Supplementary Materials for

Future Warming from Global Food Consumption

Authors: Catherine C. Ivanovich[1,2], Tianyi Sun[2], Doria R. Gordon[2,3] and Ilissa B. Ocko[2]

[1] Columbia University, Department of Earth and Environmental Sciences, New York, NY 10027
[2] Environmental Defense Fund, 1875 Connecticut Ave NW, Washington, DC 20009
[3] Department of Biology, University of Florida, Gainesville, FL 32611

Supplemental Text

Comparison of Annual Emissions Estimation to Published Literature

The Fifth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC AR5) estimates that in 2010, fossil fuel CO_2 emissions from energy use on crop lands were approximately 400-600 MMt CO_2/year[1], while the IPCC Climate Change and Land report estimates that averaged over years 2007-2016, the yearly emission of CO_2 from land use change associated with the global food system is 4,900 +/- 2,500 MMt CO_2/year[2]. Together this amounts to 5,400 +/- 2,600 MMt CO_2/year from agriculture through both energy use and land use change. FAOSTAT estimates emissions of 135 MMt CH_4 and 7 MMt N_2O in 2010[3], and the IPCC Climate Change and Land Summary for Policy Makers estimates that for the average period of 2007-2016, the annual emissions of CH_4 and N_2O were 121 +/- 36 MMt and 7 +/- 2 MMt[2]. The UNEP and CCAC Global Methane Assessment (2021) estimates that agriculture is responsible for about 40% of the total annual CH_4 emissions of 350-380 MMt/yr, for a total of roughly 140-152 MMt/yr from agricultural sources[4]. Our individual greenhouse gas emissions estimates of 4,860 MMt CO_2, 150 MMt CH_4, and 9 MMt N_2O for year 2010 are in strong agreement with those previously published.

When aggregated to total emissions in CO_2e100 to compare to previous estimates of total greenhouse gas emissions from food consumption, we estimate 12,800 MMt of CO_2e100 emissions attributed to food consumption for year 2010. This is slightly below that estimated by Poore and Nemecek 2018 (13,700 MMt of CO_2e100 for median year 2010 food production rates)[5], Crippa et. al 2021 (18,000 MMt of CO_2e100 in year 2010)[6], and Xu et al. 2021 (17,300 MMt of CO_2e100 for mean of the 2007-2013 period)[7] and falls within the bounds generated by Clark et al. 2020 (9,250-13,300 MMt CO_2e100/yr)[8] and Vermeulen et al. 2012 (9,800-16,900 MMt for year 2008; note that for proper comparison using IPCC AR4 estimates of global warming potentials, our estimates for aggregate total emissions in CO_2e100 drop to 11,400 MMt)[9]. Ahmed et al. 2020 estimates that using a 20-year timeline global warming potential, this value is 19,100 MMt CO2e20/yr based on 2015 timelines[10]. Our estimate can be converted to 21,600 MMt CO_2e20/yr for year 2010, higher on a shorter timeline compared to the contribution in CO_2e100 due to the dominance of short-lived climate pollutants.

Comparison of Greenhouse Gas Emissions Intensity to Warming Intensity

Previous analyses often rank food items by their greenhouse gas emissions intensity, but these evaluations almost always use the traditional CO_2-equivalence metric with a 100-year time horizon, or do not consider the warming contribution of non-CO_2 greenhouse gases[5,11,12]. This could skew the relative importance of different food items as discussed in the main text. In order to test the importance of CO_2e assessments in ranking food items, we calculate the relative contributions of each food group to future warming through year 2100 based on temperature change from the climate model, and compare end of century estimates in degrees Celsius to annual CO_2e emissions with both 20- and 100-year time horizons. While the exact percent contribution depends slightly on which metric is selected, we find that the rank of each food group from highest to lowest contributor to warming in 2100 is comparable to the annual per capita contribution breakdowns when using CO_2e on both 20- and 100-year time horizons (Figure S2). These ranks are also in strong agreement with those provided by previous literature[7,13]. This relationship suggests that the CO_2e metric is a decent proxy for the relative importance of each food group in contributing to future warming. However, as previously discussed, CO_2e neither quantifies the magnitude of temperature change attributed to emissions, nor accounts for the atmospheric build-up of continuous emissions over time.

