Final Essay

8.226 – MIT Spring 2022

Prof. Jeff Gore

To Be (More Plant-Based) or Not to Be (More Plant-Based)? The Role of Diet in Climate Change Mitigation

Introduction

Reducing carbon emissions is crucial to meet international climate-change mitigation goals such as the Paris Agreement 2° C target. The global agricultural system should be a major target of emissions reductions, since a quarter of global emissions originates in food-related industries and activities.[1] Recently, the plant-based (vegan) diet* has become more popular, and much research suggests that following this diet can reduce an individual's carbon footprint, especially their greenhouse gas emissions. After reviewing the relevant background, this paper discusses the extent of the individual carbon footprint (ICF) reduction in light of other individual-level actions and will also briefly consider the moral question of whether someone should follow a vegan diet.

The Environmental Impact of Livestock

Meat is environmentally dirty. It is estimated that cattle and sheep production systems alone are responsible for up to 18% of total global greenhouse gas (GHG) emissions, through the mechanisms given in Figure 1.[2] If emissions from this sector were small, or they could be eliminated quickly, there would not be much cause for concern; but it does not seem like either of these things are true. Indeed, the emissions from the food sector are so large that even if emissions from every other sector were suddenly stopped, it is doubtful humanity could attain the 2° C target.[3] And although there are many technologies that promise to reduce food sector

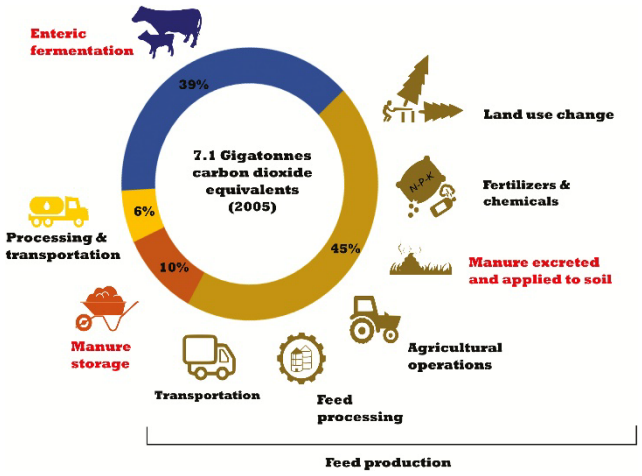

Figure 1. Fraction of different livestock emissions sources, adapted from Grossi et al (2018).

* This paper will use "plant-based diet" and "vegan diet" to denote what is often referred to in the vernacular as "veganism" or "being vegan". Technically, "veganism" refers to a *lifestyle* that minimizes contact with any animal-based products, including food but also clothing and household items.

emissions, it is unlikely that they will be able to significantly reduce the 20+ billion standing population of livestock anytime soon.[4] Moreover, meat production, and dependence of livestock more generally, has consequences beyond simply carbon emissions, including large water and land use. Consequently, even if (for instance) enough solar panels descended from the heavens to produce all the electricity needed for livestock maintenance, livestock farming would still not be environmentally friendly. This additional environmental toll of livestock farming also points to why a vegan diet, as opposed to a less restrictive vegetarian one, is preferable: milk and egg production contribute to the livestock industry as well.

The Role of Individual Diet

Climate change mitigation is hierarchical: an individual, corporation, and a nation can all reduce their carbon footprints at the level that each operates. For instance, an individual can drive an electric rather than gasoline-powered vehicle, and a nation can give tax subsidies to people who choose to do so. The question of which rung on the human ladder should bear the greatest climate change mitigation burden – individual, local, national, and so on – is beyond the scope of the current discussion. Instead, we will confine the analysis to what an individual interested in making greener choices can do – in particular as it relates to their dietary choices.

