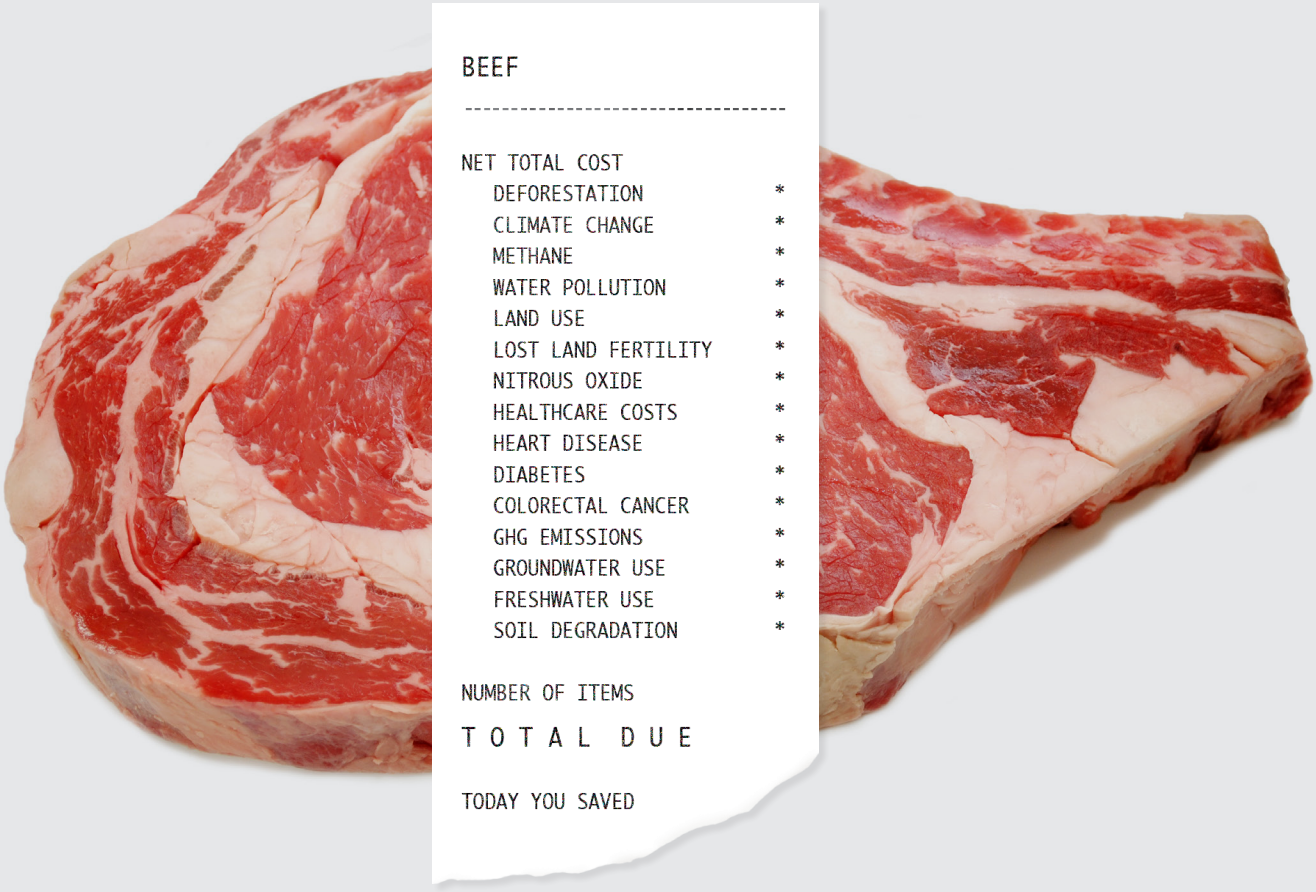

Taking a Bite Out of Climate Change: Why We Should Stop Harming the Planet and Ourselves by Eating Too Much Beef

October 2017

CLIMATEFOCUS

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1. Contents

1. Executive Summary

Beef is the most resource-intense of all protein sources.
Per kilogram, it needs more than six times the land and almost twice the amount of water to produce than chicken. Beef is also the single largest driver of tropical forest loss, especially in South America. Without substantive shifts in diets, by 2050, agricultural production will need to increase by 70% globally and double in developing countries to meet the needs of growing populations. Closing this "food gap" will require a shift away from resource-intensive beef toward less environmentally harmful dietary choices.

