

# Solving climate change requires changing our food systems

Svetlana V. Feigin<sup>1,\*</sup>, David O. Wiebers<sup>2</sup>, Daniel T. Blumstein<sup>3,4</sup>, Andrew Knight<sup>5,6,7</sup>, Gidon Eshel<sup>8</sup>, George Lueddeke<sup>9,10</sup>, Helen Kopnina<sup>11</sup>, Valery L. Feigin<sup>12</sup>, Serge Morand<sup>13,14</sup>, Kelley Lee<sup>15</sup>, Michael Brainin<sup>16</sup>, Todd K. Shackelford<sup>17</sup>, Shelley M. Alexander<sup>18</sup>, James Marcum<sup>19</sup>, Debra Merskin<sup>20</sup>, Lee F. Skerratt<sup>21</sup>, Gerben A. Van Kleef<sup>22</sup>, Amanda Whitfort<sup>23</sup>, Carrie P. Freeman<sup>24</sup>, Andrea Sylvia Winkler<sup>25,26,27</sup>

<sup>1</sup>All Life Institute, Washington, DC 20036, United States

<sup>2</sup>Mayo Clinic and Mayo Foundation, Rochester, MN 55905, United States

<sup>3</sup>Department of Ecology and Evolutionary Biology, University of CA, Los Angeles, CA 90095, United States

<sup>4</sup>The Institute of the Environment and Sustainability, La Kretz Hall, University of CA, Los Angeles, CA 90095, United States

<sup>5</sup>School of Veterinary Medicine, College of Environmental and Life Sciences, Murdoch University, Murdoch, WA 6150, Australia

<sup>6</sup>School of Environment and Science, Griffith University, Brisbane, Queensland 4111, Australia

<sup>7</sup>Faculty of Health and Wellbeing, University of Winchester, Winchester SO22 4NR, United Kingdom

<sup>8</sup>Department of Environmental Physics, Bard College, Annandale-on-Hudson, NY 12504, United States

<sup>9</sup>Centre for the Study of Resilience and Future Africa, University of Pretoria, Pretoria 0001, South Africa

<sup>10</sup>Ministry of Environment, Forest and Climate Change (MoEFCC), New Delhi 110 003, India

<sup>11</sup>Newcastle Business School, Northumbria University, Newcastle upon Tyne NE1 8ST, United Kingdom

<sup>12</sup>National Institute for Stroke and Applied Neurosciences, School of Clinical Sciences, Auckland University of Technology, Auckland 0627, New Zealand

<sup>13</sup>Faculty of Veterinary Technology (CNRS), Kasetsart University, Bangkok 10900, Thailand

<sup>14</sup>Faculty of Tropical Medicine, Mahidol University, Bangkok 10400, Thailand

<sup>15</sup>Faculty of Health Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada

<sup>16</sup>Clinical Neurosciences and Preventive Medicine, Danube University, Krems 3500, Austria

<sup>17</sup>Department of Psychology and Center for Evolutionary Psychological Science, Oakland University, Rochester, MI 48309, United States

<sup>18</sup>Department of Geography, University of Calgary, Calgary, AB T2N 1N4, Canada

<sup>19</sup>Department of Philosophy, Baylor University, Waco, TX 76798-7273, United States

<sup>20</sup>School of Journalism and Communication, University of Oregon, Eugene, OR 97403, United States

<sup>21</sup>Melbourne Veterinary School, Faculty of Science, University of Melbourne, Melbourne, Victoria 3030, Australia

<sup>22</sup>Department of Social Psychology, University of Amsterdam, Amsterdam 1001, Netherlands

<sup>23</sup>Department of Professional Legal Education, Faculty of Law, The University of Hong Kong, Hong Kong 999077, Hong Kong

<sup>24</sup>Department of Communication, Georgia State University, Atlanta, GA 30302-5060, United States

<sup>25</sup>Center for Global Health, Department of Neurology, School of Medicine and Health, Technical University of Munich, Munich D-80333, Germany

<sup>26</sup>Department of Community Medicine and Global Health, Institute of Health and Society, Faculty of Medicine, University of Oslo, Oslo 0318, Norway

<sup>27</sup>Department of Global Health and Social Medicine, Harvard Medical School, Boston, MA 02115, United States

