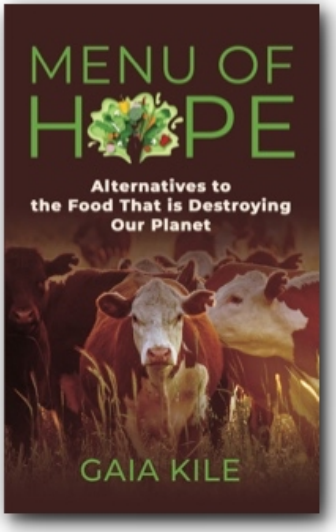


Discover how animal agriculture threatens our planet and explore solutions, from high-tech food innovations to activism, to create a sustainable and ethical future.

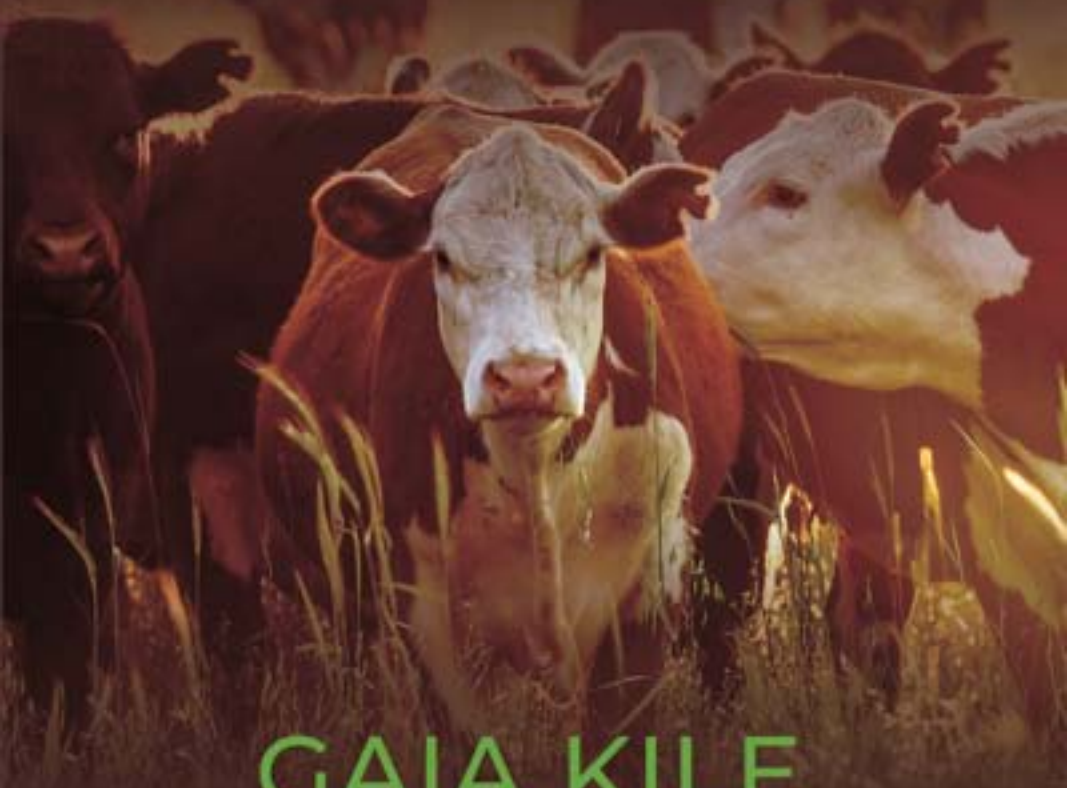
Menu of Hope

Alternatives to the Food That Is Destroying Our Planet

by Gaia Kile

MENU OF HOPE

Alternatives to the Food That is Destroying Our Planet



GAIA KILE

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Preface

This book was written before the 2024 US presidential election and published shortly after the election. The results of the election will change the course of climate action. The United States will again retreat from its climate obligations. With this election, the climate crisis has just gotten worse, and global temperatures will grow higher.

While this doesn't change the content of this book it changes the implications of that content. This is particularly true in the final chapter, my call for action. Before the elections, any action taken to address the problems of animal agriculture fit within the context of an administration that acknowledged and acted on climate change. This is no longer the case. With a shift in context, the same collective actions take on different meanings. What before might have been an effort to push for policy change, for now, may be more about building community. In the face of a government that operates by projecting fear, building community (around any issue) can be an act of resistance. In the face of a government controlled by climate change denial, in some ways, our actions may be more about laying groundwork for the future, while in another sense our actions are all the more important in creating the change we can now.

In spite of the posturing of a president, by now, nearly all of us know that we are facing a climate crisis. Climate change is real, the result of human action, and already underway. Many of us turn away from the grizzly details of the situation.

Although I am of the opinion that we don't talk enough about the climate crisis in all of its details, this book is not intended to be a rehearsal of the grizzly details. Nonetheless, before we progress to the effects of animal agriculture on climate change, I offer a very quick review of some of the concerns about the climate crisis:

The Climate Crisis

The global community has agreed to a goal of limiting global temperature rise above preindustrial levels to less than 2 degrees Celsius and preferably 1.5 degrees. The most recent global climate report estimates temperature rises of 2.2 and 3.5 degrees Celsius by 2100. Keep in mind that these temperature changes are in Celsius, 2.2 is 4 degrees Fahrenheit, and 3.5 is 6.3 degrees Fahrenheit. This is based on the successful implantation of current climate policies. But since this report came out in early 2023, we have seen an unanticipated jump in the average global temperature. The World Meteorological Organization estimates that in 2023 the average planetary surface temperature was 1.48 degrees centigrade warmer than pre-industrial levels. 2024 was 1.60 degrees warmer.

