on the environment.

The calorie conversion rates for chicken, pork, and beef are 11%, 10%, and 1%, respectively. For protein, the conversion rates are 20% for chicken, 15% for pork, and 4% for beef.

The conversion rate indicates the efficiency with which mass, calories, and/or proteins are converted in a given system. In this case, the percentages indicate the efficiency of each animal in converting calories and proteins from ingested resources, such as feed, grass, and silage, into the final product's calories and proteins (meat).

Source: [Wirsenius et al., 2010, cited by WRI, 2019](#)

With 19% of the national territory occupied by pastures, the average productivity of Brazilian livestock farming is 65.8 kg of carcass per hectare/year.

Approximately 19% of Brazil's area, roughly 161 million hectares, is occupied by pastures used for livestock production. In 2023, the stocking rate was 1.22 head of cattle per hectare, resulting in an average carcass productivity of 65.8 kg per hectare/year. However, 76% of this area has productivity below the national average.

Source: [ABIEC, 2024](#)

The water footprint of Brazilian beef varies between 29,828 and 32,470 liters of water per kg of carcass.

The calculation of the water footprint of beef was based on a cradle-to-processing plant system, encompassing meat production at the farm level and processing at the slaughterhouse. Therefore, the three main phases of beef production were considered: breeding, rearing, and feedlot. The final value is the result of the sum of the indicators of evapotranspiration, water present in the feed, consumption of groundwater and surface water from production to processing, and the use of water to treat the effluent from the factory or slaughterhouse.

Source: [Palhares et al., 2021](#)

2. Environmental performance of cultivated meat

The data below were obtained from a comparison of the life-cycle analysis of cultivated meat production on a commercial scale with that of conventional meat production in intensive systems. The analyses are based on 2030 and assume a very optimistic projection of reductions in the environmental impacts of conventional livestock farming.

Cultivated meat is 5.8 times more efficient than cattle in the process of converting feed into meat.

While in conventional meat production, a significant portion of nutrients is used to maintain the animal's bodily functions, in cultivated meat production, all nutrients are directed exclusively to cell growth. This results in more efficient use of resources, less need for land, water, and feed, and the elimination of greenhouse gas emissions associated with animal production.

Source: [Sinke et al., 2023](#)

Cultivated meat shows more than a 92% reduction in CO₂eq emissions compared with beef.

The controlled environment, direct metabolism, and the absence of waste in cultivated meat production limit emissions in the production process itself, making its carbon footprint directly tied to the energy matrix used in bioreactors and in the production of the main ingredients. In contrast, methane (CH₄) and nitrous oxide (NO_x) emissions in conventional meat production are more difficult to reduce. As the global energy system continues on the path to decarbonization, the average carbon footprint of cultivated meat will continue to decrease more rapidly than that of conventional meats.

Source: [Sinke et al., 2023](#)

Cultivated meat production represents more than a 90% reduction in land use compared with beef.

While the most common model for raising livestock demands vast expanses of land for pasture and large areas are dedicated to the production of agricultural monocultures used as feed, cultivated meat can be produced vertically in closed facilities, occupying less physical space and allowing for more efficient use of available land. In addition, cultivated meat is more efficient at converting crops into the final product and therefore requires less land.

Source: [Sinke et al., 2023](#)

Cultivated meat reduces soil acidification by more than 98% compared with beef.

Conventional meat production contributes to soil acidification through the application of nitrogen fertilizers, the decomposition of animal waste in soil, and the intensive cultivation of monocultures for feed production. In contrast, because it is produced in closed bioreactors, cultivated meat eliminates the need for vast pasture areas, reduces feed cultivation and animal waste production, and also decreases ammonia (NH₃) emissions in the soil.

Source: [Sinke et al., 2023](#)

Compared with beef, cultivated meat shows more than a 94% reduction in air pollution.

The production of meat cultivated in controlled bioreactors reduces the use of nitrogen fertilizers which, like animal waste, are sources of ammonia (NH₃), nitrogen oxides (NO_x) and nitrous oxides (N₂O) emissions, contributing to the formation of fine particles and atmospheric pollutants such as tropospheric ozone, which can also be formed through the emission of volatile organic compounds (VOCs), generated by enteric fermentation and decomposition of animal waste. Emissions of sulfur dioxide (SO₂) and nitrogen oxides from industrial processes in ingredient production and renewable energy infrastructure are the main sources of air pollution in the cultivated meat system.

Source: [Sinke et al., 2023](#).

Cultivated meat production reduces freshwater pollution by 43% compared with beef

Compared with beef, cultivated meat has a lower eutrophication impact¹ due to reduced fertilizer use in pastures, lower production of animal waste, and reduced soil compaction from cattle trampling, which translates into less runoff of nutrients, such as nitrogen (N) and phosphorus (P), from the soil to water bodies.

Source: [Sinke et al., 2023](#)

Meat production in bioreactors corresponds to a 58% increase in energy demand compared with beef. How much this increased demand will impact issues such as GHG emissions will depend on the energy matrix used and can be significantly reduced by using renewable energy.