\*Corresponding author: All Life Institute, 1025 Connecticut Ave. NW, STE 615, Washington, DC, 20036, United States. Email: [sfeigin@alllifeinstitute.org](mailto:sfeigin@alllifeinstitute.org)

## Abstract

Humanity is facing an important existential threat—irreversible climate change caused by human activity. Until recently, most of the proposals to address climate change have downplayed or ignored the adverse impact of food systems, especially intensive animal agriculture. This is in spite of the fact that up to a third of global greenhouse gas production to date can be attributed to animal agriculture. Recent developments at COP28 have signaled that the tide is turning, however, and that food systems are becoming part of global discussions on climate change solutions. The pressing nature of irreversible climate change requires rethinking our food systems. To solve the climate change crisis, we propose transitioning to a predominantly plant-based diet, and phasing out intensive animal agriculture as diets shift, without increasing pastoral farming. We suggest that such transformations in global food systems can be accomplished largely through education and large-scale public information campaigns, removal of subsidies, taxation to account for externalized costs of animal agriculture, improved labelling of products, and various investment/divestment drivers. Better metrics and industry benchmarks involving food and agriculture-specific performance indicators that reflect food system sustainability will be important. Increased global awareness of these issues and a change in mindset (which will drive political will) also are needed. Our current trajectory is untenable, and we must begin to turn the ship now towards sustainable food systems and diets.

**Keywords:** climate change; food systems; climate change mitigation; plant-based diet; factory farming

One of the most important existential threats to humanity today is irreversible climate change caused by human activity [1–5]. Exploitation of natural resources, environmental pollution, and

reliance on animal agriculture have given rise to biodiversity loss, negatively affected ecosystem functioning, spread and increased risk of global pandemics, and caused unprecedented

Received: April 3, 2024. Revised: November 29, 2024. Accepted: December 4, 2024

© The Author(s) 2025. Published by Oxford University Press.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.

changes to Earth's climate [2, 4, 6–9]. Anthropogenic release of greenhouse gases (GHG), has already caused global average temperature to increase by more than 1°C [9]. The effects of this temperature increase are observable in severe climate events and unwanted consequences resulting in human displacement, starvation, and failing crops [10–12]. To avoid additional irreversible effects of climate change, scientists have estimated that we have a very brief window of time (7–8 years) to enact meaningful changes [4, 8, 13]. Specifically, we must reduce GHG emissions by 45% (along our present trajectory, emissions are predicted to rise by 10–15%) by 2030 to limit global warming to 1.5°C above pre-industrial levels [3, 4, 13].

Many of the proposals for combatting climate change have neglected the significant adverse impacts of food systems, especially intensive animal agriculture, yet these impacts are greater than those of transportation, which deservedly receives focused attention [2, 14–16]. In particular, few scientific solutions to mediating climate change proposed over the last 20 years have taken into account that up to a third of all global anthropogenic GHG emissions are attributable to animal agriculture [2, 7, 17–20]. For example, when industrial and farm processes, packaging, waste, fuel/transport, retail/consumption, and land use change are taken into account, agriculture and food systems are responsible for approximately 34% of all global GHG emissions annually [18, 19]. As much as a third of global GHG emissions to date are accounted for by the livestock sector [7, 17]. Previous more conservative estimates of GHG emissions from animal agriculture did not take into account land use/land use change, fuel use, deforestation and desertification, eutrophication, biodiversity loss, emissions from buildings/industry, and water use [7, 18, 19].

Recent developments at the COP28 United Nations (UN) Climate Change Conference, however, signal an important shift in the global recognition of food systems as a determinant of climate change. Among the new developments were: the inclusion of food systems in climate change adaptation and mitigation responses for the first time at one of these meetings; a first-ever Global Stocktake which assessed the world's climate change responses and emphasized sustainable food production and consumption; a road map developed by the UN Food and Agriculture Organization (FAO) that proposed a 25% reduction in agri-food related emissions by 2030; and the United Arab Emirates (UAE) Declaration on Sustainable Agriculture, Resilient Food Systems and Climate Action, signed by 160 countries and territories, which committed signatories to include agriculture and food systems in national climate plans by 2025, and to reorient national policies and agricultural subsidies towards practices that reduce greenhouse gas emissions, increase ecosystem resilience, realize ecosystem services, and improve human and animal health.