References for Supplemental Text

1. IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
2. IPCC, 2019: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.
3. Food and Agriculture Organization, 2019. FAOSTAT, Rome, Italy.
4. United Nations Environment Programme and Climate and Clean Air Coalition, 2021. Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions. Nairobi: United Nations Environment Programme.
5. Poore, J. and T. Nemecek, 2018. Reducing food's environmental impacts through producers and consumers, Science, 360 (6392), 987-992. https://doi.org/10.1126/science.aaq0216
6. Crippa, M., Solazzo, E., Guizzardi, D., Monforti-Ferrario, F., Tubiello, F. N., and Leip, A., 2021. Food systems are responsible for a third of global anthropogenic GHG emissions, *Nature Food,* 2, 198-209. https://doi.org/10.1038/s43016-021-00225-9
7. Xu, X., Sharma, P., Shu, S., Lin, T., Ciais, P., Tubiello, F. N., Smith, P., Campbell, N., and Jain, A. K., 2021. Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods, *Nature Food*, 2, 724-732. https://doi-org/10.1038/s43016-021-00358-x
8. Clark, M., A., Domingo, N. G. G., Colgan, K., Thakrar, S. K., Tilman, D., Lynch, J., Azevedo, I. L., and Hill, J. D., 2020. Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets, *Science*, 370(6517), 705-708. https://doi.org/10.1126/science.aba7357
9. Vermeulen, S. J., Campbell, B. M., Ingram, J. S. I., 2012. Climate change and food systems, Annu. Rev. Environ. Resour., 37, 195-222. https://doi.org/10.1146/annurev-environ-020411-130608
10. Ahmed, J., Almeida, E., Aminetzah, D., Denis, N., Henderson, K., Katz, J., Kitchel, H., and Mannion, P., 2020. Agriculture and climate change: Reducing emissions through improved farming practices, McKinsey & Company.
11. Searchinger, T., Waite, R., Hanson, C., Ranganathan, J., Dumas, P., and E. Matthews, 2018. Creating a Sustainable Food Future, World Resources Institute, Washington, DC.
12. Delgado, C. L., 2003. Rising consumption of meat and milk in developing countries has created a new food revolution. J. Nutr., 133(11), 3907-3910. https://doi.org/10.1093/jn/133.11.3907S
13. Heller, M. C. & Keoleian, G. A., 2015. Greenhouse gas emission estimates of U.S. Dietary Choices and Food Loss, J. Ind. Ecol., 391-401. https://doi.org/10.1111/jiec.12174