Part of the energy (calories) used for biological processes in animals, such as maintaining body temperature, is replaced by electricity and heat in bioreactors, where muscle cells are cultivated. In this case, the main environmental critical points of cultivated meat production are energy use in the facilities and the production of culture medium ingredients. In the latter, energy use also plays an important role. The impacts of cultivated meat can, however, be significantly reduced by using renewable energy across facilities and the supply chain, particularly in the production of culture medium ingredients.

Source: [Sinke et al., 2023](#)

¹ Eutrophication is a process in which increased nutrient levels lead to excessive growth of algae and aquatic plants, which consume dissolved oxygen in the water, resulting in the death of fish and other aquatic organisms.

Cultivated meat production consumes 66% less water compared with beef production.

Cultivated meat production occurs in controlled environments and eliminates some of the blue-water²-intensive steps characteristic of traditional livestock farming, such as irrigation for pasture cultivation or for grains used as animal feed. In a scenario where 75% of the water is recycled at the production plant, cultivated meat would use 66% less water than beef. A further reduction in the water footprint of cultivated meat is possible through increased recycling at the facility and supply chain efforts, for example, by reducing water use in the production of culture medium ingredients.

Source: [Sinke et al., 2023](#)

3. Environmental performance of plant-based meat analogs

The data below were obtained from a life-cycle analysis of plant-based meat (produced from legumes) compared with beef. The results obtained account for the mass allocation of environmental impacts; i.e., they reflect the distribution of impacts among the different products and co-products generated during the production process. This means that products and co-products with greater mass will receive the largest share of environmental impacts.

The production of plant-based analog meat shows a 94% reduction in CO₂e emissions compared with beef.

The production of plant-based analog meats emits fewer greenhouse gases and is more efficient in converting solar energy into food than beef production. While plant-based analogs involve fewer energy-intensive steps, beef requires several energy-conversion phases (plants to feed, feed to animal growth, and finally meat), each resulting in energy losses and additional emissions. Animal rearing is the most emission-intensive phase in conventional beef production, releasing large amounts of methane (CH₄) during the digestion process of these ruminants.

Source: [Good Food Institute & EarthShift Global, 2024](#)

Plant-based analogs production reduces land use demand by 91% compared with beef.

Beef production requires large tracts of land for grazing and feed cultivation, contributing to deforestation and the opening of new areas. In contrast, plant production is more efficient in land use. Growing plant proteins uses less land to produce the same amount of protein, reducing soil degradation and conserving natural ecosystems.

Source: [Good Food Institute & EarthShift Global, 2024](#)

² Blue water refers to water drawn from natural sources, such as rivers, lakes, and aquifers, for use in production processes.

<p>Plant-based analogs production shows a 93% reduction in water consumption compared with beef.</p>	<p>Plant-based meats require much less water throughout their life cycle, mainly because they eliminate some stages of intensive blue water use characteristic of traditional livestock farming, such as irrigation for pasture cultivation or grains for animal feed. In addition, growing legumes, such as soybeans, beans, and peas, is more water-efficient than other crops.</p> <hr/> <p>Source: Good Food Institute & EarthShift Global, 2024</p>
<p>Plant-based analogs production can reduce air pollution by 91% compared with beef.</p>	<p>In beef production, manure management and nitrogen fertilizer application can release ammonia (NH₃) into the air. This pollutant, when reacting with other compounds, can form fine particles, which, when inhaled, are among the main causes of respiratory problems, such as asthma and other lung diseases. Plant-based analogs production emits substantially lower levels of these pollutants due to reduced fertilizer use and the elimination of animal waste.</p> <hr/> <p>Source: Good Food Institute & EarthShift Global, 2024</p>
<p>Plant-based analogs production results in up to a 96% reduction in water pollution compared with beef.</p>	<p>Compared with beef, plant-based analogs can reduce marine eutrophication³ by up to 96%. This positive result is due to the elimination of animal waste production and soil compaction from cattle trampling, as well as reduced fertilizer use, which translates into less runoff of nutrients, such as nitrogen (N) and phosphorus (P), from the soil into water bodies.</p> <hr/> <p>Source: Good Food Institute & EarthShift Global, 2024</p>

4. Climate change

The current protein production model is a major contributor to climate change in food systems, especially through methane (CH₄) emissions.

³ A process in which increased nutrients in bodies of water lead to excessive growth of algae and aquatic plants that consume dissolved oxygen in the water, resulting in the death of fish and other aquatic organisms.

In 2019, atmospheric carbon dioxide concentrations were higher than at any other time in the last two millennia.

In 2019, in addition to the record-high atmospheric carbon dioxide (CO₂) levels in the last two millennia, concentrations of methane (CH₄)⁴ and nitrous oxide (N₂O)⁵ were also higher than at any time in the last 800,000 years. IPCC scientists warn that as global warming intensifies, climate system changes become stronger and more frequent. With a 1.5°C increase in global temperature by 2030, we will have increasing heat waves, longer hot seasons, and shorter cold seasons. At 2°C, humanity is likely to exceed critical thresholds for agriculture and health.