For humanity to mitigate climate change successfully, it is important that the direction and momentum achieved at COP28 are sustained and accelerated, and that countries and corporate entities continue to address the environmental and nutritional burdens, including food insecurities, current food systems place on human society and its host planet. To avert a climate crisis, we cannot continue on a 'business as usual' basis [2]. Enacting meaningful change involves recognizing and addressing the role of intensive animal agriculture and animal-source food consumption in climate change mitigation (animal-source food refers to any food product derived from animals such as meat, dairy, eggs, and seafood). We are proposing a unique and novel approach to the issue of climate change mitigation; namely, that intensive animal agriculture and food systems must be part of the climate change solution.

In keeping with COP28 developments, we must undertake a global shift to a fundamentally plant-based diet and a gradual global reduction and eventual phaseout of intensive factory farming, the most prolific and damaging form of agriculture. These changes have the potential to stabilize atmospheric GHG levels for 30 years and offset our total current GHG emissions by as much as 68% by the end of the century; specifically, the global phaseout of industrialized animal agriculture and a global shift to a predominantly plant-based diet [2, 7]. Estimates of the magnitude of the effect of a gradual animal agriculture phaseout and global shift to a plant-based diet are based on research quantifying the full climate opportunity cost of current global animal agriculture production including progressive reduction in livestock production, emissions, and full biomass recovery, with full benefits realized gradually over the century [7]. Factory farms, also known as concentrated animal feeding operations (CAFOs), are a major and rapidly increasing contributor to climate change, and a mounting threat to human, nonhuman, and environmental health [7, 8, 21]. Our increasing human population and consumption of factory-farmed animal products (over 98% of farm animals in the US and 70% globally are now factory farmed) magnifies the unsustainability of our current practices [22].

The FAO has estimated that "World meat production is expected to double by 2050" [23]. Given our current trajectory, this would require that we convert approximately 80% of existing forests and shrubland into land devoted to raising animals to produce meat, dairy, and eggs—a conversion that would be unsustainable and would have a devastating impact on the Earth's climate [24, 25]. An additional 35 million km<sup>2</sup> of land would be required to meet the growing demand for animal products, equating to roughly the combined area of Australia and Africa [7]. Proponents of pastoral farming argue that pastoral farming has existed for thousands of years without the devastating impacts on our planet and major contribution to climate change that have accompanied the emergence and subsequent explosion of factory farming over the last 40–50 years [18, 21, 26, 27]. However, increasing pastoral farming to replace all factory-farmed animals would require prohibitive amounts of land. These factors make reducing demand for animal products unavoidable. As the world population increases, food insecurity and starvation will intensify if we continue to rely on a model of food production (i.e. animal factory farming) which is extraordinarily inefficient and resource intensive.

Although 83% of the world's farmland is occupied by animal agriculture, this provides just 18% of the calories and 37% of the protein humans consume, and the majority of cereals and soy produced today are fed to farm animals [28, 29]. More people could be fed with fewer resources, if the use of animals for food is reduced or eliminated [2]. Furthermore, meat consumption contributes four times as much to global GHG emissions as a plant-based diet [29]. A comprehensive meta-analysis assessing environmental impacts of food production at each stage of the supply chain found that shifting away from current diets to a diet without animal products has transformative potential [29]. The immediate adoption of a plant-based diet on a global scale would have the potential to reduce demand for land by up to 76%, GHG emissions from food by 49% (in the United States, this reduction is between 61% and 73% due to meat consumption being three times the global average), acidification and eutrophication by up to 50%, and a reduction in freshwater withdrawals by 19% for a 2010 reference year [29]. Plant food production (e.g. legumes and cereals) can be redirected to provide food for humans instead of for livestock. Overall, replacing animal-source

foods with plant-based and novel alternatives (e.g. lab-grown meat) would reduce animal agriculture's environmental impact by over 80% (in terms of land/water use and global warming potential) [30]. This study used a linear programming model to reduce the environmental impacts of the current European diet, taking into account water and land use, and global warming potential while adhering to nutritional needs and consumption constraints [30]. Having more plant food available for humans can reduce world hunger and food insecurities, while preserving biodiversity and vital ecosystems [8, 21]. Further, a global shift to a fundamentally plant-based diet will reduce the rapidly rising economic burden of medicine and healthcare [8, 31–35].