Extreme heat, deadly wet bulb temperatures, fires, sea level rise, drought, flooding, increased storm intensity, acidic oceans, loss of coral reefs, loss of biodiversity, melting polar ice caps, crop failure, and food insecurity, are some of the vocabulary of the climate crisis.

As I finish this text in January 2025, Los Angeles is burning from five fires driven by drought and 100 mph Santa Ana winds, factors exacerbated by the changing climate. Although not as extensive in area as many recent fires, two of these fires are among the top 5 most destructive of human structures in California's history. The previous two years have also had their share of climate disasters.

Americans might remember the unusual number of Canadian forest fires in 2023 that sent smoke across the Midwest and eastern U.S. seaboard, or the month of temperatures over 110 degrees Fahrenheit in the Phoenix, Arizona region that was responsible for nearly 600 deaths. You might even remember the flooding of the Burning Man festival in the Nevada desert. 2023 was the first year on record with category 5 cyclones in the seven major cyclone areas around the world. With those storms came considerable flooding. At the same time that Burning Man was drenched in mud, flooding in Libya killed over eleven thousand people. The proportional media coverage of the two events reflects the tragedy of climate politics, those who have the least and have done the least to cause the climate crisis are the most hurt by climate disaster.

Extreme heat has been called the deadliest extreme weather event with death rates often under-reported. 2024 saw extreme heat events starting as early as March and April with a heat wave that struck the region south of the Sahara desert in late March and then a region stretching from the Middle East across Southeast Asia to the Philippines was hit by deadly heat lasting much of April and into May. 2024 racked up floods, droughts, fires, and

extreme storms as well. Although Florida is notorious for its vulnerability to hurricanes, in 2024 it experienced a record number of severe storm events, and just two back-to-back hurricanes racked up over 100 billion dollars in property damage. The Amazon experienced record droughts in 2024 with as much as 50% drop in the river's water levels and accompanying forest fires. Drought in southern Africa created food insecurity for millions of people and water shortages for nearly a third of the population in certain regions.

In the last few years, the number of people suffering from chronic hunger has started to go up after decades of decline. The world already has over 20 million climate refugees, and by some estimates that could rise to over a billion by 2050. As we look ahead, the predictions for global temperature rise tend to underestimate feedback systems, where weather and temperature changes lead to increased climate change. Important examples of this include the melting of permafrost resulting in the release of methane, loss of sea ice exposing darker ocean waters that absorb more heat, increased forest fires with increased CO2 emissions, loss of carbon stores, and drought that results in increased carbon release from the soil. We don't know exactly how bad things may get at a 2- degree change or a 3 or 4-degree change. But the road ahead promises to be rough. It is unclear how many people will be killed by temperature, flooding, or crop failure due to drought. But people are already dying for all these reasons. Beyond direct consequences of climate change, conflict over water or struggles for survival increase the chances of worsening wars. These elements

are enough to paint an unpleasant picture of the future. If climate tipping points make things worse could we face societal collapse? Then what? Do we return to chopping trees for firewood for all our energy needs? Although they are a minority, some climate scientists have raised the question of whether we may be heading towards human extinction.

This is why my friend Andrew says he wants a better catastrophe. While things are getting hotter and we still keep emitting more greenhouse gasses, there are also positive signs: the energy transition is underway, and it is likely that we will hit peak CO2, the point of maximum CO2 emissions within the next few years. Some estimates suggest that we already have. Importantly the public is becoming increasingly aware and concerned about climate and global ecological problems we face. Nearly all projections assume at best limited changes in what we eat—what's on the menu. Nonetheless, as this book layout, changing the menu is perhaps our best chance for hope.

Introduction

Animals Are a Problem

Yes, animal agriculture, the raising of animals for human consumption, is an environmental problem. The impact of cattle production is particularly egregious, but raising mammals, fowl, and fish, all add to the level of global greenhouse gasses. Even so, focusing on the climate crisis or greenhouse gasses understates the scope of the problems we face. Several major global systems have been identified as necessary for a sustainable and habitable planet. Animal agriculture has a direct impact on nearly all of them. Ultimately the disruption of these systems threatens our life on this planet.

Considering the scope of the problems caused by animal agriculture, it is easy to be hopeless. But to contend with a problem, we first need to see and understand it. Then we can turn to looking for frameworks capable of addressing the problem and finally, we can take action. This could be the formula for a manifesto, but this book is not intended to offer a definitive thesis or single solution. Instead, it points to important issues anyone concerned about climate or the environment should know about. And it offers a variety of approaches, strategies, and actions that offer a menu of ways to respond to our planetary crisis. The book is an invitation to readers to participate in a much-needed discussion and ultimately, I hope it is an inspiration to action.

Those of us who take the risks of climate change seriously recognize that many things need to change to get to a

sustainable world. Some are relatively trivial considering the attention they get. For instance, in a world flooded with plastic waste, focusing only on our choice of what to drink through amounts to grasping at straws. Some things that need to change are more fundamental. Animal agriculture is fundamental. Although environmental activists have raised concerns about animal agriculture for decades, the issue has largely been excluded from the mainstream discussion of climate change. Recently there has been a growing understanding that animal agriculture poses a threat to our efforts to limit climate change. At the core of this threat is cattle and beef production with its demand for feed and land, and its production of methane. Nonetheless, the extent of the threat remains vastly underappreciated.

The first chapter of this book looks at the problem of animal agriculture and climate change. This starts with the impact of animal agriculture as seen by the Intergovernmental Panel on Climate Change (IPCC), the global scientific body established to address issues related to climate change, including an estimation of the benefit if the world miraculously went vegan. There is a spectrum of other estimates of the effect of animal agriculture on the climate that deserve further consideration. It's not enough to acknowledge the span of the different estimates. It is important to understand how different numbers were arrived at. The differences between various life cycle analyses largely stem from what is being measured and who is doing the measuring.