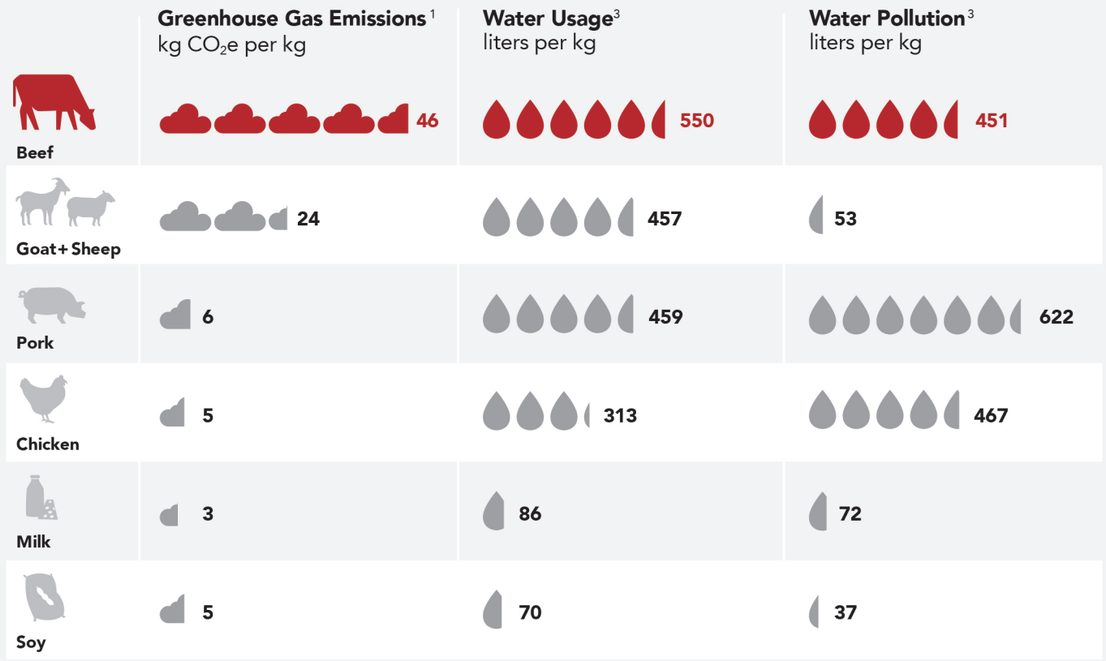
Globally, emissions from beef are equal to 6 percent of global human-made emissions, or more than half of the European Union's annual emissions.[1] **Yet, the sector receives little attention relative to other emissions sources of similar magnitude.** The beef sector's emissions result primarily from cattle's digestive processes and the production of grains needed to feed them. Producing feed and keeping animals on pastures also requires large areas of land, much of which is acquired through the clearing of forests—another significant source of emissions.

Reducing beef consumption in the US and Brazil, and stabilizing at current levels in China, would reduce greenhouse gas emissions by 472 megatons of carbon dioxide equivalent, equal to taking 100 million cars off the road.
This assumes that beef consumption is halved in the US, reduced by 25% in Brazil, and frozen at 2010 levels in China. More than a third of the world's beef is produced and consumed in these three countries. The size of the sector, and expected growth in beef demand, makes them important players in the strategy to curb emissions and reduce other environmental impacts from beef production. For the purposes of this study, the impacts of changes in beef consumption were simulated using the Global Biosphere Management Model (GLOBIOM).

Eating less beef would result in significant health benefits and reduced healthcare costs.
High consumption of red meat increases the risk of developing heart disease, cancers, and diabetes. According to the World Cancer Research Fund, a maximum weekly intake of 300g of red meat (including beef, pork, goat, lamb, and mutton) is recommended to maintain a healthy diet. In both the US and Brazil, not including other red meats, the amount of beef consumed per person is almost twice this recommended maximum and among the highest in the world. The adoption of healthier diets could reduce or avoid billions of dollars in healthcare costs in the two countries, as well as in China.