Non-communicable diseases linked to the consumption of animal-source foods, are resulting in disabilities and chronic conditions that, in turn, are major drivers of current and future healthcare costs [35, 36]. Consumption of meat, dairy, and eggs contributes to the development of chronic cardiometabolic and cardiovascular diseases, including obesity, diabetes, hypertension, coronary artery and heart disease, autoimmune disorders, and many forms of cancer (e.g. pancreatic and colorectal) [32–35, 37–42]. Antibiotic-resistant infections in humans are associated with proximity to animal farms and with manure applications to crop fields, and are a global health threat, killing approximately 700 000 people worldwide annually [43, 44]. Approximately 80% of antibiotics sold in the United States are used in livestock feeds [43, 45]. The manure produced by farm animals contains resistance genes, antibiotics, and antibiotic resistant bacteria [43]. Thus, proximity and exposure to animal farms and manure crop applications poses a risk to members of the community for anti-biotic resistant infections [43]. Additionally, lethal human zoonoses such as avian influenza (bird flu) and H1N1 (swine flu) resulting from factory farming operations are far more common today than historically, and threaten to cause pandemics as bad or even worse than COVID-19 [25, 26, 46, 47]. Shifting to a more plant-based diet could prevent 5.1 million human deaths annually; a completely plant-based diet could prevent 8.1 million deaths annually by 2050 [31]. Researchers achieved these estimates by comparing the average current European diet to three diet scenarios: healthy global diet, vegetarian diet, and vegan diet in terms of mortality association with weight and dietary risk factors [31]. The health benefits of a predominantly plant-based diet were attributed to lower prevalence of obesity, increased fruit and vegetable consumption, and lower red meat consumption [31]. The economic benefits of a predominantly plant-based diet could yield up to 31 trillion US dollars annually in healthcare cost savings and productivity gains due to decreases in diet-related diseases [31].

Using plants to feed companion animals also should be included in the global shift away from animal agriculture. Pet dogs and cats consume at least 9% of all livestock annually and 20% in the US (which has higher pet ownership than the global average) [48, 49]. Large amounts of land could be freed up globally by adopting nutritionally sound plant-based diets for humans, as well as for pet dogs and cats [48, 49]. Land saved would exceed the areas of nations such as India and Russia for humans, Mexico or Saudi Arabia for dogs, and Germany or Japan for cats [48]. Such land could be used for climate mitigation through afforestation, biodiversity preservation, and production of healthy plant-based foods for humans. For example, restoring agricultural land (within forest ecosystems) back to forest will double GHG emission reductions, allowing us to reach 92% of land sector mitigation potential and halve ecosystem decline by 2050 [50]. Nutritionally sound plant-based diets for humans, dogs, and cats

would reduce GHGs by quantities greater than all the GHG emissions produced by: the entire EU (for humans), the UK (for dogs), and New Zealand (for cats) [48]. Enormous volumes of freshwater would also be saved, and food energy savings associated with a plant-based diet for humans could feed another 5.3 billion people or 2/3 of Earth's current population, as significant additional numbers could be fed using plant-based diets for dogs and cats [48, 51]. When commercially available plant-based pet diets are formulated to be nutritionally-sound, health outcomes are normally good [52, 53].

Plant derived food sources such as beans, nuts, seeds, grains, peas, lentils, and tofu can replace meat, alongside recently developed plant-based alternatives to meat/dairy/eggs (i.e. novel foods developed to mimic the taste/consistency of animal products), and lab-cultured meat products (also referred to as “clean meat” or “future foods”) [8, 50, 54, 55]. Replacing animal products with plant, novel, and future foods will reduce the environmental impact of animal agriculture in terms of global warming potential, and use of land and water by up to 80% [30]. Even animal products with the lowest impact (e.g. eggs, poultry) have a greater impact on climate change than do plant foods, and this alone points to a need for fundamental dietary change [29].

Challenges such as nutritional, socio-economic, trade and supply chain factors, need to be addressed in the global transition to a predominantly plant-based diet and phaseout of industrialized animal agriculture. We acknowledge that many rural and low-middle income countries (LMICs) rely on animal farming for their livelihoods. The onus is on wealthier nations to drive change in our food systems and support communities and LMICs through local and global investment initiatives [2]. High-emitting and high-income countries could financially support agricultural productivity, restoration of land and high-carbon forests, and support food security in LMICs [17]. Also, with small nutritional adjustments, animal-source foods could be replaced by existing crops in terms of calories, protein, and fat while significantly reducing food's carbon footprint [7, 56].