Because cattle play such a central role in climate change it is easy to skip over other animals. Chapter 2 turns to the other major farm animals and their greenhouse gas impact. The

chapter also focuses on other environmental and global public health problems related to animal agriculture. Climate is but one existential environmental threat. The planetary boundaries framework identifies eight other potential threats. Human pandemics are yet another threat exacerbated by animal agriculture.

The third chapter of this book turns to four types of solutions:

1. Proposals from agriculturalists focus on optimizing animal agriculture primarily through efficiency and carbon capture. Agriculture is very complex, and disagreements abound about what is most efficient and what carbon capture has to offer, but one popular "solution" could be making things worse.
2. High-tech strategies suggest substitutes for animal agriculture. These approaches read like science fiction but in conjunction with other new food strategies they are starting to be implemented.
3. A perspective of public health experts is presented in a report on diet and climate change commissioned by the prestigious medical journal, *Lancet*.
4. Finally, for animal rights activists, the solution is straightforward: stop consuming animal products. But even those who agree with the ethical premise can struggle to apply it.

The book's concluding chapter turns to activism and organizing. To do this it reviews the issues of the book, touches on issues of policy, and looks at challenges related to coalition building and change-making. It also offers examples of actions and invites the readers' involvement.

Starting With Science and Debate

To make sense of the big issues like planetary sustainability and global food production, good science matters. Scientific consensus is built on debate. A key rule of the debate is that arguments must be based on evidence. Among scientists, Peer-reviewed publications are the primary way evidence is presented. The peer-review process enlists experts in a scientific field to referee the rules of evidence. As science moves forward there is an ever-growing body of peer-reviewed evidence. Sometimes consensus emerges spontaneously from the evidence. In other cases, science uses expert bodies to evaluate the evidence. The Intergovernmental Panel on Climate Change (IPCC) is constituted to assess, evaluate, and present consensus statements on the science of climate change. Other global and governmental organizations play important roles in scientific assessments. For instance, the UN's Food and Agriculture Organization is a source of information and assessments about the impact of global food production.

World-class scientists can also be brought together to develop contexts for making sense of the available science. The Project Drawdown, the Planetary Boundaries Framework, and the EAT-Lancet Commission are all examples of this type of consensus-building process that we will look at in the pages ahead.

Expert opinion is an appropriate starting point for social discourse around these types of big issues. But expert opinion isn't the end of the discussion. Experts don't

always agree, and new discoveries or interpretations can challenge existing scientific conclusions.

Even when there is a strong degree of scientific consensus, debate continues within the confines of the consensus, and scientific conclusions are open to reassessment. Like the rule about scientific arguments, reassessment must align with the evidence.

In Chapter 1 we see that differences in interpretation of the evidence can lead to different conclusions. This might be called the politics of science. In Chapter 3 we encounter a claim that could overturn the consensus about cattle and climate. Extraordinary claims like this need extensive evidence, but in this case, sufficient evidence is lacking.

Unfortunately, arguments that don't hold up to scientific scrutiny can win in the courts of public opinion and the halls and chambers of policymakers. This is why scientific literacy, including understanding the areas of genuine debate in science, is so important. With this kind of scientific literacy people can more meaningfully participate in very important conversations: discussions of the social significance and public policy implications of the science.

This book looks at information presented by experts, international panels, scientific government bodies, and independent experts as well as research reviews and scientific studies. In comparing conflicting opinions, it is

also relevant to consider the biases, interests, and influences that contribute to the shape of the arguments.

Chapter 1

Animal Agriculture: A Climate Disaster

Experts tend to agree that animal agriculture is a major contributor to climate change, but there is less agreement about how much it contributes. In this chapter, we will start by looking at land use and climate as discussed by the Intergovernmental Panel on Climate Change. Then we will look at the potential climate benefits of moving away from animal consumption as discussed by Project Drawdown. Finally, we will look at five different calculations of the relative climate impact of animal agriculture. These different calculations have vastly different estimates of the relative impact that animal agriculture has on the climate. The point in discussing these divergent estimates is not so much to make a case for a particular number, but to make sense of why such vastly different numbers are used. This includes the important point that the mainstream estimate doesn't look at the whole picture.

The Intergovernmental Panel on Climate Change

IPCC Consensus Science and Consensus Politics

In terms of expert scientific consensus, the Intergovernmental Panel on Climate Change (IPCC) reports are significant intellectual achievements. These works are massive in scope and depth of assessment. Their focus, reviewing the science behind the climate crisis, is as important and pressing as any intellectual task we face. The participation of world-class scientists and governments from

over 200 nations is truly phenomenal, particularly in light of their consistent consensus. Nonetheless, their consensus represents the least common denominator, and governmental influence can result in a document that understates certain issues. The impact of animal agriculture on the climate crisis is such an issue.