Source: [ONU Brasil, 2021](#)

The transition to alternative proteins could decarbonize the equivalent of 95% of aviation industry emissions.

Current prediction models indicate that alternative proteins will account for 11% of all protein consumption by 2035. If this projected market share holds over time, a reduction of 0.85 Gt CO₂eq⁶ by 2030 will be possible – equivalent to decarbonizing 95% of the aviation industry.

Source: [Boston Consulting Group, 2022](#)

Without adaptation⁷ to climate change, global crop yields are likely to decline by at least 5% by 2050, with steeper declines by 2100.

The 2014 IPCC⁸ report predicts that, without adaptation to climate change, global crop yields are likely to decline. To mitigate this impact, it will be necessary to implement several adaptive strategies, including diversifying diets by introducing new foods, cultivating crops more resistant to high temperatures, developing efficient water-conservation systems, and modifying agricultural production methods in regions where climate change makes the cultivation of certain crops unfeasible.

Source: [WRI, 2018](#)

⁴ Greenhouse gas with a warming potential 34 times greater than CO₂ in 100 years.

⁵ Greenhouse gas with a warming potential 298 times greater than CO₂ in 100 years.

⁶ Gigatons of CO₂ equivalent.

⁷ Adaptation focuses on reducing the vulnerability of human and natural systems, addressing the effects of climate change that are already underway or are inevitable.

⁸ Intergovernmental Panel on Climate Change.

In 2010, the livestock industry was responsible for more than 70% of global land-use sector emissions⁹.

According to the IPCC, emissions from the Agriculture, Forestry and Other Land Uses sector were 10-12 Gt CO₂eq in 2010. During the same period, according to the FAO¹⁰, livestock farming emitted more than 8 Gt CO₂eq, approximately 70% of the sector's total emissions, including feed production activities, deforestation for pasture, crop planting for feed, enteric fermentation in ruminants, and animal waste management.

Source: [ClimateWorks Foundation, 2021](#)

In 2021, when Brazil's total gross greenhouse gas emissions were 2.4 Gt CO₂eq, food systems accounted for an estimate of 73.7% of these emissions.

Of these 1.8 Gt CO₂eq (73.7%), which are related to food systems, approximately 1 Gt CO₂eq (56.3%) can be attributed to the Land Use, Land-Use Change, and Forestry (LULUCF) sector, which includes deforestation records (areas of forest or native vegetation giving way to food production). At the same time, activities carried out 'within the farm gate' in the Agriculture and Livestock sector rank second, contributing 600.8 Mt CO₂eq (33.7%). The Energy sector ranks third with 5.6% of the total, followed by the Waste sector with 4.2%, and the Industrial Processes and Product Use sector with a share of less than 1%.

Source: [SEEG-OC, 2023](#)

Beef was the product responsible for the largest share of greenhouse gas emissions from food systems in 2021, accounting for 77.6% of total emissions, equivalent to 57.2% of Brazil's emissions.

Of the emissions associated with Brazilian beef production, which total 1.4 Gt CO₂eq, the largest share comes from the Land Use, Land-Use Change, and Forestry (LULUCF) sector, totaling 978.1 Mt CO₂eq and representing 70.6% of these emissions. Another large share comes from the agriculture and livestock sector, with 404.8 Mt CO₂eq, representing 29.2% of the total emissions from beef production.

Source: [SEEG-OC, 2023](#)

⁹ The land-use sector refers to human activities related to the management and use of land that directly affect the climate. This sector includes agriculture, forestry, pasture management, conservation of natural ecosystems, and other practices that affect land use.

¹⁰ Food and Agriculture Organization.

Between 1990 and 2021, 97% of greenhouse gas emissions from Land Use Change processes in Brazil were associated with deforestation or the conversion of native vegetation to pasture and crops.

The Land Use, Land-Use Change, and Forestry (LULUCF) sector in food systems was responsible for net emissions of 33.7 Gt CO₂eq in Brazil between 1990 and 2021. During this period, the process responsible for the largest share of gross LULUCF emissions was Land Use Change, with 32 Gt CO₂eq, almost all of which (97%) is due to deforestation or conversion of native vegetation to pasture and crops. In 2021, LULUCF was responsible for 1 Gt CO₂eq in emissions, a 23% increase from 2020.

Source: [SEEG-OC, 2023](#)

Approximately 50% of global methane emissions from the food system come from livestock, with 45% originating from enteric fermentation in ruminants and about 4% from animal waste management.

In 2017, 380 Mt of methane (CH₄) were emitted, or approximately 10.3 Gt CO₂eq, representing about 20% of greenhouse gas emissions in the same period. The food system accounts for 60% of CH₄ emissions, with livestock farming being the most emitting activity (50%), followed by food waste (20%), rice cultivation (13%), biomass burning (7%), biofuel combustion (6%), and energy inputs for agricultural production (4%).

Source: [ClimateWorks Foundation, 2023](#)

Compared with 2019 levels, global methane emissions need to be reduced by 34% by 2030 and by 45% by 2050 to achieve projections that limit the increase in global temperature to 1.5°C.