Additional investment and development in technologies are required to achieve more affordable and readily available alternatives to eggs, dairy, and meat [57]. Further, government and business initiatives to increase the availability and supply of nutritious plant-based foods are needed. For example, plant-based meals can be used as the default option for catering and institutional dining such as university cafeterias and restaurants [58–61]. Land previously used for animal agriculture could be restored or used to grow new crops or used for power generation [2]. Tax cuts and funded health campaigns to reduce animal-source food consumption can help make plant-based alternatives less expensive [2]. Government subsidies previously provided to the animal agriculture industry and taxes can be used to aid farmers in their transition from animal to non-animal agriculture and for the development of technological innovations for plant-based foods. The global costs to humanity (in economic, health, social, and climate terms) of unabated agricultural emissions far outweigh these challenges. Failure to act may result in irreversible climate changes characterized by environmental, agricultural, and human degradation [8, 17].

Several strategies may help achieve a gradual global phaseout of factory farming and adoption of a fundamentally plant-based diet. For example, removal of subsidies from animal-source foods and taxation of such foods to reflect externalized costs of animal agriculture will help reshape markets to make it less profitable to engage in current practices (factory farming) and more profitable to shift to other products (e.g. plant-based foods). Also, public

education and information campaigns highlighting the health and environment benefits of plant-based diets and the detrimental effects of factory farming, combined with product labelling that reflects climate change impact and human/animal/environmental health consequences, can inform consumers and reduce demand for animal-source foods [2, 7, 21, 29].

Developing scientifically valid and uniform industry benchmarks, inclusive of food and agriculture-specific performance indicators, will provide a sustainability ranking rubric for the food system, helping to inform investment and divestment decisions [2]. Such an environmental sustainability ranking rubric can be applied to corporations and countries [2]. Further, taxes on animal products can be used for: plant food production and investment in plant-based crops to feed humans; land carbon sequestration through afforestation of previously farmed land, and trophic rewilding [21, 62–65].

The adoption of a more plant-based diet and the gradual phaseout of factory farming should be incorporated into country-specific and global GHG targets, policy changes, and education initiatives at the forefront of climate mitigation strategies [7, 29]. Achieving these ends would allow us to feed all or most of the world's one billion people who suffer from food insecurity in addition to reducing the risks of zoonotic pandemics, deforestation, and biodiversity loss [8, 21, 26, 66]. It would end the killing of billions of farmed land animals, trillions of wild-caught and farmed fish, and marine animals annually [48]. On a personal level, adoption of a plant-based diet is the single most effective way to reduce one's impact on the planet [2, 7, 67].

The unsustainability of our current course and the urgency for actions to change our food systems are undeniable [2, 8]. The critical changes will require a shift in our global mindset from a human-centric paradigm to a more All Life or One Health paradigm in government policy and corporate behavior. We must rethink our relationship with all life on Earth, and our many impacts on Earth itself [26, 68]. Our survival, that of nonhuman animals, ecosystems, and the planet depend on recognizing the interconnectedness of all life and our mindfulness in the choices we make. What is good for the planet and its nonhuman inhabitants is virtually always in the best interests of humans [8]. Restraint, compassion, and empathy for how our everyday activities affect nonhuman animals and planet Earth is needed, now. The future of humanity and all life on our planet depends on sustainability, and the data indicate that we will not succeed on the issue of climate change unless we change the way that we produce and consume food [2, 7, 8].

## Acknowledgements

The authors have no acknowledgements to report.

## Author contributions

Svetlana Feigin (Conceptualization [lead], Writing—original draft [lead], Writing—review & editing [lead]), David Wiebers (Conceptualization [equal], Writing—review & editing [equal]), Daniel Blumstein (Writing—review & editing [equal]), Andrew Knight (Writing—review & editing [equal]), Gidon Eshel (Writing—review & editing [equal]), George Lueddeke (Writing—review & editing [equal]), (Helen Kopnina Writing—review & editing [equal]), Valery Feigin (Writing—review & editing [equal]), Serge Morand (Writing—review & editing [equal]), Kelley Lee (Writing—review & editing [equal]), Michael Brainin (Writing—review & editing [equal]), Todd Shackelford (Writing—review &

editing [equal]), Shelley Alexander (Writing—review & editing [equal]), James Marcum (Writing—review & editing [equal]), Debra Merskin (Writing—review & editing [equal]), Lee Skerratt (Writing—review & editing [equal]), Gerben van Kleeft (Writing—review & editing [equal]), Amanda Whitfort (Writing—review & editing [equal]), Carrie Freeman (Writing—review & editing [equal]), Andrea Winkler (Writing—review & editing [equal])

Conflict of interest: The authors have no conflict of interest to declare.