The IPCC Process

The IPCC does not generate new science; it assesses existing scientific literature. Its reports are written by hundreds of world-class scientists, nominated by participating governments and observer organizations. Initial drafts are subject to review including comments from within the IPCC and thousands of outside experts. The authors respond to all comments. This leads to the second draft which goes through additional review, including governmental review, leading to a final draft along with a summary for government policymakers and a technical summary. The summary for policymakers which is the most read part of each report is subject to line-by-line editing by member governments. The fact that the IPCC does reach a consensus including universal government approval is impressive. On a regular basis, governments with vastly different political interests agree to massive statements regarding the science and implications of climate change. If we care about the peer review, the IPCC deserves credit for its extensive and global review process.[1]

However, there is a fatal shortcoming in this process worth mentioning; the political dynamics of multi-governmental approval tend to result in reports that understate the severity of the problem and can avoid targeting primary elements of

concern. This is particularly troubling when the underlying science points to factors that are major contributors to climate change, and government representatives can weed out references to those factors. This censoring usually occurs when governments are acting in the interest of powerful industries.[2] An additional limitation is that scientific reviews are only as good as the research they are reviewing. Another issue is that some decisions on how to calculate the impact of animal agriculture on climate change are more political than strictly scientific.[3] Furthermore, the question of how we divide up the factors that affect climate change matters. That is to say what factors count as parts of the calculation of animal agriculture's impact on the climate? Of particular importance is the issue of whether land use and lost opportunity cost are counted. Land used for grazing or feeding cattle can't be used for tropical rainforests. The rainforest will always take up and hold more carbon than agricultural land. As we will see it makes quite a difference whether the opportunity to do something else with the land is calculated into the climate impact of animal agriculture.

IPCC Special Report on Climate Change and Land

The IPCC Special Report: *Climate Change and Land* was published in 2019. It addresses climate change, "desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems." These topics are covered extensively, but unfortunately, some of the important points about food and agriculture are hidden deep in the document. Nonetheless, near the start of the document, in the summary for policymakers, there is important information about land

use. If read carefully this can give us insights into the problems with animal agriculture.

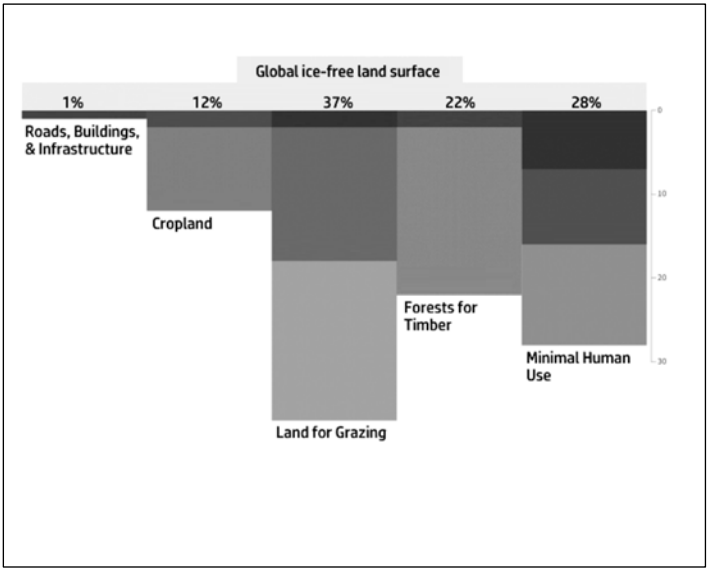


Figure 1. Based on a chart from the IPCC special report: Climate Change and Land (2019)[4]

The IPCC divides land into five categories, infrastructure which includes cities and roads, croplands, grazing lands, managed forests, and land with minimal human use. Around 50% of the earth's "ice-free" land is used for food production, grazing lands, and nearly all croplands.[4] In addition to grazing lands, much of the world's croplands are dedicated to growing fodder for livestock. As a percentage of all the land that is used to grow food, as much as 83% is used for animal production. This leaves only 17% of food-producing lands for growing the plant-based foods that humans eat directly.

These numbers are particularly telling when considered in relation to the percentage of calories humanity gets from plant-based foods compared with foods from animal sources. Worldwide, about four-fifths of our calories come from the 14% of agricultural land that produces plants for direct human consumption. In terms of calories per land area, this results in a plant-to-animal ratio of more than 20 to 1. Put another way, on average an area of land growing crops for direct human consumption produces twenty times more food calories than an equal area of land dedicated to producing food sourced from animals.[5] Overall, land that is used for plant-based food is used far more efficiently than land used to produce food from animals.

Although the most often referenced calculations ignore it, land use is one major reason why eating a plant-based diet is an important aspect of addressing climate change. Reducing livestock production also reduces other climate challenges such as methane production from animal manure and ruminants' digestion.

Greenhouse Gas Basics

Greenhouse gasses (GHGs) play a critical role in regulating Earth's temperature by trapping energy from the sun in the Earth, its oceans, and the atmosphere. While this effect is necessary for maintaining a habitable temperature, human activities have increased the concentration of GHGs. Human-caused GHGs are sometimes called anthropogenic. Increasing levels of GHGs increase the trapped energy leading to a hotter and less habitable global climate.

The three main greenhouse gasses responsible for anthropogenic climate change are carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). Their impact is governed by three factors, quantity, relative effect, and duration. The most prevalent greenhouse gas is CO2, followed by methane and then nitrous oxide. But the most powerful greenhouse gas is nitrous oxide followed by methane and lastly CO2. Methane is the shortest-lived greenhouse gas. We measure the rate at which greenhouse gasses break down in terms of the half-life of the gas, methane's half-life is around 10 years, and CO2 and nitrous oxide both have half-lives of over 100 years. The relative impact of greenhouse gasses is calculated in CO2 equivalents (CO2 eq) but as we will see the calculated equivalence depends on the timeframe under consideration. Throughout this book "CO2 eq" or "CO2 equivalent", and occasionally simply "carbon" are used interchangeably with the more colloquial term "greenhouse gasses" although CO2 eq can have numerical values assigned to it. Because we are

concerned with the process of raising levels of greenhouse gasses over time CO2 eq is often measured per year.

Other factors that affect greenhouse gasses and global temperatures include carbon sequestration and solar reflection. Sequestration refers to carbon dioxide pulled from the atmosphere and stored away where it no longer contributes to climate change. Similarly, the more solar radiation is reflected back into space rather than absorbed as heat, the less the climate impact. Clouds for instance are highly reflective.