Current global greenhouse gas (GHG) emission levels are around 51 Gt CO₂eq, with methane (CH₄) accounting for approximately 20% of these emissions. According to IPCC scenario projections that limit global warming to 1.5°C, global GHG emissions are estimated to fall to approximately 31 Gt CO₂eq in 2030, a 43% reduction (34% for CH₄), and to 9 Gt CO₂eq in 2050, an 87% reduction (45% for CH₄). With the largest share of CH₄ emissions originating from food systems, dietary changes, with a greater adoption of non-ruminant proteins, could reduce emissions by up to 0.65 Gt CO₂eq/year by 2030. Between 2030 and 2050, these benefits could be even greater, reaching a reduction of 1.2 Gt CO₂eq/year.

Source: [ClimateWorks Foundation, 2023](#)

Current emissions from the food system alone are projected to prevent the goal of limiting global temperature rise to 1.5°C.

The cumulative emission limits must be 705 and 1,816 Gt CO₂eq, respectively, to have a 50% chance of achieving the 1.5°C and 2°C targets. The prediction for cumulative food system emissions from 2020 to 2100 is 1,356 Gt CO₂eq. Therefore, even if all emissions from other economic sectors were halted in 2020 and remained at zero until 2100, food system emissions alone would prevent the 1.5°C target from being achieved between 2051 and 2063. However, these emissions can be reduced by 14-48% by 2050 through dietary changes, improved crop yields, reduced food waste, and greater production efficiency.

Source: [Clark et al., 2020](#)

Alternative proteins rank second among the most promising interventions for mitigating greenhouse gas emissions in the agri-food sector.

Of the 26 most promising interventions for mitigating emissions in the agri-food sector, alternative proteins are ranked second in terms of climate mitigation potential, with 6.1 Gt CO₂eq/year. In first place is reforestation (8.47 Gt CO₂eq/year) and in third place is the reduction of deforestation (6.0 Gt CO₂eq/year). Notably, alternative proteins contribute to these other two interventions by freeing up vast areas of land for reforestation and reducing the main drivers of deforestation pressure: beef production and soybean production for animal feed (mainly for chickens, pigs, and farmed fish).

Source: [World Bank, 2024](#)

Alternative proteins have 9 times the mitigation potential of the second-most-promising intervention for reducing emissions from meat production.

Compared with the second-most-promising intervention for reducing emissions from meat production (improved digestibility of ruminant feed, with 680 Mt CO₂eq/year), alternative proteins have 9 times the mitigation potential. The potential of feed additives (e.g., algae) is 380 Mt CO₂eq/year, and for improved ruminant productivity is 179 Mt CO₂eq/year. Other interventions in the food system that have less than one-tenth of the potential impact of alternative proteins include fertilizer innovation (480 Mt CO₂eq/year), rice innovation (243 Mt CO₂eq/year), and animal waste management (118 Mt CO₂eq/year).

Source: [World Bank, 2024](#)

By replacing 50% of the main animal products, greenhouse gas emissions from agriculture and land use would decrease by 31% in 2050 compared with 2020.

In the baseline scenario, where dietary patterns remain unchanged, emissions from agriculture and land use are expected to increase by 15% by 2050. However, by replacing 50% of the main animal products (pork, chicken, beef, and milk) with plant-based products, emissions from agriculture and land use could decrease by 31% (2.1 Gt CO₂eq/year) by 2050, compared with 2020. Carbon sequestration on the spared lands would increase by 3.3 Gt CO₂eq/year, resulting in a 6.3 Gt CO₂eq/year reduction in all agricultural emissions. of land use compared with the baseline scenario in 2050.

Source: [Kozicka et al., 2023](#)

In 2019, global greenhouse gas emissions were estimated at 52.6 Gt CO₂eq.

Global greenhouse gas (GHG) emissions in 2019 were estimated at 52.6 Gt CO₂eq, excluding emissions from forests and other land uses. This estimate covers up to 95% of global GHG emissions in the baseline year and was released in November 2023, alongside the synthesis report on the Nationally Determined Contributions (NDCs) of the 195 signatory countries of the Paris Agreement.

Source: [UNFCCC, 2023](#)

5. Food security

The growing world population demands greater efficiency from the food system, which already consumes significant amounts of natural resources and incurs substantial losses in the production of calories and proteins.

The world population is expected to reach 8.5 billion people in 2030 and 9.7 billion in 2050.

Of the 9.7 billion people who will occupy the planet in 2050, projections indicate a population of 749 million people in the Latin America and Caribbean region. For Brazil, in that same year, the prediction is 231 million people.

Source: [United Nations, 2022](#)

On average, 9.2% of the world's population (735 million people) faced hunger in 2022.

Global hunger is measured by the prevalence of undernourishment and is estimated to have affected 691-783 million people worldwide in 2022. In South America, this situation affected 26.8 million people, with 10.1 million in Brazil alone, on average, from 2020 to 2022.

Source: [FAO, 2023](#)

Approximately 29.6% of the global population (2.4 billion people) were in a situation of moderate or severe food insecurity in 2022.