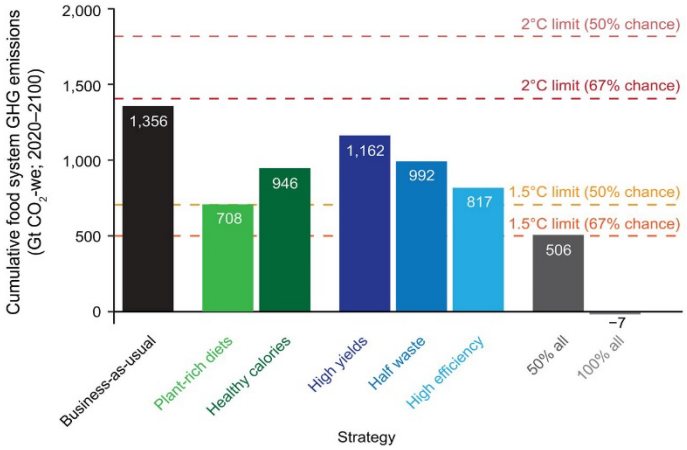

Figure 2. Cumulative emissions under different food emissions reduction strategies, adapted from Clark et al (2020).

We have just seen that given the role of livestock production in GHG emissions, this interested individual should give some thought to reducing their ICF here. The food sector is broad, so in principle there is much that can be done. However, practically speaking (unless this person is a farmer, corporate leader, government official, etc.), an individual can only really focus on their dietary choices. If one eats less animal-based products, the reasoning goes, there is marginally less demand for these products, and so less of them are produced.[*] Thus, an individual can have a meaningful impact on one facet of the food sector – livestock production.

But is this true? The research suggests it is. Figure 2 shows a result from a study evaluating the possible reductions in GHG emissions under different dietary regimes. Under the "Plant-rich diet" regime, wherein only moderate amounts of meat, eggs, and dairy are consumed globally (such as a Mediterranean diet), global GHG emissions are halved. Another study suggested that "Changing diets may be more effective than technological mitigation options for avoiding climate change," while another study asserts, "GHG emissions cannot be sufficiently mitigated without dietary changes towards more plant-based diets".[5,6]

[*] A more advanced economic argument holds that one person eating less meat (or milk or eggs, etc.) will only reduce the price of meat for everyone else. The section on counter-arguments will address this point.

Thus, there is broad support for the higher sustainability of vegan diets (or any diet with sufficiently lower animal product consumption). This is not to say that these diets are carbon free, as emissions still are released in cultivation and processing of the plants; but, overall, plant-based replacements such as tofu are associated with lower GHG emissions, less land use, and less scarcity-weighted water use.[7]

Plant-based Diets in Comparison with Other Greener Choices

It is clear, then, that the research suggests an aggregate move towards diets richer in plant-based products will cause a decrease in global carbon emissions. Each individual who eats a plant-based diet contributes to this aggregate both directly, through their participation, and indirectly, by setting a precedent that encourages others to follow. However, there are also other actions environmentalist-inclined people can take to reduce emissions, and if it is the case that these are more effective than plant-based diets, it should be better to focus on adopting them instead.

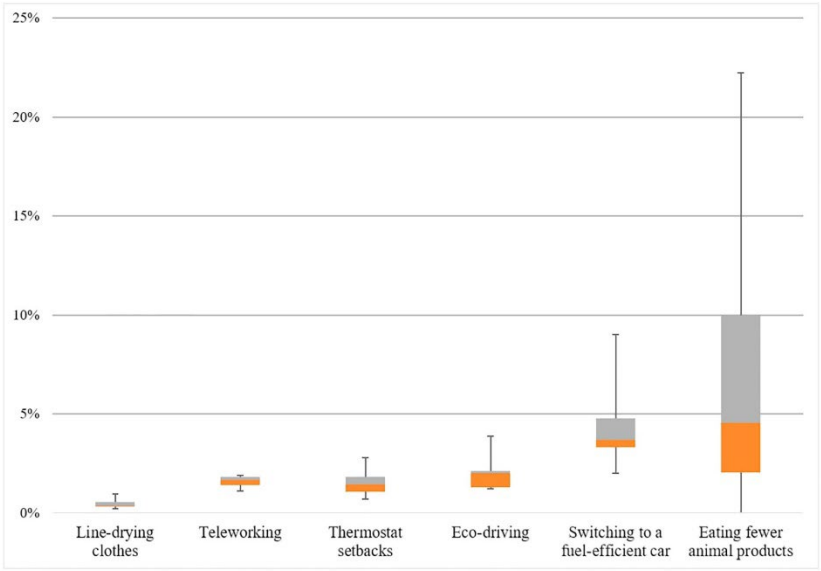

Figure 3. Emissions reductions estimates associated with various behaviors. Adapted from Lacroix (2018).