## Funding

None declared.

## Data availability

Available from the corresponding author upon reasonable request.

## Statement of ethics

Not applicable, no participants were involved.

## References

1. Ceballos G, García A, Ehrlich PR. The sixth extinction crisis: loss of animal populations and species. *J Cosmol* 2010 1821;8:31.
2. Feigin SV, Wiebers DO, Lueddeke G et al. Proposed solutions to anthropogenic climate change: a systematic literature review and a new way forward. *Heliyon* 2023;9:e20544.
3. IPCC. Intergovernmental Panel on Climate Change. Summary for policymakers. In: Global warming of 1.5 degrees C. [www.ipcc.ch/sr15/](http://www.ipcc.ch/sr15/) (14 February 2024, date last accessed).
4. IPCC. Intergovernmental Panel on Climate Change. Summary for policymakers. In: Climate change 2021: the physical science basis. [www.ipcc.ch/](http://www.ipcc.ch/) (20 February 2024, date last accessed).
5. Bradshaw CJ, Ehrlich PR, Beattie A et al. Underestimating the challenges of avoiding a ghastly future. *Front Conserv Sci* 2021;1:9.
6. IPCC. Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. 2022. <https://www.ipcc.ch/report/ar6/wg2/> (1 February 2024, date last accessed).
7. Eisen MB, Brown PO. Rapid global phaseout of animal agriculture has the potential to stabilize greenhouse gas levels for 30 years and offset 68 percent of CO2 emissions this century. *PLoS Clim* 2022;1:e0000010.
8. Wiebers DO, Feigin VL, Winkler AS. All Life Protection and Our Collective Future. *Neuroepidemiology* 2022;56:147–50.
9. Pörtner HO, Scholes J, Agard J et al. Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change (Version 5). 2021. <https://zenodo.org/records/5101125> (10 February 2024, date last accessed).
10. Kim SM, Mendelsohn R. Climate change to increase crop failure in US. *Environ Res Lett* 2023;18:014014.
11. Goulart HMD, van der Wiel K, Folberth C et al. Storylines of weather-induced crop failure events under climate change. *Earth Syst Dynam* 2021;12:1503–27.
12. Berchin II, Valduga IB, Garcia J et al. Climate change and forced migrations: an effort towards recognizing climate refugees. *Geoforum* 2017;84:147–50.