In 2022, 2.4 billion people worldwide were food-insecure¹¹. In South America, 159 million people faced this same challenge, with 70.3 million in Brazil alone, on average, from 2020 to 2022.

Source: [FAO, 2023](#)

By 2050, maintaining the same global consumption pattern, the food system will demand 49% more land than in 2020, emit 46% more greenhouse gases, and consume 34% more water.

Considering the 2050 scenario, in which developing countries have the highest rates of economic and population growth and adopt food consumption patterns similar to those of developed countries today, the environmental intensity of these diets requires unsustainable growth of the food system.

Source: [Credit Suisse Research Institute, 2021](#)

The production of major crops accounts for 90% of the global calorie supply. However, 41% of the calories produced are lost in the food system.

Only 59% of the total calories produced by major crops are supplied to the population by the global food system. Of these, 55% come from plant-based foods and only 4% from animal sources. A significant portion of this calorie loss is due to animal feed. After consuming 36% of calorie production, it returns only 4% to the food system as animal products, resulting in an 89% loss.

Source: [Cassidy et al., 2013](#)

Alternative proteins can help alleviate food insecurity by reducing the risk of spikes in food prices due to demand for animal feed.

Lobell et al. (2011) found that climate trends between 1980 and 2008 led to a 3% loss in calories, resulting in an approximately 20% increase in commodity prices compared with a counterfactual scenario without warming. Price increases would clearly be much greater under projected yield losses of 9% (by 2050) and 25% (by 2098) in a high-emissions scenario (RCP 8.5). Baldi et al. (2021) estimate that a 4% shift to plant-based meats would result in crop prices 13-23% lower on average than in a counterfactual scenario without plant-based meat.

Source: [Innovation Commission: Climate Change, Food Security, Agriculture, 2023](#)

6. Health

The widespread use of antibiotics in animal production jeopardizes the effectiveness of modern medical treatments and threatens the resilience of the food system.

¹¹ Food insecurity is the condition in which people face difficulties accessing food due to a lack of resources.

In 2019, 1.27 million people are estimated to have died as a result of Antimicrobial Resistance (AMR).

This estimate of the number of deaths directly attributable to Antimicrobial Resistance (AMR) is based on a hypothetical scenario in which drug-resistant infections were instead susceptible to them. In other words, antibiotics would have been effective in eliminating bacteria, thereby avoiding deaths. One strategy to mitigate the risk of loss of effectiveness of medical treatments is to reduce people's exposure to antibiotics not used to treat human diseases. The increasing use of antibiotics in agriculture and livestock farming has been identified as a potential contributor to AMR in humans, although the debate remains divided.

Source: [Murray et al. 2022](#)

By 2050, 10 million lives per year and a cumulative total of US\$100 trillion in economic output are estimated to be at risk due to the increase in drug-resistant infections.

Antibiotics are a special category of drugs that underpin modern medicine as we know it. If they lose their effectiveness, essential medical procedures such as abdominal surgeries, cesarean sections, joint replacements, and treatments that suppress the immune system, such as chemotherapy for cancer, can become too dangerous to perform. Most of the direct impact and much of the indirect impact of Antimicrobial Resistance (AMR) will fall on low- and middle-income countries.

Source: [Review on Antimicrobial Resistance, 2016](#)

More than 70% of the total volume of antibiotics defined as important drugs for humans by the Food and Drug Administration (FDA) is sold for use in animals in the USA.

There are often many opportunities in intensive farming environments for drug-resistant bacteria to be transferred, for example, between thousands of chickens raised in the same environment. Considering that G20 countries account for 80% of global meat production, a large share of antibiotic consumption in livestock, and that the likelihood of generating drug resistance currently falls on them.

Source: [FDA](#) and [FAO](#) cited by [Review on Antimicrobial Resistance, 2016](#)

75 to 90% of antibiotics administered to animals are not metabolized and are excreted into soils, waterways, and sewage systems.

Antibiotics can reach the environment through three main channels: animal waste, human waste, and manufacturing waste. They can contaminate soil, crops, and water sources, leading to the development of drug resistance among the pathogens with which they interact.

Source: [Marshall, BM, Levy SB cited by Review on Antimicrobial Resistance, 2016](#)

In some cases, plant-based analog products have demonstrated nutritional value comparable to that of animal-derived products and, in certain aspects, superior value.

In the comparative study, 59 products available on the Brazilian market were sampled: 26 meat products of animal origin and 33 plant-based analogs. Analysis of label information revealed that 50% of meat products have a high saturated fat content, compared with 33% in the plant-based sample. Regarding sodium, 58% of animal-based products showed high levels, compared with 33% of plant-based foods. Plant-based products stood out for their fiber content, with 76% considered a 'fiber source,' compared with only 4% for animal-based products. This characteristic of plant-based products helps prevent heart disease, diabetes, irritable bowel syndrome, and obesity. While the protein assessment of plant-based products indicated a need for improvement compared with traditional products, all analyzed plant-based products have sufficient protein levels to be considered protein sources.

Source: [The Good Food Institute, 2022](#)

7. Production and consumption

Understanding the scale of animal slaughter and the overall flow of resources in the food system is fundamental to highlighting the need to develop more sustainable food production methods and to ensure food security.