The transition to lower beef consumption requires a careful balance between reducing demand, improving production methods, and supporting rural producers to shift away from the cattle sector to alternative and diverse sources of income. Strategies to reduce or stabilize consumption should be accompanied by policies that help farmers cope with reduced demand. In the US, a 50% reduction in consumption would likely drive some farmers and feedlot operators out of business. In Brazil and China, our model shows that the cattle sector would still see some growth regardless of the reduced consumption due to population growth and exports to other countries. Rather than driving farmers out of business, the reduction would reduce the motivation of farmers to expand or enter into the beef business.

Figure 1: Environmental Impacts of Major Proteins†



† All figures are rounded to nearest whole number.

1. Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A. & Tempio, G. 2013. *Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities.* Food and Agriculture Organization of the United Nations (FAO), Rome. For soy: FAO (2010) *Greenhouse Gas Emissions from the Dairy Sector: A Lifecycle Assessment*

2. Calculation of the area of forest cleared is based on attributing land use change to the agricultural commodity produced on the cleared land (i.e. a direct approach), rather than allocating land use change to the commodity based on their relative contribution to the expansion of agricultural area (i.e. an indirect approach). Source: Henders, S., Persson, U. M. & Kastner, T. (2015) Trading forests: land-use change and carbon emissions embodied in production and exports of forest-risk commodities, Environ. Res. Lett. 10 (2015) 125012. And calculations based on European Commission (2013) The impact of EU consumption on deforestation: Comprehensive analysis of the impact EU consumption on deforestation. Technical Report 063

3. Includes water stored in soils and groundwater reservoirs. Extcludes rainwater. Source: Mekonnen, M. M. & Hoekstra, A. Y. (2012) A Global Assessment of the Water Footprint of Farm Animal Products, Ecosystems 15: 401-415; and Mekonnen, M. M. & Hoekstra, A. Y (2010) The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products. Value of Water Research Report Series No. 47

4. Median values derived from a range. Source: Flachowsky, G., Meyer, U. & Südekum, K.H. (2017) Land Use for Edible Protein of Animal Origin—A Review, *Animals*, 7 (3): 25; and Langemeier, M. (2016) *International Benchmarks for Soybean Production.* farmdoc daily (6):171, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign.

2. Eating Beef: *What Does It Really Cost?*

The world's population is on the rise. With more mouths to feed on a limited amount of land, our dietary choices have a bigger environmental impact than many of us are aware. The choice to eat beef has a particularly large impact on climate, forests and soils, and its production needs more land and water than any other source of protein.[2] There are also strong indications that eating red meat—including beef—increases the risk of developing certain cancers, heart diseases and diabetes.

More than a third of the world's beef is consumed in just three countries: the US, Brazil and China.[3] The amount of beef eaten per person in the US and Brazil is among the highest in the world: the average person eats the equivalent of more than two steaks a week (Figure 1).[4] This is almost twice as high as the maximum recommended intake of red meat (which includes the intake of pork, goat meat, lamb, and mutton).[5]

In China, beef intake is lower. There, the average person eats the equivalent of less than a third of a steak per week.[6] However, the country's large population and expected growth in beef demand mean that in absolute terms the country is—and will likely continue to be—a major consumer of the commodity.

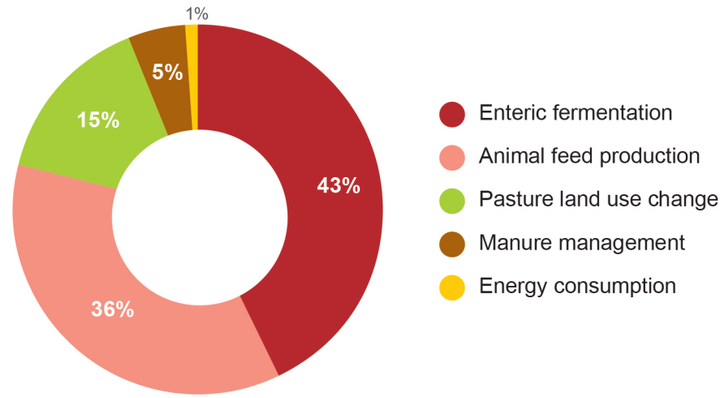
CLIMATE IMPACTS

Meat production from beef and dairy cattle emits 2.8 gigatons of carbon dioxide equivalent (Gt CO_2e) in greenhouse gas emissions annually[7]—almost 6% of all man-made emissions and two-thirds of emissions from the livestock sector.[8] These emissions occur all along the supply chain, mostly on the farm as a result of cattle's digestion processes, leading to methane emissions in a process termed enteric fermentation. A short-lived gas, methane, has a particularly strong greenhouse gas effect (Figure 2).[9]