IPCC on Diet

The IPCC *Climate Change and Land Report* looks at diet change as a strategy for addressing climate change. Compared with other strategies, the report found both that diet change can provide major carbon reduction and that there is a high level of evidence to support this finding. The IPCC standard for a major reduction is more than three gigatons CO2 equivalent per year which amounts to about 5% of total global greenhouse gas emissions. Other responses with strong evidence and major potential include reducing deforestation, for which animal agriculture is the major cause, increasing organic carbon in the soil, and reduction of post-harvest and consumer food waste.

But what is meant by diet change? The report provides a summary of several studies regarding the mitigation potential of eight different diet strategies if they were adopted worldwide. All the studies reviewed were clear about the potential of diet to reduce greenhouse gasses. The data

suggest that if the global population became entirely vegan, as much as eight gigatons CO2 eq per year could be cut. To put eight gigatons CO2 eq in context, the IPCC estimates that the total anthropogenic greenhouse gas equivalent in 2019 was approximately 59 gigatons. In other words, around 13 or 14 percent of the 2019 greenhouse gas equivalent could be cut by the human population going vegan. As we will see this isn't the whole picture, reducing animal agriculture not only has the potential to reduce emissions but also to free up land with the potential to pull carbon out of the atmosphere.

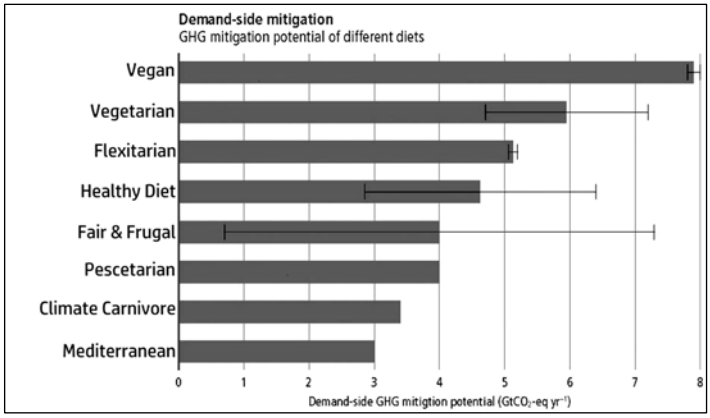


Figure 1. Based on a chart from the IPCC special report: Climate Change and Land (2019). With the following category descriptors: Vegan, no animal source; Vegetarian, meat/seafood once a month; Flexitarian, limited meat, and dairy; Healthy Diet, limited sugar, meat, and dairy; Fair & Frugal, limited animal source food but rich in calories; Pescetarian, a diet consisting of seafood; Climate Carnivore, limited ruminant meat and dairy; Mediterranean, moderate meat but rich in vegetables.[2]

Of the diets the report considered, a vegetarian diet is the next best scenario for GHG reduction. If everyone adopted a vegetarian diet with eggs and dairy, estimates suggest that greenhouse gas reduction would reach three-fourths of the

potential of the fully vegan scenario. Nonetheless, by cutting down on meat, and beef in particular, all eight diets appear to have the potential for atmospheric carbon reduction of at least three gigatons CO2 equivalent per year.[4]

The IPCC Climate Change and Land Report offers another insight worth keeping in mind. Climate change will contribute to desertification, and desertification and land degradation are also the result of poor land stewardship. As land degrades, carbon stored in soil escapes into the atmosphere as greenhouse gasses. Depending on the use and condition of land, the same acreage may be either a source of greenhouse gas or a sink for sequestering carbon. Although this is important and useful when thinking about how to farm, it can become a distraction from the question of what to farm, which is a more poignant question when focusing on the overall impact of climate change.[4]

Big Ag Influence on the IPCC

In 2023 The IPCC published its 6th synthesis report. The objective of this synthesis is to integrate findings from the three IPCC working groups and the three special reports.[6] Unfortunately, the important insights about food choices and Animal Agriculture that the IPCC special report on *Climate Change and Land* covered, were actively excluded from the synthesis report. We know because an organization called Scientists Rebellion released an earlier version of the report that stated that “Plant-based diets can reduce GHG emissions by up to 50% compared to the average emission-intensive Western diet” and that shifting to plant-based diets “can lead to substantial reductions in GHG emissions”. But these comments were removed in the published edition because of representatives from the major beef exporting

countries of Brazil and Argentina whose comments were leaked. They successfully had all references to plant-based diets and the environmental impact of meat removed.[7]

Project Drawdown

As the IPCC Land report pointed out, in terms of land use strategies, a change to a more plant-rich diet is one of the most effective strategies for reducing greenhouse gasses. But where does diet fit into the overall efforts to curb climate change? Project Drawdown is a venture focused on identifying and ranking solutions to the climate crisis. The project has enlisted hundreds of scientists and researchers. They have identified around "100 solutions that are available now, growing in scale, financially viable, and measurable."[8] These scientists' estimates of which solutions have the greatest ability to "draw down" the levels of greenhouse gasses in the atmosphere have changed over time and

Top 3 Solutions to Climate Change

Solutions	2°C	Scenario 1	Solutions	1.5°C	Scenario 2
Reduced Food Waste	**1**	88.50	**Wind Turbines (Onshore)**	**1**	143.56
Plant-Rich Diet	**2**	78.33	**Utility Solar (PV)**	**2**	111.59
Family Planning and Education	**3**	68.90	**Plant-Rich Diet**	**3**	103.11

Total gigatons of CO2-equivalent emissions that could be reduced by 2050.
Chart 1. Based on data from project drawdown (Oct 2023)[9]

depending on how they divide the categories. In their current list, solutions are based on two scenarios, one where the global temperature increase is kept below 2 degrees centigrade and a second where the temperature is kept below 1.5 degrees centigrade. In these scenarios, the adoption of plant-rich diets comes in second and third place respectively.[9]

As impressive as this is, a case can be made that the impact of a vegan diet has been underestimated and a plant-based diet should be first in our priorities. Before we look at underestimates, we can get to the top of the list for Scenario 1 by squabbling over how to split the categories. If we follow the IPCC categorization, food waste should be considered as two separate issues: retail and consumer waste is big in the wealthier parts of the world, whereas post-harvest loss is the problem faced more by poorer regions. Based on this categorization, adopting a plant-rich diet becomes the strategy with the greatest drawdown capacity. In Scenario 2, plant-rich diets come in third behind onshore wind power and utility-scale solar photovoltaic power.