In 2024, 39.27 million cattle, 6.46 billion chickens, and 57.86 million pigs were slaughtered in Brazil.

Chicken and pig slaughter in 2024 registered the highest values in the historical series that began in 1977, with 13.64 million and 5.33 million tons of carcasses¹², respectively. Cattle slaughter, in turn, increased by 15.2% compared with 2023, reaching the highest level in the history of the research, which began in 2013, resulting in the production of 10.24 million tons of carcasses.

Source: [IBGE, 2025](#)

In 2024, approximately 810,000 heads of cattle were estimated to have been slaughtered without inspection in Brazil.

The difference between the total number of whole pieces of raw bovine hides received by tanneries and the number of cattle slaughtered under some sanitary inspection service can be understood as an approximation of uninspected slaughter. In 2024, based on the historical series of these two variables, the uninspected slaughter rate in the period can be inferred at 2.1%.

Source: [IBGE, 2025](#)

¹² The definition of carcass refers to the body of a slaughtered animal after the removal of the head, hide (or skin), hooves, tail, and internal organs.

Aquaculture production needs to more than double between 2010 and 2050 to meet the projected 58% increase in fish consumption.

In this projection, as wild fish catches decrease by 10% between 2010 and 2050, aquaculture productivity must increase, and this requires addressing the current environmental challenges of fish farms, including wetland conversion, the use of wild fish in feed, high freshwater demand, and water pollution.

Source: [WRI, 2018](#)

In 2023, feed production in Brazil was estimated to have consumed around 53 million tons of corn and 18 million tons of soybean meal.

Production for the year 2023 was estimated at more than 83 million tons of feed and concentrates (excluding mineral salt). The aforementioned amount can be divided into 43.4 million tons for chickens, 20.8 million tons for pigs, and 12.1 million tons for cattle. The remainder is distributed among dogs and cats, fish and shrimp, horses, and others.

Source: [SINDIRAÇÕES, 2023](#)

With 76% of global consumption, soybeans are mainly used for animal feed.

Between 2017 and 2019, 76% of global soybeans were used for animal feed, with 37% for chicken farming, 20.2% for pigs, 5.6% in aquaculture, 2% for cattle and dairy, and the remaining 13% distributed among pets and other animals. Only about 20% of global soybean production is used for human consumption, mainly as vegetable oil. Manufacturing biofuels, lubricants, and other industrial processes consumes the remaining 4% of global production.

Source: [Our World In Data, 2024](#)

95% of annual forest loss occurs in the tropics, and Brazil leads the ranking, accounting for 33% of this loss.

While soybean cultivation is no longer the main driver of deforestation in the Amazon Rainforest — unlike the USA, which already had cultivated areas and produced more than 20 million tons per year since the 1960s — soybean production in Brazil only reached this scale in the 1990s. Since then, the cultivated area has expanded by about 140%. These new areas continue to emerge in other biomes, mainly in the Cerrado, and also from the conversion of pastures into cultivated areas. Since 2018, Brazil has led global soybean production, accounting for 41% of total production in 2023.

Source: [Our World In Data, 2024](#)

Of global cultivation of the main crops, 24% is directed to animal feed, accounting for 53% of vegetable protein production.

While direct human consumption accounts for 67% of the volume of the 41 main crops globally, this share represents only 40% of global vegetable protein production. Meanwhile, 53% of global vegetable protein production is directed to animal feed through crops such as corn, soybeans, and oilseed meal, which are denser in calories and protein.

Source: [Cassidy et al., 2013](#)

In Brazil, animal feed consumes 41% of the calories from the cultivation of the main crops and 79% of protein production.

Of the 41 main crops, 41% of calories are destined for animal feed, 45% for human consumption, and 14% for biofuel production. In the case of proteins produced by these crops, the largest share (79%) is destined for animal feed, and only 16% of national production reaches human consumption.

Source: [Cassidy et al., 2013](#)

Brazil leads the ranking of beef exports: for every 5 kg of beef traded worldwide, approximately 1 kg originated in the country.

In 2023, Brazil set a record for beef exports, reaching 2.29 million tons. This volume accounted for 18.7% of global beef exports, consolidating Brazil's position as the world's largest beef exporter.

Source: [ABIEC, 2024](#)

Brazil is the second-largest worldwide producer of beef, with a carcass weight equivalent of 10.6 million tons.

Among the countries that have produced the most beef over the last 10 years, Brazil stands out, with production growing the most and currently accounting for 13.8% of global production, second only to the USA. The Brazilian cattle herd, estimated at 197.2 million animals, is also the second largest in the world, behind only India. Most of these animals in Brazil are raised in extensive systems (pastures), and only 17% of the total cattle slaughtered are finished in feedlots.

Source: [ABIEC, 2023](#) and [ABIEC, 2024](#)

In the next 10 years, Brazil's share of global beef production is expected to increase from 13.8% to 21%.