Emissions from cattle depend on how and where animals are reared. In the US and Europe, for example, animals are typically reared in industrial farms. In such concentrated systems, animals produce large quantities of manure, causing substantial methane and nitrous oxide emissions. In Latin America, cattle are raised mainly in extensive pastures, roaming freely with manure left on fields. These systems are often inefficient, with farmers investing little in animal breeding or health or pasture productivity. Producing beef this way also causes deforestation, with farmers clearing forested land to make way for pastures. Pasture expansion is the largest driver of forest loss, occurring mainly in Latin America, and is estimated to be responsible for 0.5 to 1 Gt CO_2e in emissions.[10]

Figure 2: Sources of greenhouse gas emissions associated with beef production.

Source: Opio et al. (2013).[11]



HEALTH IMPACTS

A large number of studies have found links between red and processed meat consumption and increased risks of developing heart disease, diabetes, and several types of cancer (Figure 3). Globally, these three diseases already generate costs in the order of USD 1.65 trillion.[12]

Public health guidelines[13] from the World Cancer Research Fund International therefore recommend not eating more than 300g of red meat—a medium-sized steak—a week, very little of which may be processed, if any.[14] Excessive consumption of beef is characteristic of much of North and South America, as well as Europe. In the US and Brazil, the consumption of beef alone is almost double the recommended red meat intake, without considering pork or other red meats.

In other parts of the world, although beef is not part of a traditional diet, consumption is rising quickly as household incomes increase and Western diets—including fast foods like burgers or barbecued food—are becoming popular. This is particularly concerning and could take a large toll on public health costs in large and emerging economies such as China.

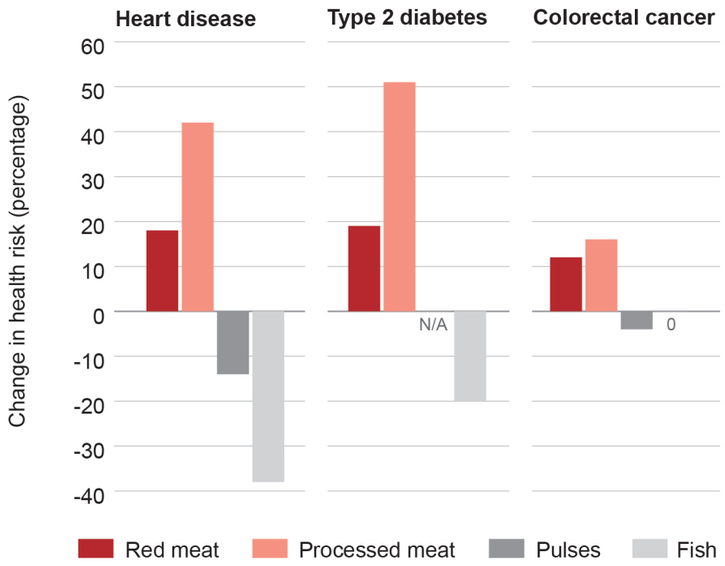


Figure 3: Health risk of eating different types of food.

The serving size used by these studies ranged from 20–100 grams per day.

Source: Climate Focus analysis based on Micha et al. (2010 & 2012), World Cancer Research Fund International/American Institute for Cancer Research. (2017), Daviglus et al. (1997), Yu et al. (2014); Zhang et al. (2013), Hu et al. (2014), Afshin et al. (2014), Schwingshackl et al. (2017), Aune et al. (2017); Meng et al. (2013), and Vieira et al. (2016).[15]

FORESTS

The area of forest cleared for beef is more than twice the combined area cleared for palm oil, soy, and wood products (Figure 1). Forests are cleared either to make way for extensive cattle pastures—often as a first step to using land for other purposes—or for planting crops that will be used as animal feed.[16] Deforestation associated with beef is particularly pronounced in South America, especially in Brazil, Paraguay, Bolivia, and Colombia, with cattle ranching expected to further drive deforestation in the region.[17]