References for Emissions Database Literature Review

1. Aguilera, E., Guzman, G., and Alonso, A., 2015. Greenhouse gas emissions from conventional and organic cropping systems in Spain. I. Herbaceous crops, Agron. Sustain. Dev., 35, 713-724, https://doi.org/10.1007/s13593-014-0267-9.
2. Alemu, A. W., Ominski, K. H., Tenuta, M., et al. 2016. Evaluation of greenhouse gas emissions from HOG manure application in a Canadian cow-calf production system using whole-farm models, Animal Production Science, 56(10), pp. 16, DOI 10.1071/AN14994.
3. Arunrat, N. and Pumijumnong N., 2017. Practices for reducing greenhouse gas emissions from rice production in Northeast Thailand, Agriculture, 7(1), 4, doi:10.3390/agriculture7010004.
4. Aryal, J. P., Sapkota, T. B., Jat, M. L., and Bishnoi, D. K., 2015. On-farm economic and environmental impact of zero-tillage wheat: A case of North-West India, Expl. Agric., 51(1), pp. 1-16, doi:10.1017/S001447971400012X
5. Astier, M., Merlin-Uribe, Y., Villamil-Echeverri, L., Garciarreal, A., Gavito, M. E., and Masera, O. R., 2014. Energy balance and greenhouse gas emissions in organic and conventional avocado orchards in Mexico, Ecological Indicators, 43, 281-287, https://doi.org/10.1016/j.ecolind.2014.03.002.
6. Astuti, R. S. D. and Hadiyanto, H., 2018. Estimating environmental impact potential of small scale fish processing using life cycle assessment, Journal of Ecological Engineering, 19(6), 65-74, https://doi.org/10.12911/22998993/91879
7. Bartl, K., Verones, F., and Hellweg, S., 2012. Life cycle assessment based evaluation of regional impacts from agricultural production at the Peruvian coast, Environmental Science and Technology, 46, 9872-9880, dx.doi.org/10.1021/es301644y
8. Basarab, J., Baron, V., Lopez-Campos, O., Aalhus, J., Haugen-Kozyra, K., and Okine, E., 2012. Greenhouse gas emissions from calf- and yearling-fed beef production systems, with and without the use of growth promotants, Animals, 2, 195-220, doi:10.3390/ani2020195.
9. Bava, L., Zucali, M., Sandrucci. A., and Tamburini, A., 2015. Environmental impact of the typical heavy pig production in Italy, Journal of Cleaner Production, 140(2), 685-691, https://doi.org/10.1016/j.jclepro.2015.11.029.
10. Biswas, W. K., Barton, L., and Carter, D., 2008. Global warming potential of wheat production in Western Australia: A life cycle assessment, Water and Environment Journal, 22(3), 206-216, doi:10.1111/j.1747-6593.2008.00127.x
11. Boissy, J., Aubin, J., Drissi, A., van der Werf, H. M. G., Bell, G. J., and Kaushik, S. J., 2011. Environmental impacts of plant-based salmonid diets at feed and farm scales, Aquaculture, 321, 61-70, https://doi.org/10.1016/j.aquaculture.2011.08.033
12. Bos, J. F. F. P., de Haan, J., Sukkel, W., and Schils, R. L. M., 2014. Energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands, Wageningen Journal of Life Sciences, 68, 61-70, https://doi.org/10.1016/j.njas.2013.12.003
13. Brodt, S., Kendall, A., Mohammadi, Y., Arslan, A., Yuan, J., Lee, I., and Linquist, B., Life cycle greenhouse gas emissions in California rice production, Field Crops Research, 169, 89-98, http://dx.doi.org/10.1016/j.fcr.2014.09.007
14. Buchspies, B., Tölle, S. J., and Jungbluth, N., 2011. Life Cycle Assessment of high-sea fish and salmon aquaculture, ESU-services Ltd., Schaffhausen, Switzerland.
15. Cardoso, A. S., Berndt, A., Leytem, A., Alves, B. J. R., de Carvalho, I. D. N. O., de Barros Soares, L. H., Urquiaga, S., and Boddey, R. M., 2016. Impact of the intensification of beef production in Brazil on greenhouse gas emissions and land use, Agricultural Systems, 143, 86-96, http://dx.doi.org/10.1016/j.agsy.2015.12.007
16. Castanheira, E. G. and Freire, F., 2013. Greenhouse gas assessment of soybean production: Implications of land use change and different cultivation systems, Journal of Cleaner Production, 54, 49-60, https://doi.org/10.1016/j.jclepro.2013.05.026.
17. Castanheira, E. G., Acevedo, H., and Freire, F., 2014. Greenhouse gas intensity of palm oil produced in Colombia addressing alternative land use change and fertilization scenarios. Applied Energy, 114, 958-967, http://dx.doi.org/10.1016/j.apenergy.2013.09.010