Several studies have evaluated the impact of various behavioral changes on individual carbon emission. One comprehensive such study produced the results seen in Figure 3.[8] Eating fewer animal products has the highest median estimate, and has the potential for substantial emissions reductions. The study separately evaluated air travel, as the emissions reductions there depend highly on how much air travel the individual in question does. As an example case, the authors note "a 60% reduction in air travel for a higher-income household has the potential to reduce GHG emissions by 16.9% of that household's total footprint." Yet removing all animal products can still beat even this significant reduction in air travel, having the potential to reduce household emissions by over 20% if all household members adhere to a strictly plant-based diet. Even more well-known green behaviors, like switching to a fuel-efficient vehicle, don't come close to the maximum emissions reductions from eating more plant-based foods.

It should be noted that there are other options for individuals not represented in the study, although these can be more expensive and prohibitive for some people. One example is using installed solar panels for household electricity production. Depending on the numbers used, this change can actually be competitive or better with switching to a fully plant-based diet.[9,10] Unfortunately, it is only accessible to homeowners, is expensive, and has a decreasing individual ICF reduction with larger household size.

Moral Considerations

So if a diet high in plant-based foods is so good for the environment, why is it relatively rare? It is important to note that plant-rich diets are only rare in certain cultures, especially Western ones. Worldwide, most protein comes from plant-based foods – it is only in countries like the U.S. where most protein comes from animal sources.[11] In addition, it is also Western countries that have historically been the source of most carbon emissions, having industrialized first centuries ago.[12] Given the projected impact of carbon emissions over the next century, it is not a stretch to assume climate change mitigation as an issue of moral concern (i.e., not acting to reduce carbon emissions in full knowledge of the consequences is wrong). Taken together, these considerations suggest that the burden of adopting a more plant-based diet should fall on individuals in wealthy Western countries. It should be noted that this analysis does not take into account animal welfare, which in the eyes of some philosophers affords additional moral importance to the vegan diet.[13]

It is important to clarify that, if one's interest is simply climate change mitigation, it is not necessary to wholeheartedly adopt a vegan diet – only to reduce consumption of animal-based foods. A good baseline is to try to consume less than 50 g of meat daily (paying particular attention to reducing consumption of red meat, the greatest environmental foe), which is associated with about a 20% reduction in daily dietary GHG emissions[14] from a high-meat diet (>100 g of meat consumed daily). However, if one's interest in GHG *minimization*, then a vegan diet – which has consistently shown to minimize emissions – is the most consistent course of action.

Counter-Arguments and Responses

A common criticism of plant-based diets is acknowledging they are better for the environment, but pointing out potential negative health consequences that should discourage people from adopting them. Indeed, a plant-based diet has the potential for several micronutrient deficiencies (especially vitamin B12, which is not present in any plant-based sources), along with some macronutrient ones too (especially protein).[15] However, these deficiencies can be overcome cheaply with supplements or products fortified with these nutrients, and by more careful shopping at the grocery store, making sure to select enough plant-based protein products to reach recommended daily intakes. One might think such selective shopping is more expensive, but in fact it is noticeably cheaper.[16] But for those interested in simply reducing their carbon footprint (and hence who remain omnivorous), a relatively small amount of meat consumption can still provide crucial nutrients like vitamin B12.[11]

Another critique is that some plant-based foods end up having a higher ICF because of the fuel required to transport them by plane, or because of higher water usage (in the case of, for instance, almond milk) than other substitutes or the substituted product.[17] However, this is less a criticism of plant-based diets in general and more of a reminder that simply branding something as "plant-based" does not automatically make it greener (or healthier) than any animal product. In other words, increasing plant-based food intake does not absolve an individual of the responsibility to remain vigilant of their consumption.

It is relevant to note that none of the studies reviewed for this paper indicated that plant-based diets could be detrimental to sustainability efforts, and indeed an explicit search for such results turned up nil. There is little question as to the impact of plant-based diets in and of themselves. However, one additional target of criticism is the idea that one person can really make a difference. The economic argument goes like this: one person reduces their meat consumption, and because of elasticities of supply and demand, the price of meat is reduced, encouraging others to buy more meat. The net result is that there is the same amount of meat consumed as before. Crucially, though, those people who made up the deficit are now spending more money on meat than they did before, as supply (and therefore price) has returned to its original level – but these consumers are now buying more meat. Anyway, this argument does not hold up to a practical decision-making critique: we do not always base decisions on "it's just going to happen anyway." There are other strong reasons to adopt a plant-based diet – it's cheaper, as noted earlier, and when planned appropriately, healthier than a meat-based diet (a consequence not relevant to the overall topic but apropos here).[11] One last counter to this argument is that even if it were true on a local scale, it could never be true writ large. If 10 million Americans suddenly stopped eating meat, there would be a drastic decrease in demand that could not be made up by others without compromising their health. Individual change is necessary for aggregate change, and is often a conduit for it.