SOILS

Beef production needs more land than any other source of animal protein (Figure 1).[18] Much of this land could be used for other purposes, especially as global demand for food and fibers is growing. Keeping too many animals on a single plot of land and managing this land poorly leads to nutrients being lost from soils.[19] Although cattle grazing can improve soil fertility if pastures are managed well, often the overuse of fertilizers and covering of soils with manure leads to environmental pollution and eventual soil loss.[20] In Brazil, for example, degradation affects about 60% of pastures and results in less productive lands.[21]

The crops grown to feed animals—most commonly soy—can also cause soils to lose their fertility. Intensive crop cultivation often involves planting large areas with a single crop. To keep these areas generating good harvests requires high inputs of chemicals and fertilizers, causing water contamination and damaging soil quality and structure over the long term.

WATER USE & POLLUTION

Beef production uses large amounts of ground and freshwater and contributes to the depletion of this increasingly scarce resource. Water consumption is especially high when cattle are raised in confined systems. On average, beef needs more water than any other food type—equivalent to close to four bathtubs of water per kilogram (Figure 1).[22] It also causes considerable water pollution, contaminating three bathtubs of water per kilogram of beef produced—a magnitude similar to chicken, but lower than pork (Figure 1).[23]

Beef also consumes by far the largest amount of rainwater—equivalent to 93 bathtubs per kilogram, mainly in pastures and feed-crop production.[24] The use of rainwater does not directly harm the environment, and in some dry regions, land used for cattle would not be suitable for other uses. Rain-fed land is a scarce resource, however, that in view of the growing demand for food, fiber and fuel could be put to more efficient uses in many regions.

3. The Mitigation Opportunity of De-beefing our Diet

Estimates show that without shifts toward healthier diets, agricultural production will need to increase by 70% globally and double in developing countries to feed a projected nine billion people in 2050, most of whom will live in cities.[25] Closing this "food gap" will require both dietary changes and more efficient ways of producing the food that we need. Shifting our diets away from highly resource-intense beef to food sources that are able to provide us with protein without using as much water, land, and other inputs would significantly benefit the climate, our health, and food security.

Box 1: How is reduced beef consumption modeled?

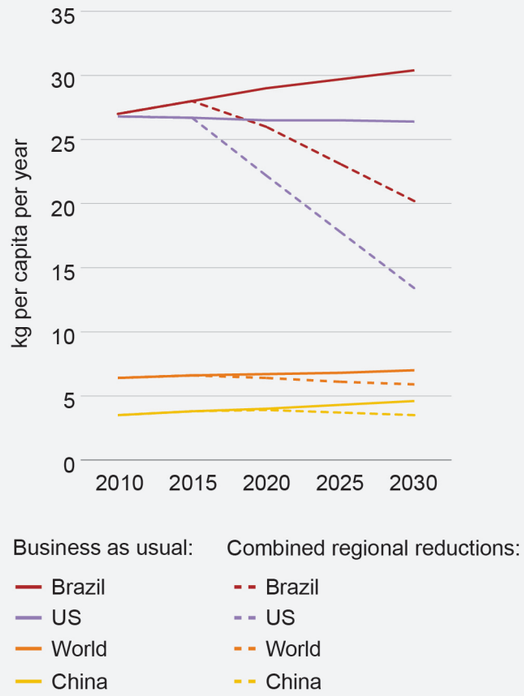
To determine the global impacts of reducing beef consumption, we ran a simulation using the Global Biosphere Management Model (GLOBIOM). This model simulates the relationships among systems involved in the provision of food and forest products. The model considers changes in population, economic growth, technological innovation, dietary preferences and policies in order to determine the possible impacts of reducing beef consumption. It also takes into account of the global availability of land for animal grazing and feed production.