18. Cederberg, C. and Flysjo, A., 2004. Life cycle inventory of 23 dairy farms in South-Western Sweden, Swedish Institute for Food and Biotechnology, https://www.semanticscholar.org/paper/Life-Cycle-Inventory-of-23-Dairy-Farms-in-Sweden-Cederberg-Flysj%C3%B6/85fee19ea1f8265f28e37bb061e83c3f682138d9
19. Cederberg, C., Meyer, D., and Flysjo, A., 2009. Life cycle inventory of greenhouse gas emissions and use of land and energy in Brazilian beef production, Swedish Institute for Food and Biotechnology. https://pure.au.dk/portal/en/publications/life-cycle-inventory-of-greenhouse-gas-emissions-and-use-of-land-and-energy-in-brazilian-beef-production(fbed51d0-74f4-11de-bac6-000ea68e967b).html
20. Cederberg, C., Persson, M. U., Neovius, K., Molander, S., and Clift, R., 2011. Including carbon emissions from deforestation in the carbon footprint of Brazilian Beef, Environmental Science & Technology, 45(5), 1773-1779, DOI: 10.1021/es103240z.
21. Cerutti, A. K., Bruun, S., Donno, D., Beccaro, G. L., and Bounous, G., 2013. Environmental sustainability of traditional foods: The case of ancient apple cultivars in Northern Italy assessed by multifunctional LCA, Journal of Cleaner Production, 52, 245-252, http://dx.doi.org/10.1016/j.jclepro.2013.03.029
22. Cherubini, E., Zanghelini, G. M., Alvarenga, R. A. F., Franco, D., and Soares, S. R., 2015. Life cycle assessment of swine production in Brazil: a comparison of for manure management systems, Journal of Cleaner Production, 87, 68-77, http://doi.org/10.1016/j.jclepro.2014.10.035
23. Christoforou, E., Fokaides, P. A., Koroneos, C. J., and Recchia, L., 2016. Life Cycle Assessment of first generation energy crops in arid isolated island states: the case of Cyprus, Sustainable Energy Technologies and Assessments, 14, 1-8, http://dx.doi.org/10.1016/j.seta.2016.01.005
24. Cunha, C. S., Lopes, N. L., Veloso, C. M., Jacovine, L. A. G., Tomich, T. R. Pereira, L. G. R., and Marcondes, M. I., 2016. Greenhouse gases inventory and carbon balance of two dairy systems obtained from two methane-estimation methods, Science of the Total Environment, 571, 744-754, https://doi.org/10.1016/j.scitotenv.2016.07.046
25. de Figueiredo, M. C. B., Kroeze, C., Potting, J., Barros, V. D. S., de Aragao, F. A. S., Gondim, R. S., Santos, T. D. L., de Boer, I. J. M. D, 2013. The carbon footprint of exported Brazilian yellow melon. Journal of Cleaner Production, 47, 404-414, https://doi.org/10.1016/j.jclepro.2012.09.015
26. de Figueiredo, M. C. B., Potting, J., Lopez, S. L. A., and Bezerra, M., 2015. Environmental assessment of tropical perennial crops: The case of the Brazilian cashew, Journal of Cleaner Production, 112, 131-140, http://dx.doi.org/10.1016/j.jclepro.2015.05.134
27. Dekker, S. E. M., de Boer, I. J. M., Aarnink, A. J. A., and Groot Koerkamp, P. W. G., 2008. Environmental hotspot identification of organic egg production, 6th International Conference on Life Cycle Assessment in the Agri-Food Sector, retrieved from: http://library.wur.nl/WebQuery/wurpubs/371129.
28. Dekker, S. E. M., de Boer, I. J. M., Vermeij, I., Aarnink, A. J. A., and Groot Koerkamp, P. W. G., 2011. Ecological and economic evaluation of Dutch egg production systems, Livestock Science, 139, 109-121, http://dx.doi.org/10.1016/j.livsci.2011.03.011
29. Dolman, M. A., Vrolijk, H. C. J., and de Boer, I. M. J., 2012. Exploring variation in economic, environmental, and societal performance among Dutch fattening pig farms, Livestock Science, 149, 143-154, http://dx.doi.org/10.1016/j.livsci.2012.07.008
30. Fallahpour, F., Aminghafouri, A., Behbahani, A. G., and Bannayan, M., 2012. The environmental impact assessment of wheat and barley production by using life cycle assessment (LCA) methodology, Environ. Dev. Sustain., 14, 979-992, DOI 10.1007/s10668-012-9367-3
31. Fantin, V. , Buttol, P., Pergreffi, R., and Masoni, P., 2012. Life cycle assessment of Italian high quality milk production. A comparison with an EPD study, Journal of Cleaner Production, 28, 150-159, http://dx.doi.org/10.1016/j.jclepro.2011.10.017
32. Flysjo, A., Henriksson, M., Cederberg, C., Ledgard, S., and Englund, J. E., 2011. The impact of various parameters on the carbon footprint of milk production in New Zealand and Sweden, Agricultural Systems, 104, 459-469, http://dx.doi.org/10.1016/j.agsy.2011.03.003.
33. Fusi, A., Guidetti, R., and Benedetto, G., 2014. Delving into the environmental aspect of a Sardinian white wine: From partial to total life cycle assessment, Science of the Total Environment, 472, 989-1000, http://dx.doi.org/10.1016/j.scitotenv.2013.11.148