According to the OECD, global consumption of processed beef is projected to reach 51 million tons in the next decade. Global per capita consumption has fluctuated around 6 kg/year in the last decade. While in most regions this consumption tends to decrease, in the APAC (Asia-Pacific) region, it should increase by 0.4 kg/year. In response, according to ABIEC, beef production should increase by 8% and account for 12% of the global meat production growth by 2033.

Source: [OECD, 2023](#), and [ABIEC, 2024](#)

Per capita beef consumption in Brazil reached 37.46 kg per inhabitant, one of the highest in the world, and accounts for 71.47% of national production.

The Brazilian domestic market consumes 71.47% of all beef produced (at all levels of inspection and in informal markets), resulting in a per capita consumption of 37.46 kg per inhabitant in 2023. Projections indicate that domestic consumption should still grow, reaching a total of 9 million tons carcass equivalent in 10 years.

Source: [ABIEC, 2023](#) and [ABIEC, 2024](#)

8. Natural resources

The high demand for land for animal protein production in the food system puts significant pressure on ecosystems, intensifying deforestation to create new pastureland and promoting monoculture cultivation.

A 10% decline in crop yields would increase the need for land by 45%.

The 2014 IPCC report predicts that, without adaptation to climate change, global crop yields are likely to decline. A 10% drop in crop yields can increase the need for agricultural land by 45% due to the non-linear relationship between yields and land use. To mitigate this impact, strategies include improving agricultural efficiency through resilient crops and precision agriculture, enhancing soil health with regenerative practices, optimizing water management, reducing food losses and waste, and investing in agricultural research and supporting farmers.

Source: [WRI, 2018](#)

Brazilian agriculture and livestock farming have grown by 50% over the last 38 years. This increase, greater than the area of the state of Mato Grosso, was 95.1 million hectares and is equivalent to 10.6% of the national territory.

In 1985, 22% (187.3 million ha) of Brazilian territory was occupied by agriculture and livestock farming. In 2022, 38 years later, they occupied 33% (282.5 million ha) of Brazilian territory, an increase of over 50%. Pasture areas expanded by 61 million ha, which is more than the area of the state of Minas Gerais, while the area destined for agriculture increased by 42 million ha, equivalent to twice the territory of the state of Paraná.

Source: [MapBiomass, 2023](#)

64% of the expansion of agriculture and livestock farming in Brazil is due to deforestation for pasture.

The states of Mato Grosso and Pará, where Brazilian agriculture and livestock farming have advanced the most in recent decades, have the highest absolute deforestation rates for pasture. In addition to the 64% growth resulting from the opening of new pasture areas, direct deforestation for agriculture accounts for 10% of this expansion, and the remaining 26% comes from the occupation of already anthropized areas for agricultural production.

Source: [MapBiomass, 2023](#)

Over the last 39 years, pasture areas in the Amazon have increased by 363%. During the same period, practically 100% of the soybean cultivation areas in the biome were formed, currently totaling approximately 5.9 million hectares.

In 2023, the pasture area in the Amazon reached 59 million hectares, with 78% of this area formed since 1985 and 44% being new areas less than 20 years old. Overall, agriculture and livestock farming in the Amazon have expanded by 417% in the last 39 years and currently occupies 15.8% of the biome's area.

Source: [MapBiomass, 2024](#) and [MapBiomass, 2024](#)

In the Cerrado, 47% of the biome's area is occupied by agriculture and livestock farming, with approximately 35.5% used for pasture and soybean cultivation.

Between 1985 and 2023, the area dedicated to soybean cultivation in the Cerrado increased by more than 15 times, reaching 19.4 million hectares, of which about 41% was savanna before 1985. During the same period, pasture areas grew by 62% and currently represent more than 25% of the biome's total area.

Source: [MapBiomass, 2024](#)

In 2023, pasture areas in Brazil totaled 164 million hectares, approximately 20% of the Brazilian territory.

Between 2000 and 2023, 59 million hectares were converted to pasture, with about 84% of this area originally comprising native vegetation. Currently, the Cerrado (51 million ha) and the Amazon (59 million ha) together account for 67% of Brazil's pasture areas.

Source: [MapBiomass, 2024](#)

If we combine global pastures with the amount of agricultural land used for animal feed, livestock farming represents 80% of the occupation of arable land on the planet.

Of the Earth's surface, which represents 29% (141 million km²) of the planet's surface, only 76% (107 million km²) is considered habitable. Currently, agriculture and livestock farming occupy 45% (48 million km²) of the planet's habitable surface, with 80% of this area used for livestock farming (6 million km² for animal feed cultivation plus 32 million km² for pastures), which represent 17% and 38% of the global supply of calories and protein, respectively. In contrast, while only 16% of the area used for agriculture (8 million km²) is dedicated to the cultivation of crops for human consumption, it accounts for 83% and 62% of the global supply of calories and protein, respectively.

Source: [Our World In Data, 2024](#)

With the replacement of 50% of the main animal products in the diet, in addition to the net reduction¹³ in forests and natural lands that would be almost entirely halted, the global agricultural area and water use would decrease by 12% and 10%, respectively, rather than increase.