We modeled the impacts of reduced per capita beef consumption with a focus on three countries selected because of their high levels of beef consumption (Brazil and the US) or their projected rise in consumption (China). We modeled a reduction in per capita beef consumption between 2010 and 2030, distributed across these three countries as follows:

- In the US, a 50% reduction between 2010 and 2030. While this is a substantial decrease, total per capita red meat consumption would still remain higher than recommended levels.[26]
- In Brazil, a 25% reduction between 2010 and 2030. Brazilian consumption of beef would still remain almost 30% higher than the maximum recommended total red meat intake level.
- In China, stabilization at 2010 beef consumption levels. China's per capita beef consumption is well below world average. However, its total red meat[27] consumption including pork is far above the intake levels recommended for a healthy diet.[28]

Our model assumes that reduced consumption occurs simultaneously in all three countries by these magnitudes, as illustrated in Figure 4 below.

Figure 4: Modeled beef consumption reduction scenarios per capita and year, comparing the modeled scenario (dashed line) with the projected business-as-usual consumption levels (solid line).
Source: GLOBIOM projections



MITIGATION BENEFITS

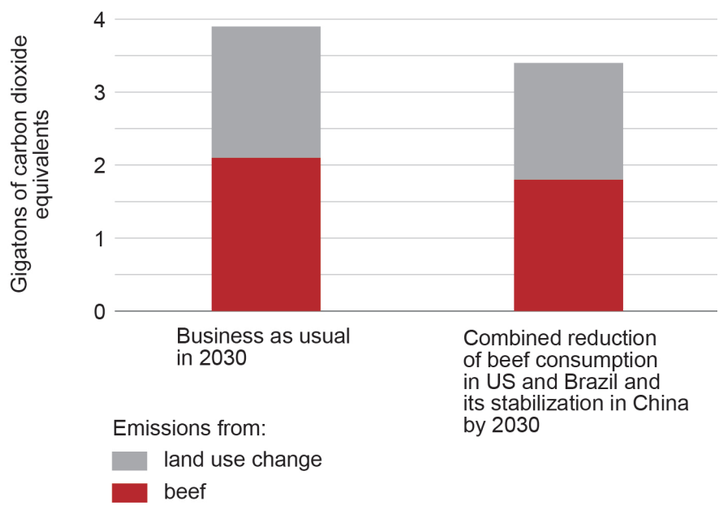
At the global level, reducing the beef consumed in line with the scenarios modeled in Box 1 has the potential to reduce emissions by 472 megatons of CO_2 equivalent (Figure 5). This is comparable to taking 100 million cars off the road, or a reduction in 12% of greenhouse gas emissions, attributed to the beef sector.[29] Emissions from land-use change (mainly deforestation) would decline by 14% compared to a business-as-usual scenario by 2030.

In individual countries (Figure 6), the reduction potentials are significant, especially in the US, where a 50% reduction in beef consumption would nearly halve emissions from the sector. In the scenario modeled, by 2030, beef would no longer account for the largest share of emissions from the livestock sector, instead contributing emissions of a similar magnitude compared to dairy and pork production. In Brazil, direct beef emissions would decline by a quarter, and emissions occurring as a result of agricultural expansion and associated land-use change would be almost halved by 2030. In China, stabilized consumption would avoid a 23% increase in emissions from beef production by the same year.

Although agricultural systems are highly interconnected, our modeled outcomes do not result in higher emissions in other parts of the world. Reductions in beef consumption in the US and Brazil, and stabilization in China, would not substantially increase the consumption of other commodities such as milk, sheep and goat meat, poultry, or crops in the US or Brazil. In China, however, a decrease in domestic production of cattle would likely lead to a small increase in domestic consumption of other animal protein sources.

Figure 5: Change in greenhouse gas emissions, by source, and magnitude of modeled reductions by 2030

Source: GLOBIOM Projections. [30]