34. García, B. G., Jiménez, C. R., Aguado-Giménez, F., and García, J. G., 2016. Life Cycle Assessment of gilthead seabream (Sparus aurata) production in offshore fish farms, Sustainability, 8, pp.19, https://doi.org/10.3390/su8121228
35. García, B. G., Jiménez, C. R., Aguado-Giménez, F., and García, J. G., 2019. Life Cycle Assessment of seabass (Dicentrarchus labrax) production in offshore fish farms: Variability and multiple regression analysis, Sustainability, 11, pp. 21, https://doi.org/10.3390/su11133523
36. Geough , E. J. M., Little, S. M., Janzen, H. H., McAllister, T. A., McGinn, S. M., and Beauchemin, K. A., 2012. Life-cycle assessment of greenhouse gas emissions from dairy production in Eastern Canada: A case study, J. Dairy Sci., 95, 5164-5175, http://dx.doi.org/ 10.3168/jds.2011-5229
37. Gonzales-Garcia, S., Belo, S., Dias, A. C., Rodrigues, J. V., da Costa, R. R., Ferreira, A., de Andrade, L. P., and Arroja, L., 2015. Life cycle assessment of pigmeat production: Portuguese case study and proposal of improvement options, Journal of Cleaner Production, 100, 126-139, http://dx.doi.org/10.1016/j.jclepro.2015.03.048
38. Grassini, P. and Cassman, K. G., 2011. High-yield maize with large net energy yield and small global warming intensity, PNAS, 109(4), 1074-1079, http://www.pnas.org/cgi/doi/10.1073/pnas.1116364109
39. Groonroos, J., Seppälä, J., Silvenius, F., and Mäkinen, T., 2006. Life cycle assessment of Finnish cultivated rainbow trout, Boreal Environment Research, 11, 401-414.
40. Guerci, M., Luciana, B., Zucali, M., and Anna, S., 2013. Effect of farming strategies on environmental impact of intensive dairy farms in Italy, Journal of Dairy Research, 80, 300-308, doi:10.1017/S0022029913000277
41. Gutierrez, A. S., Eras, J. J. C., Billen, P., and Vandecasteele, C., 2016. Environmental assessment of pig production in Cienfuegos, Cuba: Alternatives for manure management, Journal of Cleaner Production, 112, 2518-2528, http://dx.doi.org/10.1016/j.jclepro.2015.09.082
42. Harada, H., Kobayashi, H., and Shindo, H., 2007. Reduction in greenhouse gas emissions by no-tilling rice cultivation in Hachirogata polder, northern Japan: Life-cycle inventory analysis, Soil Science and Plant Nutrition, 53, 668-677, doi: 10.1111/j.1747-0765.2007.00174.x
43. He, X., Qiao, Y., Liu, Y., Dendler, L., Yin, C., and Martin, F., 2016. Environmental impact assessment of organic and conventional tomato production in urban greenhouses of Beijing city, China, Journal of Cleaner Production, 134(A), 251-258, https://doi.org/10.1016/j.jclepro.2015.12.004
44. Hokazono, S., Hayashi, K, and Sato, M, 2009. Potentialities of organic and sustainable rice production in Japan from a life cycle perspective, Agronomy Research, 7(Special Issue 1), 257-262.
45. Iribarren, D., Moreira, M., and Feijoo, G., 2010. Implementing by-product management into the Life Cycle Assessment of the mussel sector, Resources Conservation and Recycling, 54, 1219-1230, https://doi.org/10.1016/j.resconrec.2010.03.017
46. Jayasundara, S. and Wagner-Riddle, C., 2013. Greenhouse gas emissions intensity of Ontario milk production in 2011 compared with 1991, Can. J. Anim., Sci., 94, 155-173, doi:10.4141/CJAS2013-127
47. Kehagias, M. C., Michos, M. C., Menexes, G. C., Mamolos, A. P., Tsatsarelis, C. A., Anagnostopoulos, C. D., and Kalburtji, K. L., 2015. Energy equilibrium and carbon dioxide, methane, and nitrous oxide-emissions in organic, integrated and conventional apple orchards related to Natura 2000 site, Journal of Cleaner Production, 91, 89-95, http://dx.doi.org/10.1016/j.jclepro.2014.12.007
48. Keyes, S., Tyedmers, P., and Beazley, K., 2015. Evaluating the environmental impacts of conventional and organic apple production in Nova Scotia, Canada, through life cycle assessment, Journal of Cleaner Production, 104, 40-51, https://doi.org/10.1016/j.jclepro.2015.05.037
49. Khoshnevisan, B., Rafiee, S., Omid, M., Mousazedeh, H., and Clark, S., 2014. Environmental impact assessment of tomato and cucumber cultivation in greenhouses using life cycle assessment and adaptive neuro-fuzzy inference system, Journal of Cleaner Production, 73, 183-192, http://dx.doi.org/10.1016/j.jclepro.2013.09.057
50. Koga, N., Sawamoto, T., and Tsuruta, H., 2006. Life cycle inventory-based analysis of greenhouse gas emissions from arable land farming systems in Hokkaido, northern Japan, Soil Science and Plant Nutrition, 52(4), 564-574, DOI: 10.1111/j.1747-0765.2006.00072.x
51. A. Korsaeth , Jacobsen, A. Z., Roer, A.-G., Henriksen, T. M., Sonesson, U., Bonesmo, H., Skjelvåg, A. O., and Strømman, A. H. 2012. Environmental life cycle assessment of cereal and bread production in Norway,