Coming in third place for action to reduce greenhouse gasses certainly still points to the importance of a more plant rich diet. But the project drawdown calculation doesn't show the full potential of a plant-based diet. Scenario 2 assumes that 75 % of the population limits meat consumption to 57 grams of meat a day. This is not the IPCC scenario where everyone goes vegan. Setting aside the practicality of how to get there, assuming 100% of the population at 100% vegan over the same period would provide enough emission reduction to

push the impact of a fully plant-based diet ahead of the number one solution for Scenario 2.

As significant as wind and solar development are, and even if, as Scenario 2 suggests, they have more potential than a plant-based diet to drawdown atmospheric carbon levels, from the perspective of which strategy needs our attention the most, diet may come first. A case can be made that wind and solar have both been following exponential growth curves and exponential cost drops. These technologies are reaching a rate of growth that is promising. This isn't to say that there isn't more to be done in terms of advocating for and adopting onshore wind and utility-scale solar photovoltaic electricity. But in terms of where things currently stand and where they are going, plant-based diets need the push more.

Project Drawdown's calculations are based on a 30-year estimate, their model assumes a changing impact and a linear progression moving gradually to a more plant-rich diet. Another way to ask the question is what percent of anthropogenic (human-caused) climate change is due to animal agriculture. I'll consider five calculations and some of the debate around these calculations.

Estimates of Climate Impact

All estimates of the percent of total climate impact from animal agriculture look at emissions, but very different conclusions are reached depending on (1) what emissions are included, (2) the relative impact assigned to different greenhouse gasses, and (3) how the issue of land use is considered. If you see an estimate in the single digits, they are likely not taking into account all relevant emissions. We

will look at an example of this only to drive home this point. Methane is a major concern, particularly in the case of ruminant animals such as cows. But if you just look at methane you are overlooking agricultural CO2 and nitrous oxide emissions. Another important issue is the difference between avoided land conversion and potential carbon sequestration "opportunity costs". Land conversion has to do with carbon loss from the cutting down of forests while carbon sequestration looks at the cost of not doing something else with the land, such as "rewilding" or reforesting. Part of the difference between the frequently referenced FAO estimate[10] and some of the estimates that calculate higher percentages of greenhouse gasses is the difference between measures of land conservation alone and estimates including the lost opportunity cost of potential carbon sequestration. As one of the scenarios below points out there are alternative uses of land that don't involve sequestering carbon per se that could also reduce total greenhouse gas emissions.

Animal Agriculture's Share

I spoke with one life cycle analyst who has published extensively on the value of changing to a more plant-based diet. He argues that within the generally accepted range of estimates, even the lower percentages justify addressing the greenhouse gasses from livestock. Nevertheless, the broad scope of available estimates surpasses what he considered the generally accepted range. The variety of calculations found in the public discourse is so wide that on one end, animal agriculture's contribution to climate change seems to be almost a rounding error, and at the other extreme, calculations suggest that animal agriculture is responsible for the vast majority of greenhouse gas emissions.

Another life cycle analyst raised questions about whether the lowest and highest estimates that we will consider were valid enough to be included in the discussion. I think it is important to consider both extremes because both are easily found in social media. But this is not to equate the two extremes. At first glance, this can play into the narrative that climate science is uncertain. In fact, the difference in estimates reflects the measuring of different things. This is why a review of these numbers is important. Any estimate of the relative impact (percent of total human impact) of animal agriculture on climate change will look at emissions, but very different conclusions are reached depending on what emissions are counted, how they are counted, and how land use is considered. I include both because it further demonstrates the point that the number you get depends on what you count. If we want a full accounting of the climate change impact of animal agriculture a full count of relevant factors is needed. On the high end, our concerns should focus on accuracy.

We will look at five different estimates including a lowball calculation from Frank Mitloehner,[11] a representative of the meat industry. His estimated percent of greenhouse gas emissions looks at the smallest slice of the pie. The most frequently quoted emissions estimates are from the UN Food and Agriculture Organization (FAO).[10, 12, 13] Other estimates of the percentage of climate impact tend to calculate the relative impact of methane considerably higher. And they take into account carbon opportunity cost. Carbon opportunity cost refers to the carbon sequestration potential of land if it isn't used for animal agriculture.

The IPCC and the FAO

The IPCC estimates that approximately eight gigatons of CO2 equivalent emissions could be reduced by a planet-wide switch to a vegan diet. Reducing emissions by eight gigatons through eliminating all animal agriculture amounts to about 13.5% of total human greenhouse gas emissions. This percentage comes from calculations by the UN Food and Agriculture Organization (FAO). The FAO has published estimations of greenhouse gas emissions in 2006[10] 2013[12] and 2017[13]. These studies' calculations of animal agriculture's emissions as a percentage of total human-made greenhouse gasses range from 14.5 % to 18 % (Note that the difference between the vegan switch and the animal agriculture source can be accounted for by the greenhouse gasses attributed to growing plants for human consumption that would be needed to replace animal products). This range is frequently compared with the total emissions from the transportation sector. There is good reason to believe that these numbers are too low, but first, let's look at an even lower number.