HEALTH BENEFITS

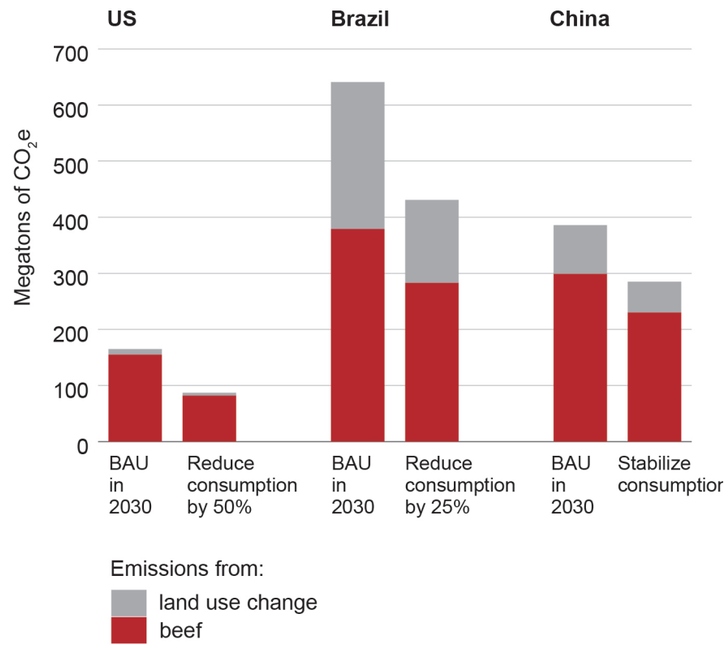
Modifying our diets to be in line with dietary recommendations—which includes reduced consumption of red meat and other dietary changes—could reduce global healthcare costs by an estimated USD 735 billion per year by 2050.[31] Replacing beef with plant-based proteins, including legumes and pulses, is beneficial to health. Studies indicate that these foods can protect against coronary heart disease,[32] type 2 diabetes, and bowel cancers, and are key factors in weight control.[33] In addition to these health benefits, these sources of protein are rich in vitamins, minerals and fibers.[34]

In both the US and Brazil, the amount of beef consumed per person is far higher than recommended for a healthy diet.[35] In the US, the adoption of healthier diets would reduce healthcare costs by USD 77–93 billion a year.[36] In Brazil, a shift to healthier diets with decreased consumption of meat—in particular beef—could avoid increased healthcare costs from obesity and related chronic diseases by more than USD 10 billion a year by 2050.[37]

In China, avoiding an increase in beef consumption is in line with the Chinese government's objective of halving the amount of meat eaten per person, which could avoid significant negative health and economic impacts.[38] The effect of poor diets and physical inactivity on medical costs, labor productivity, and the overall economy is huge, estimated to reach 8.7 percent of the country's Gross National Product by 2025.[39]

Figure 6: Change in greenhouse gas emissions in the US, Brazil and China, by source, and magnitude of modeled reductions by 2030

Source: GLOBIOM Projections.



FOOD SECURITY

The move toward reduced beef consumption is not only important for climate change mitigation but also for meeting increasing demand for food, fibers, and fuel. Curbing the projected growth in beef production—the most resource-intensive of all animal proteins—is likely to make more land available for other productive uses and avoid negative environmental impacts, both from extensive smallholder and industrialized production. Growth rates in agricultural yields are below what is needed to meet future food demand in the face of world population growth. A shift in patterns of production and consumption is needed to meet future demand for food. Sparing land used for pasture and feed production for less extensive and more sustainable crops helps to enhance global food security.

EFFECTS ON BEEF PRODUCERS

A reduction in per capita beef consumption would not be without impacts on beef producers. In the US' agricultural sector, beef production is the biggest source of farm income, representing 21% of income from agricultural commodities.[40] In Brazil, the beef sector is of major economic importance, generating almost 7 percent of gross domestic product (USD 130 billion). According to the latest agricultural consensus, there are 570,000 smallholder cattle ranchers in the legal Amazon.[41] These smallholders are particularly vulnerable to changes in demand and price shocks, and are increasingly exposed to global beef markets and to the risks of declining pasture productivity. In China, the cattle industry has grown rapidly in the past few decades but domestic production is still unable to meet increasing domestic demand.[42] Production is largely dominated by small-scale producers, but many of them are withdrawing from production. There is a trend toward larger producers and industrialized feedlots that are better able to produce beef efficiently and at scale.[43]

Our findings indicate that in Brazil and China, the modeled scenarios would avoid some of the projected growth in production by 2030. Despite reduced per-capita consumption, production would continue to increase due to global demand and population growth.[44] Rather than driving farmers out of business, the reduction would therefore reduce the motivation of farmers to expand or enter into the beef business. The effects would be severe in the US, however, where a 43% reduction in production could drive many farmers and feedlot operators out of business. A decline in prices could also put a burden on smallholders in Brazil, in particular where they operate marginal businesses and lack adaptive capacities.