13. Lenton TM, Rockström J, Gaffney O *et al.* Climate tipping points—too risky to bet against. *Nature* 2019;**575**:592–5. <https://doi.org/10.1038/d41586-019-03595-0>
14. Chapman L. Transport and climate change: a review. *J Transp Geogr* 2007;**15**:354–67.
15. Sims R, Schaeffer R, Creutzig F *et al.* Transport. 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*. 2014.
16. Byrne L, Bach V, Finkbeiner M. Urban transport assessment of emissions and resource demand of climate protection scenarios. *Clean Environ Syst* 2021;**2**:100019. <https://doi.org/10.1016/j.cesys.2021.100019>
17. Hayek MN, Harwatt H, Ripple WJ *et al.* The carbon opportunity cost of animal-sourced food production on land. *Nat Sustain* 2020;**4**:21–4.
18. Crippa M, Solazzo E, Guizzardi D *et al.* Food systems are responsible for a third of global anthropogenic GHG emissions. *Nat Food* 2021;**2**:198–209.
19. Tubiello FN, Rosenzweig C, Conchedda G *et al.* Greenhouse gas emissions from food systems: building the evidence base. *Environ Res Lett* 2021;**16**:065007.
20. Bowen KJ, Ebi K, Friel S. Climate change adaptation and mitigation: next steps for cross-sectoral action to protect global health. *Mitig Adapt Strateg Glob Change* 2014;**19**:1033–40. <https://doi.org/10.1007/s11027-013-9458-y>
21. Wiebers DO, Feigin VL. Heeding the call of COVID-19. *Anim Sentience* 2021;**30**(1).
22. FAIRR. FAIRR Initiative. *Factory Farming: Assessing Investment Risks*. 2016. <https://www.fairr.org/wp-content/uploads/2015/12/FAIRR-Factory-Farming-Assessing-Investment-Risks-2016-Report.pdf> (25 February 2024, date last accessed).
23. FAO. Emissions due to agriculture. Global, regional and country trends 2000–2018. Vol. No 18. 2020. <https://www.fao.org/3/cb3808en/cb3808en.pdf> (14 February 2024, date last accessed).
24. Rowan AN. Impact of animal agriculture on land use. *WellBeing News* 2020;**2**:2.
25. Morand S. The role of agriculture in human infectious disease outbreaks. *CABI Rev* 2022;**(17)**:060.
26. Wiebers DO, Feigin VL. What the COVID-19 crisis is telling humanity. *Neuroepidemiology* 2020;**54**:283–6.
27. Benton TG, Bieg C, Harwatt H *et al.* *Food system impacts on biodiversity loss. Three levers for food system transformation in support of nature* Chatham House, London. 2021. <https://www.chathamhouse.org/2021/02/food-system-impacts-biodiversity-loss> (5 February 2024, date last accessed).
28. Rossi J, Garner SA. Industrial farm animal production: a comprehensive moral critique. *J Agric Environ Ethics* 2014;**27**:479–522.
29. Poore J, Nemecek T. Reducing food's environmental impacts through producers and consumers. *Science* 2018;**360**:987–92.
30. Mazac R, Meinilä J, Korkalo L *et al.* Incorporation of novel foods in European diets can reduce global warming potential, water use and land use by over 80%. *Nat Food* 2022;**3**:286–93.
31. Springmann M, Godfray HCJ, Rayner M *et al.* Analysis and valuation of the health and climate change cobenefits of dietary change. *Proc Natl Acad Sci U S A* 2016;**113**:4146–51.
32. Willett W, Rockström J, Loken B *et al.* food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet* 2019;**393**:447–92.
33. Amuasi JH, Lucas T, Horton R *et al.* Reconnecting for our future: the lancet one health commission. *Lancet* 2020;**395**:1469–71.
34. Tuso PJ, Ismail MH, Ha BP *et al.* Nutritional update for physicians: plant-based diets. *Perm J* 2013;**17**:61–6.
35. Hemler EC, Hu FB. Plant-based diets for personal, population, and planetary health. *Adv Nutr* 2019;**10**:S275–S283.
36. Fardet A, Boirie Y. Associations between food and beverage groups and major diet-related chronic diseases: an exhaustive review of pooled/meta-analyses and systematic reviews. *Nutr Rev* 2014;**72**:741–62.
37. Hull SC, Charles J, Caplan AL. Are we what we eat? The moral imperative of the medical profession to promote plant-based nutrition. *Am J Cardiol* 2023;**188**:15–21.
38. Ornish D, Ornish A. *Undo It!: How Simple Lifestyle Changes Can Reverse Most Chronic Diseases*. New York: Ballantine Books; 2022.
39. Hooda J, Shah A, Zhang L. Heme, an essential nutrient from dietary proteins, critically impacts diverse physiological and pathological processes. *Nutr* 2014;**6**:1080–102.
40. Zur Hausen H, Bund T, de Villiers E-M. Infectious agents in bovine red meat and milk and their potential role in cancer and other chronic diseases. *Curr Top Microbiol Immunol* 2017;**407**:83–116.
41. Wolk A. Potential health hazards of eating red meat. *J Intern Med* 2017;**281**:106–22.
42. Feigin VL, Stark BA, Johnson CO *et al.* Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Neurol* 2021;**20**:795–820.
43. Casey JA, Curriero FC, Cosgrove SE *et al.* High-density livestock operations, crop field application of manure, and risk of community-associated methicillin-resistant *Staphylococcus aureus* infection in Pennsylvania. *JAMA Intern Med* 2013;**173**:1980–90.
44. O'Neill J. *Tackling drug-resistant infections globally: final report and recommendations*. 2016. [https://amr-review.org/sites/default/files/160518\\_Final%20paper\\_with%20cover.pdf](https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf) (10 February, date last accessed).
45. Love DC, Davis MF, Bassett A *et al.* Dose imprecision and resistance: free-choice medicated feeds in industrial food animal production in the United States. *Environ Health Perspect* 2011;**119**:279–83.
46. Capua I, Alexander DJ. Avian influenza: recent developments. *Avian Pathol* 2004;**33**:393–404.
47. Greger M. *Bird Flu: A Virus of Our Own Hatching*. New York: Lantern Books; 2006.
48. Knight A. The relative benefits for environmental sustainability of vegan diets for dogs, cats and people. *PLoS One* 2023;**18**:e0291791.
49. Okin GS. Environmental impacts of food consumption by dogs and cats. *PLoS One* 2017;**12**:e0181301.
50. Kozicka M, Havlík P, Valin H *et al.* Feeding climate and biodiversity goals with novel plant-based meat and milk alternatives. *Nat Commun* 2023;**14**:5316.
51. Pimentel D, Berger B, Filiberto D *et al.* Water resources: agricultural and environmental issues. *BioScience* 2004;**54**:909–18.
52. Domínguez-Oliva A, Mota-Rojas D, Semendric I *et al.* The impact of vegan diets on indicators of health in dogs and cats: a systematic review. *Vet Sci* 2023;**10**:52.
53. Knight A, Light N. The nutritional soundness of meat-based and plant-based pet foods. *Rev Electron Vet* 2021;01–21.
54. Eshel G, Stainier P, Shepon A *et al.* Environmentally optimal, nutritionally sound, protein and energy conserving plant based alternatives to US meat. *Sci Rep* 2019;**9**:10345.
55. Shapiro P. *Clean Meat: how Growing Meat without Animals Will Revolutionize Dinner and the World*. Simon and Schuster; 2018.
56. Springmann M, Wiebe K, Mason-D'Croz D *et al.* Health and nutritional aspects of sustainable diet strategies and their