Acta Agriculturae Scandinavica, Section A – Animal Science, 62(4), 242-253, DOI: 10.1080/09064702.2013.783619

52. Kramer, K. J., Moll, H. C., Nonhebel, S., and Wilting, H. C., 1999. Greenhouse gas emissions related to Dutch food consumption. Energy Policy, 27(4), 203-216, https://doi.org/10.1016/S0301-4215(99)00014-2
53. Lillywhite, R., Chandler, D., Grant, W., Lewis, K., Firth, C., Schmutz, U., and Halpin, D., 2007. Environmental footprint and sustainability of horticulture (including potatoes) – a comparison with other agricultural sectors, Warwick HRI, University of Warwick, pp. 159.
54. Litskas, V. D., Mamolos, A. P., Kalburtji, K. L., Tsatsarelis, C. A., and Kiose-Kampasakali, E., 2011. Energy flow and greenhouse gas emissions in organic and conventional sweet cherry orchards located in or close to Natura 2000 sites, Biomass and Bioenergy, 35, 1302-1310, http://dx.doi.org/10.1016/j.biombioe.2010.12.023
55. Martin-Gorriz, B., Soto-Garcia, M., and Martin-Alvarez, V., 2014. Energy and greenhouse-gas in agriculture of SE (southeast) Spain. Effects of alternative water supply scenarios, Energy, 77, 478-488, http://dx.doi.org/10.1016/j.energy.2014.09.031
56. Mashoko, L., Mbohwa, C., and Thomas, V. M., 2010. LCA of the South African sugar industry, Journal of Environmental Planning and Management, 53(6), 793-807, https://doi.org/10.1080/09640568.2010.488120
57. Mathot, M., Van Stappen, F., Loriers, A., Planchon, V., Jamin, J., Corson, M., and Stilmant, D., 2014. Environmental impacts of milk production in southern Belgium: Estimation for nine commercial farms and investigation of mitigation via better manure management, Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector, 772-781, 8-10 October 2014, San Francisco, USA.
58. Mazzetto, A. M., Feigl, B. J., Schils, R. L. M., Cerri, C. E. P., and Cerri, C. C., 2015. Improved pasture and herd management to reduce greenhouse gas emisisons from a Brazilian beef production system, Livestock Science, 175, 101-112, http://dx.doi.org/10.1016/j.livsci.2015.02.014
59. Michos, M. C., Mamolos, A. P., Menexes, G. C., Tsatsarelis, C. A., Tsirakoglou, V. M., and Kalburtji, K. L., 2012. Energy inputs, outputs, and greenhouse gas emissions in organic, integrated and conventional peach orchards, Ecological Indicators, 13, 22-28, doi:10.1016/j.ecolind.2011.05.002
60. Mohammadi, A., Rafiee, S., Jafari, A., Dalgaard, T., Knudsen, M., T., Keyhani, A., Mousavi-Avval, S. H., and Hermansen, J. E., 2013. Potential greenhouse gas emission reductions in soybean farming: a combined use of Life Cycle Assessment and Data Envelopment Analysis, Journal of Cleaner Production, 54, 89-100, http://dx.doi.org/10.1016/j.jclepro.2013.05.019
61. Taufiq, M., Padmi, T., and Rahardyan, D. B., 2016. Life cycle assessment of dairy farms, Reviews on Environmental Health, 31(1), 187-190, https://doi.org/10.1515/reveh-2015-0037
62. Murphy, C. W. and Kendall, A., 2013. Life cycle inventory development for corn and stover production systems under different allocation methods, Biomass and Bioenergy, 58, 67-75, http://dx.doi.org/10.1016/j.biombioe.2013.08.008
63. Nemecek, T., Weiler, K., Plassmann, K., and Schnetzer, J., 2011. Geographical extrapolation of environmental impact of crops by the MEXALCA method, Agroscope Reckenholz-Tanikon Research Station ART, Zurich, Switzerland.
64. Nikkhah, A., 2017. Life cycle assessment of the agriculture sector in Iran (2007-2014), Sustainability, 37(5), 1750-1757, https://doi.org/10.1002/ep.12831
65. Nilsson, K., Flysjo, A., Davis, J., Sim, S., Unger, N., and Bell, S., 2010. Comparative life cycle assessment of margarine and butter consumed in the UK, Germany, and France, The International Journal of Life Cycle Assessment, 15(9), 916-926, https://doi.org/10.1007/s11367-010-0220-3
66. Noponen, M. R. A., Edwards-Jones, G., Haggar, J. P., Soto, G., Attarzadeh, N., and Healey, J. R., 2012. Greenhouse gas emissions in coffee grown with differing input levels under conventional and organic management, Agriculture, Ecosystems, and Environment, 151, 6-15, https://doi.org/10.1016/j.agee.2012.01.019
67. Norton, T. 2008. Enhancing environmental sustainability in the processing potato industry, Horticulture Australia Ltd, Sydney, Australia.
68. Oelbermann, M., 2014. Sustainable agroecosystems in climate change mitigation, Wageningen Academic Publishers, Wageningen, The Netherlands.