4. Conclusions

Significant climate, food security, and health benefits make a drive toward sustainable diets an essential element of climate policies. Most of humanity can and should reduce or avoid excessive and unhealthy beef consumption, thereby helping to reduce global greenhouse gas emissions and improve public health. Livestock production and consumption are significant sources of greenhouse gas emissions, with beef being the most emissions-intensive source of animal protein. Beef uses more land and freshwater than any other type of food and pollutes local water resources. The amount of land needed means that the sector is also the most important driver of deforestation in Latin America.

This study analyzed the impacts of reducing the excessive consumption and inefficient production of beef on greenhouse gas emissions, health, food security and the economy. Our findings show that action to reduce or stabilize beef consumption in just three countries—Brazil, China, and the US—has the potential to:

- **Avoid emissions of 472 Mt CO_2e by 2030**, comparable to taking 100 million cars off the road. The findings of our modeling indicate that the beef sector could contribute to a substantial share of emissions reductions needed to limit the rise of global temperatures to 1.5°C to 2°C, as agreed to in the Paris Agreement.
- **Changing our diets – and eating less beef – would result in positive health outcomes and reduced healthcare costs.** Reduced or avoided consumption of red meat could lower the incidence of heart disease, diabetes, and cancer. Consumption of beef alone in the US and Brazil is almost twice as high as the maximum recommended daily intake of all red meats.

Reducing consumption calls for a socially balanced transition away from beef. Except for the US, our findings do not point to major negative impacts on beef producers. Nevertheless, policies to curb excessive beef consumption need to be accompanied by measures that allow structural adjustments for producers, especially smallholder farmers. This could include supporting cattle ranchers to develop more diversified agricultural systems and products, as well as providing financial support and capacity building to enable farmers to adopt improved and more efficient management practices.

Endnotes

1. Emissions from the beef sector were 2.8 gigatons of carbon dioxide equivalents (Gt CO_2e) per year. See Opio, C., Gerber, P., Mottet, A., Falcucci, A., Tempio, G., MacLeod, M., et al. (2013). *Greenhouse gas emissions from ruminant supply chains—A global life cycle assessment*. Rome: Food and Agricultural Organization. EU emissions for 2015 were 4.5 Gt CO_2e (Source: Eurostat. (2017). *Greenhouse Gas Emissions Explained*. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics). Anthropogenic GHGs reached 49 Gt CO_2e in 2010. See Intergovernmental Panel on Climate Change. (2014). Summary for Policymakers, In: *Climate Change 2014, Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK, and New York: Cambridge University Press.
2. This includes the use of rainwater, feed sources that are not edible by humans, and land that would not have been used for other purposes. With growing pressure on resources, alternative uses for these resources need to be explored (e.g. feed that is non-edible for humans could be used for bioenergy).
3. OECD-FAO. (2016). *OECD-FAO Agricultural Outlook*, in OECD Agriculture Statistics database. http://dx.doi.org/10.1787/agr-outl-data-en
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6. OECD. (2017). *Meat consumption (indicator)*. DOI: 10.1787/fa290fd0-en and GLOBIOM Projections modeled for this paper
7. These numbers likely underestimate emissions from land use change.
8. Opio, C., Gerber, P., Mottet, A., Falcucci, A., Tempio, G., MacLeod, M., Vellinga, T., Henderson, B., & Steinfeld, H. (2013). *Greenhouse gas emissions from ruminant supply chains—A global life cycle assessment*. Rome, Italy: Food and Agriculture Organization of the United Nations.
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11. Land use change emissions are based on conservative assumptions and focus on a select few countries in Latin America (Brazil, Chile, Paraguay, Nicaragua, Honduras, Ecuador, Panama, El Salvador and Belize), likely underestimating the magnitude of this emissions source. Animal feed production includes emissions from land use change from soybeans, applied and deposited manure on crop fields, feed production and emissions from the application of fertilizers and crop residues on land.
12. Bloom, D., Cafiero, E., Jané-Llopis, E., Abrahams-Gessel, S., Bloom, L., Fathima, S., et al. (2011). *The Global Economic Burden of Non-Communicable Diseases*. Geneva: World Economic Forum.
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14. World Cancer Research Fund International (September 2017).
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16. The numbers in the graph only take into account deforestation for pasture expansion and not for feed production.
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