Conclusion

People in Western cultures eat a lot of meat, and like other lifestyle choices, this decision comes with environmental consequences. Meat is, in general, not a relatively environmentally friendly food option, and a sizeable body of research suggests that reducing meat consumption (or going plant-based entirely) can have a measurable, meaningful impact on one's ICF. It is "the single biggest way to reduce your impact on planet Earth," according to one researcher[18], and so for people not in positions of power or influence, it is one of the best individual actions to take. For people living in Western nations, adopting a more plant-based diet is relatively easy. It may also be the more moral choice, especially when animal welfare is considered. All told, an individual's diet plays an important role in their carbon emissions, and becoming more plant-based is an effective, evidence-based strategy to live a greener life.

References

1. Food production is responsible for one-quarter of the world's greenhouse gas emissions. *Our World in Data* https://ourworldindata.org/food-ghg-emissions.
2. Kinley, R. D. *et al.* Mitigating the carbon footprint and improving productivity of ruminant livestock agriculture using a red seaweed. *J. Clean. Prod.* **259**, 120836 (2020).
3. Clark, M. A. *et al.* Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. *Science* **370**, 705–708 (2020).
4. Robinson, T. P. *et al.* Mapping the Global Distribution of Livestock. *PLOS ONE* **9**, e96084 (2014).
5. Springmann, M. *et al.* Options for keeping the food system within environmental limits. *Nature* **562**, 519–525 (2018).
6. Analysis and valuation of the health and climate change cobenefits of dietary change. https://www.pnas.org/doi/10.1073/pnas.1523119113 doi:10.1073/pnas.1523119113.
7. Poore, J. & Nemecek, T. Reducing food's environmental impacts through producers and consumers. *Science* **360**, 987–992 (2018).
8. Lacroix, K. Comparing the relative mitigation potential of individual pro-environmental behaviors. *J. Clean. Prod.* **195**, 1398–1407 (2018).
9. Zhai, P., Larsen, P., Millstein, D., Menon, S. & Masanet, E. The potential for avoided emissions from photovoltaic electricity in the United States. *Energy* **47**, 443–450 (2012).
10. Wang, M., Mao, X., Gao, Y. & He, F. Potential of carbon emission reduction and financial feasibility of urban rooftop photovoltaic power generation in Beijing. *J. Clean. Prod.* **203**, 1119–1131 (2018).
11. Byrd-Bredbenner, C., Moe, G., Berning, J. & Kelley, D. *Wardlaw's perspectives in nutrition*. (McGraw-Hill Higher Education, 2012).

12. Where in the world do people emit the most CO2? *Our World in Data* https://ourworldindata.org/per-capita-co2.
13. *Animal Rights*. (Palgrave Macmillan UK, 1996). doi:10.1007/978-1-349-25176-6.
14. Scarborough, P. *et al.* Dietary greenhouse gas emissions of meat-eaters, fish-eaters, vegetarians and vegans in the UK. *Clim. Change* **125**, 179–192 (2014).
15. Medawar, E., Huhn, S., Villringer, A. & Veronica Witte, A. The effects of plant-based diets on the body and the brain: a systematic review. *Transl. Psychiatry* **9**, 1–17 (2019).
16. Sustainable eating is cheaper and healthier - Oxford study | University of Oxford - https://www.ox.ac.uk/news/2021-11-11-sustainable-eating-cheaper-and-healthier-oxford-study. https://www.ox.ac.uk/news/2021-11-11-sustainable-eating-cheaper-and-healthier-oxford-study.
17. Gray, R. Why the vegan diet is not always green. https://www.bbc.com/future/article/20200211-why-the-vegan-diet-is-not-always-green.
18. We Need to Talk About Meat | UNFCCC. https://unfccc.int/blog/we-need-to-talk-about-meat.