69. O'Brien, D., Shalloo, L., Patton, J., Buckley, F., Grainger, C., and Wallance, M., 2012. A life cycle assessment of seasonal grass-based and confinement dairy farms, Agricultural Systems, 107, 33-46, doi:10.1016/j.agsy.2011.11.004
70. O'Brien, D., Capper, J. L., Garnsworthy, P. C., Grainger, C., and Shalloo, L., 2014. A case study of the carbon footprint of milk from high-performing confinement and grass-based dairy farms, J. Dairy Sci., 97(3), 1835-1851, http://dx.doi.org/ 10.3168/jds.2013-7174
71. Pathak, H., Sankhyan, S., Dubey, D. S., Bhatia, A., and Jain, N., 2012. Dry direct-seeding of rice for mitigation greenhouse gas emission: field experimentation and simulation, Paddy Water Environ., DOI 10.1007/s10333-012-0352-0
72. Penati, C. A., Tamburini, A., Bava, L., Zucali, M., and Sandrucci, A., 2016. Environmental impact of cow milk production in the Central Italian Alps using life cycle assessment, Italian Journal of Animal Science, 12(96), 584-592, https://doi.org/10.4081/ijas.2013.e96
73. Phetteplace, H. W., Johnson, D. E., and Seidl, A. F., 2001. Greenhouse gas emissions from simulated beef and dairy livestock systems in the United States, Nutrient Cycling in Agroecosystems, 60, 99-102, https://doi.org/10.1023/A:1012657230589
74. Pratibha, G., Srinivas, I., Rao, K. V., Raju, B. M. K., Thyagaraj, C. R., et al. 2015. Impact of conservation agriculture practices on energy use efficiency and global warming potential in rainfed pigeonpea-castor systems, Europ. J. Agronomy, 66, 30-40, http://dx.doi.org/10.1016/j.eja.2015.02.001.
75. Prudencio de Silva, V., van der Werf, H. M. G., Soares, S. R., and Corson, M., 2014. Environmental impacts of French and Brazilian Broiler chicken production scenarios: An LCA approach, J. Environ. Manage., 15, 222-231, doi: 10.1016/j.jenvman.2013.12.011
76. Ramjeawon, T., 2004. Life cycle assessment of cane-sugar on the island of Mauritius, Int. J. LCA, 9(4), 254-260, http:lldx.doi.orcjIlO.106511ca2004.03.151
77. Ridoutt, B. G., Sanguansri, P., and Harper, G. S., 2011. Comparing carbon and water footprints for beef cattle production in Southern Australia, Sustainability, 3, 2443-2455, doi:10.3390/su3122443
78. Rinaldi, S., Barbanera, M., and Lascaro, E., 2014. Assessment of carbon footprint and energy performance of the extra virgin olive oil chain in Umbria, Italy, Science of the Total Environment, 482-483, 71-79, http://dx.doi.org/10.1016/j.scitotenv.2014.02.104