An Incomplete Estimate

The lowest calculation I could find is not a global calculation and is simply an incomplete number. It comes from the meat industry champion Frank Mitloehner. He runs a center at UC Davis that is almost entirely funded by the cattle industry. This center was conceived of by a cattle industry non-profit, has an advisory board composed of funders, and works closely with the cattle industry on messaging. Mitloehner's work has been described as "discordant with the scientific

consensus" and the case he makes is insufficient to challenge the consensus.[14]

Mitloehner estimates greenhouse gasses from US livestock at 4.2% of all US anthropogenic emissions. I mention his number only because it is referenced in social media. Although he bases his numbers on EPA estimates[15], there are several reasons why this number is so low. Foremost is that it is only a measure of methane from manure and enteric fermentation, the source of cattle's methane burps. Several other sources are not included in this figure. Most conspicuously absent are the emissions from the croplands and grazing fields that make up livestock fodder. Mitloehner has received considerable criticism for failing to take into account a full life cycle analysis. The EPA numbers are also not global, they only represent US emissions. Due to America's industry and high energy use, total US per capita greenhouse gas emissions are greater than the global average. This makes the relative role of livestock methane lower.[16] Mitloehner argues that US cattle rearing is more efficient, with less emissions than cattle production in other parts of the world. Although this argument about efficiency may be at least partially true, it doesn't get US meat consumers off the hook. Every year the US exports billions of pounds of beef while also importing billions of pounds for domestic consumption. The meat market is global so the contribution of beef to greenhouse gas emissions should be measured in terms of its global aggregate impact.[17] The argument that the FAO estimates are too high is far-fetched. The FAO numbers are more legitimately critiqued in the other direction.

Calculations from the Worldwatch Institute

Calculating the percentage of the total greenhouse gas emissions due to a given sector of human activity depends on what is counted and how it is counted. These are issues that are sometimes as much political choices as they are about correct scientific procedures.

Until recently, the highest estimate of greenhouse gasses from animal agriculture was the 2009 response to *Livestock's Long Shadow,* the 2006 FAO estimate of 18%. The 2009 response was published by the Worldwatch Institute. Anhang and Goodland, two environmental experts from the World Bank, calculated total livestock emissions at an astonishing 51%, more than half of all human-caused greenhouse gasses! How did the Worldwatch Institute publication get a percentage nearly three times higher than the FAO calculation? According to their report, the three main sources of uncounted greenhouse gasses include undercounted methane, overlooked land use, and overlooked animal respiration. There are also several smaller uncounted sources and misallocated greenhouse gasses that the Worldwatch report identifies.[18]

Counting Methane

Methane has a much stronger greenhouse warming potential (GWP) than CO2, but it also breaks down quicker than CO2. The half-life of atmospheric methane is around 9 years, whereas CO2 has a half-life of more than 100 years. The FAO reports take the total lifetime warming potential of methane and divide that by 100 years. The Worldwatch calculations assume a 20-year effect. There are two arguments for this shorter period for methane: first, it

dissipates more quickly than CO2, and second, cutting methane emissions has a greater impact on climate in the short term, in part because it does dissipate quicker. The importance of short-term mitigation of climate change includes an acknowledgment that we are in a critical period of climate disruption.

Respiration

The idea that animals' breathing should count as a contribution to global warming may seem self-evident—after all, animals exhale CO2. Or it may appear to be a misunderstanding—exhaled carbon is part of the carbon cycle where plants take in exhaled CO2 to make carbohydrates that are consumed by animals, metabolized, and exhaled. Anhang and Goodland point out that “tens of billions more livestock are exhaling CO2 than in preindustrial days.” Perhaps the respiration of livestock should be thought of as a measurable surrogate for carbon that could be stored in areas of land if they were not used for animal agriculture. Since “overlooked land use” is a separate category, this may look like counting that category twice. But the number they offer for carbon savings from other land uses is at the low end of “what if” scenarios. In their text they point out that “by itself, leaving a significant amount of tropical land used for grazing livestock and growing feed to regenerate as forest could potentially mitigate as much as half (or even more) of all anthropocentric GHGs.”

The controversy raised by the Worldwatch paper has not been resolved. A rebuttal was published by some of the authors of the FAO report.[19] The authors of the Worldwatch paper in turn published a defense against the rebuttal.[20] But

the FAO moved on, publishing other reports with numbers even lower than the 18% figure. The FAO published its last calculations in 2017.

A "Conservative" Minimum

More recently Nicholas Carter an environmental scientist has looked at the question of what percent of anthropogenic climate change is related to agriculture. He has taken FAO numbers and used the 20-year time frame for calculations of methane, Importantly, he argues that the 20-year time frame is validated by the IPCC. Additionally, he includes accounting for carbon opportunity cost, assuming that 10 percent of land used for grazing could revert to forest. Carter argues that the question of whether animal respiration should be counted rests on complex science that has not been settled yet. Nonetheless, because of the degree of controversy around this question, he excludes CO2 attributed to animal respiration in his calculations. He concludes that 37% marks a conservative minimum value for greenhouse gasses from animal agriculture. Unfortunately, Carter has been unable to publish his work. He says there isn't interest in the question from the journals he has approached.