In the baseline scenario, where dietary patterns remain unchanged, the agricultural sector exerts more pressure on natural resources, the agricultural area grows by 4% (219 million ha), nitrogen input into agricultural land grows by 39% (59 Mt), and water use increases by 6% (197 km³). By replacing 50% of the main animal-based products (pork, chicken, beef, and milk) with plant-based products, these pressure drivers are mitigated, the global agricultural area is reduced by 12% (653 Mha), as is water use, which decreases by 10% (291 km³), and the net reduction of forests and natural lands is almost entirely halted. If the agricultural land saved within forest ecosystems is restored to forests, the climate benefits could double, reaching 92% of the previously estimated land sector mitigation potential. Furthermore, the restored area could contribute 13% to 25% of the global land restoration needs estimated under Target 2 of the Kunming-Montreal Global Biodiversity Framework by 2030, and future declines in ecosystem integrity by 2050 would be more than halved.

Source: [Kozicka et al., 2023](#)

9. Economics

The transition to a food system that favors the production of alternative proteins offers significant economic opportunities, including job creation and reduced costs associated with mitigating greenhouse gas emissions.

The adoption of substitutes for animal-based foods could generate US\$5.5 trillion in climate change mitigation benefits by 2050.

In this scenario, where alternative proteins account for more than 50% of the global protein market, methane (CH₄) emissions from enteric fermentation and animal waste management will fall to less than half between 2020 and 2050, driven by reduced demand for livestock products. Emissions from fertilizer use stabilize as the decline in feed demand is offset by increased demand for food crops. And finally, carbon emissions from land-use change decrease rapidly and remain close to zero after 2035, as land dedicated to agricultural production declines (both arable land for feed production and pasture for livestock production).

Source: [ClimateWorks Foundation, 2021](#)

¹³ Net forest reduction refers to the net loss of forest areas, i.e., when deforestation exceeds reforestation or natural forest regeneration.

The transition to alternative proteins could generate more than US\$740 billion in Gross Value Added (GVA) for the sector by 2040 and reach US\$1.1 trillion by 2050.

Currently, the Gross Value Added (GVA) of alternative protein products is US\$29 billion, with plant-based milk being the main contributor. With the rapid deployment of plant-based products, cellular agriculture, and alternative dairy products, GVA is expected to grow 10.9% annually, reaching US\$1.1 trillion by 2050 and accounting for more than 50% of the global protein market. Of this increase, plant-based options will account for 24%, cellular agriculture 56%, and plant-based dairy products 20%.

Source: [ClimateWorks Foundation, 2021](#)

To unlock the full benefits of alternative proteins, global public spending on Research, Development, and Demonstration (RD&D) and commercialization needs to increase to US\$4.4 billion and US\$5.7 billion per year, respectively.

According to the GFI, for comparison, public spending in the alternative protein sector on RD&D and commercialization totaled only US\$55 million and US\$30 million, respectively, in 2020. These investments could be leveraged if private organizations accounted for the positive externalities¹⁴ of alternative proteins (including reduced emissions and pollution, improved biodiversity outcomes, and knowledge dissemination).

Source: [ClimateWorks Foundation, 2021](#)

The transition from a diet based on livestock products derived from ruminants to alternative proteins could create 83 million new jobs and generate approximately US\$686 billion in Gross Value Added (GVA) for the sector by 2050.

Investing in innovations to reduce methane (CH₄) emissions from livestock, rice, and feed losses could generate more than 120 million jobs by 2050, with 40 million jobs created by 2030. Expanding investment in alternative proteins, necessary to shift diets away from products derived from ruminants, could generate up to 83 million jobs by 2050. Investments in CH₄ mitigation measures could generate approximately US\$700 billion in GVA by 2050, with alternative proteins dominating value addition and representing almost 98% of the total value through innovations by 2050.

Source: [ClimateWorks Foundation, 2023](#)

¹⁴ These are benefits that an economic activity or action generates, affecting other people or society as a whole, without those beneficiaries paying for them.

By 2023, countries worldwide are estimated to have invested US\$1.67 billion in the alternative protein sector.

The newly announced estimate of global public funding for alternative proteins totaled US\$523 million in 2023, bringing the cumulative value invested in the sector to US\$1.67 billion. Of the 2023 total, governments announced US\$190 million for research and development, US\$162 million for commercialization, and US\$170 million for initiatives combining both.

Source: [The Good Food Institute, 2024](#)

The climate risks of the food system were valued at approximately US\$1.5 trillion in 2018.

The concept of planetary boundaries serves as a useful framework for tracking and communicating the impacts of human activities on environmental issues, including climate and nature. A recent update to this model reveals that boundaries in the spheres of climate change, biosphere integrity, changes in the Earth system, changes in freshwater, biogeochemical cycles, and new entities (synthetic chemicals, radioactive materials, and human interventions) have been violated, which could lead to irreversible damage to the planet's ecosystem. At the macro level, climate risks to the food system were estimated at around US\$1.5 trillion in 2018, and this value is even higher for nature, at US\$1.7 trillion.

Source: [The Food and Land Use Coalition, 2019, cited by FAIRR, 2024](#)

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