- association with environmental impacts: a global modelling analysis with country-level detail. *Lancet Planet Health* 2018;**2**:e451–e461.
57. Anomaly J. Cultured meat would prevent the next Covid crisis. *Anim Sentience* 2020;**30**:2237.
  58. Ginn J, Sparkman G. Can you default to vegan? Plant-based defaults to change dining practices on college campuses. *J Environ Psychol* 2024;**93**:102226.
  59. Taufik D, Bouwman EP, Reinders MJ et al. A reversal of defaults: Implementing a menu-based default nudge to promote out-of-home consumer adoption of plant-based meat alternatives. *Appetite* 2022;**175**:106049.
  60. Zhang A, Boronowsky R, Braverman I et al. Using the default nudge to increase plant-based meal consumption on college campuses. *Curr Dev Nutr* 2022;**6**:84.
  61. Zhang AW, Wharton C, Cloonan S et al. Changing the default meal option at university events to reduce harmful environmental impacts: Six randomized controlled trials. *Appetite* 2024;**200**:107572.
  62. Schmitz OJ, Sylvén M, Atwood TB et al. Trophic rewilding can expand natural climate solutions. *Nat Clim Chang* 2023;**13**:324–33.
  63. Nordgren A. Ethical issues in mitigation of climate change: the option of reduced meat production and consumption. *J Agric Environ Ethics* 2012;**25**:563–84. <https://doi.org/10.1007/s10806-011-9335-1>
  64. Wirsenius S, Hedenus F, Mohlin K. Greenhouse gas taxes on animal food products: rationale, tax scheme and climate mitigation effects. *Clim Change* 2011;**108**:159–84.
  65. Smith P, Haberl H, Popp A et al. How much land-based greenhouse gas mitigation can be achieved without compromising food security and environmental goals? *Glob Chang Biol* 2013;**19**:2285–302. <https://doi.org/10.1111/gcb.12160>
  66. Mace JL, Knight A. Influenza risks arising from mixed intensive pig and poultry farms, with a spotlight on the United Kingdom. *Front Vet Sci* 2023;**10**:1310303.
  67. González AD, Frostell B, Carlsson-Kanyama A. Protein efficiency per unit energy and per unit greenhouse gas emissions: potential contribution of diet choices to climate change mitigation. *Food Policy* 2011;**36**:562–70.
  68. Freeman CP, Merskin D. Fostering human animal earthling identities in Just One Health messages for multi-species food justice. *CABI One Health* 2023.