The Highest Estimate

In 2021 a position paper by a systems specialist Sailesh Rao, published in the Journal of Ecological Society, revisited the question of what percentage of anthropogenic greenhouse gasses comes from animal agriculture. Rao uses a model that assumes optimized use. Rao calculated that animal agriculture was responsible for fully 87% of all anthropogenic greenhouse gasses! Rao argues that the IPCC made four

mistakes in their calculations. Like Anhang and Goodland, and Carter, this paper points out the problem with calculating methane's effect over 100 years, but Rao goes further by calculating methane's effects over a 10-year period. He calculates the carbon opportunity cost due to animal agriculture by borrowing an estimate for the carbon sequestration potential of reforesting all the lands that were forested in 1800.[21] His figure for total potential carbon storage from reforestation is 265 gigatons of carbon. This is equivalent to approximately one-third of all CO2 emissions since 1750.

Rao makes an additional point that although atmospheric CO2 takes over 100 years to break down, only 45% of CO2 remains in the atmosphere. The oceans are the largest sink for CO2, which creates other problems, particularly acidification. Nonetheless, carbon pulled out of the air does not contribute to solar radiation retention which is at the root of global warming. Finally, Rao raises the concern that the IPCC relies on data from the FAO, an organization with formal ties to the International Meat Secretariat and the International Dairy Federation, two industry promotion organizations.[22] Other than coverage in the "vegan" press, Rao's paper has largely been ignored although it has received criticism for some of its math calculations.

Making Sense of Different Numbers

The point of reviewing the spectrum of calculations of relative climate effects from animal agriculture is not to nail down a specific number. After all, it's a moving target. If things go as currently forecasted, humans will eat more meat, and through the implementation of renewable energy and other

technologies, other sources of greenhouse gasses will begin to decrease. Whatever the present relative effect of animal agriculture is, it is on track to get larger, that is to say, to get worse.

The immense differences in these calculations are also not a reason to say, “no one really knows,” and to give up on finding any meaning in them. On the contrary, by comparing different estimates we can see why there are such differences in the numbers. The different percentages of climate impact ascribed to animal agriculture depend on what is being included in the calculations and how those factors are weighted. In the case of methane, the period over which its effects are calculated matters. If methane’s effect is amortized over a shorter period, the relative weight of its impact is more. Regarding land use, results will vary depending on whether one counts only the forests being destroyed in service of the animal industry or the potential for former forests to grow back. The failure to account for the carbon opportunity costs potential of reforestation, rewilding, or other uses of land that is involved in animal production, will underestimate the potential climate benefit of moving away from meat.

If the assumptions and calculations of Goodland and Anhang, Carter, or Rao give us the most accurate assessment, then animal agriculture becomes the economic sector with the largest impact on the climate crisis. If Rao is correct, it starts looking like animal agriculture is virtually the only industry that matters in the short run. On the other hand, if a case can be made that the best way to calculate the impact of methane is over 100 years, and if we don’t consider

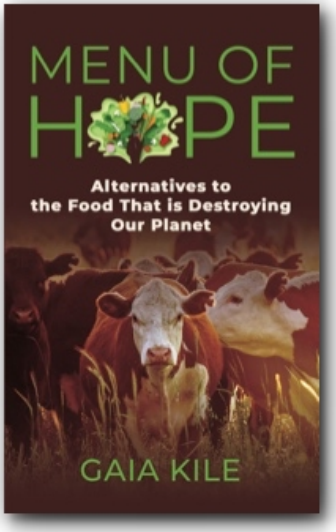
the carbon-storing potential of land currently used for animal agriculture, then addressing animal agriculture is still important—over time becoming an increasingly more important part of the climate problem. The demand for meat continues to rise globally. Furthermore, there is an energy revolution underway. Solar and wind power are already the most affordable energy on the planet, and renewable energy now accounts for nearly a third of all electric generation worldwide. Against the backdrop of success on this front, the relative importance of animal agriculture is becoming bigger.

Let's return to the IPCC report on climate change and land use. Its estimate of potential greenhouse gas mitigation from changing to a vegan diet is in line with estimates for animal agriculture that are calculated by the UN Food and Agriculture Organization (FAO). However, the IPCC also acknowledges the potential of mitigating greenhouse gasses by increasing the world's forests. Three factors can expand the world's forest: reducing deforestation, increasing reforestation, and afforestation, which refers to growing trees where there wasn't a forest before. The IPCC calculations regarding the potential to reduce greenhouse gasses through diet change, take into account deforestation. Within their report, estimates of the potential of reforestation and afforestation are separate from calculations of agricultural impact. These numbers must balance the issue of climate with concerns about food security. For instance, planting trees on agricultural land in one part of the world could create food needs that lead to greater deforestation elsewhere.

Source of estimate:	Mitloehner	FAO	Carter	World Watch	Rao
Estimated % Global Greenhouse Gas due to animal agriculture	4.2	11 to 18	≥ 37	≥ 51	87
Methane impact over *100 years*	X (US only)	X			
Methane impact over *20 years*			X	X	
Methane impact over *10 years*					X
Fossil fuel used for fertilizer & on the farm		X	X	X	X
Soil release of CO2		X	X	X	X
Deforestation for new farmland		X	X	X	X
Processing and transporting meat		X	X	X	X
NO2 gasses		X	X	X	X
(low) Carbon opportunity cost			X	X	
(high) Carbon opportunity cost					X
Livestock Respirations				X	X

Factors accounted for in various estimates of the percent of human caused global greenhouse gas related to animal agriculture. Chart 2.

While the IPCC indicates that radical diet change could clean up as much as 8 Gigatonnes CO2 equivalent per year, they estimate that reforestation could mitigate as much as 10.1 Gigatonnes CO2 equivalent. The reference model that the IPCC uses for this estimate is based on an assumption that reforestation happens on pastureland in forest areas but not on cropland. The model takes into account food security concerns. It assumes some possibility of dietary change, but it doesn't report on exactly how much. The greater the shift towards a vegan world the more crop land could be freed up to allow more reforestation.



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Menu of Hope

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by Gaia Kile