79. Rivas-Garcia, P., Botello-Alvarez, J. E., Seabra, J. E. A., da Silva Walter, A. C., and Estrada-Baltazar, A., 2015. Environmental implications of anaerobic digestion for manure management in dairy farms in Mexico: a life cycle perspective, Environmental Technology, 36(17), 1-38, DOI: 10.1080/09593330.2015.1024758
80. Rosa, D., Figueiredo, F., Castanheira, E. G., and Freire, F., 2017. Life-cycle assessment of fresh and frozen chestnut, Journal of Cleaner Production, 140, 742-752, http://dx.doi.org/10.1016/j.jclepro.2016.04.064
81. Samson, R., 2012. Environmental and Socioeconomic Life Cycle Assessment of Canadian Milk, Quantis Canada, AGECO, and CIRAIG for Dairy Farmers of Canada.
82. Sandrucci, A., Bava, L, Zucali, M., Guerci, M., and Tamburini, A., 2014. How can farming intensification affect the environmental impact of milk production? J. Dairy Sci., 97, 4579-4593, http://dx.doi.org/ 10.3168/jds.2013-7530
83. Sasu-Boakye, Y., Cederberg, C., and Wirsenius, S., 2014. Localising livestock protein feed production and the impact on land use and greenhouse gas emissions, Animal, 8(8), 1339-1348, doi:10.1017/S1751731114001293
84. Saunders, C. and Barber, A., 2007. Comparative energy and greenhouse gas emissions of New Zealand's and the UK's dairy industry, Lincoln University Research Report No. 297, Lincoln, New Zealand.
85. Schmidt, J. H., 2007. Life cycle assessment of rapeseed oil and palm oil, Department of Development and Planning Aalborg University Ph.D. Thesis, pp. 277, retrieved from: https://core.ac.uk/download/pdf/60370684.pdf
86. Segura, M. and Andrade, H. J., 2012. Huella de carbono en cadenas productivas de café con diferentes estándares de certificación en Costa Rica, Luna Azul, 35, 60-77.
87. Shin, R. and Searcy, C., 2018. Evaluating the greenhouse gas emissions in the craft beer industry: An assessment of challenges and benefits of greenhouse gas accounting, Sustainability, 10, pp. 30, https://doi.org/10.3390/su10114191

88. Soltani, A., Rajabi, M. H., Zeinali, E., and Soltani, E., 2013. Energy inputs and greenhouse gases emissions in wheat production in Gorgan, Iran, Energy, 50, 54-61, http://dx.doi.org/10.1016/j.energy.2012.12.022
89. Soni, P., Taewichit, C., and Salokhe, V. M., 2013. Energy consumption and CO2 emissions in rainfed agricultural production systems of Northeast Thailand, Agricultural Systems, 116, 25-36, http://dx.doi.org/10.1016/j.agsy.2012.12.006
90. Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., and de Haan, C., 2006. Livestock's Long Shadow, Food and Agriculture Organization, Rome, Italy, pp. 390.
91. Stichnothe, H. and Schuchardt, F., 2011. Life cycle assessment of two palm oil production systems, Biomass and Bioenergy, 35, 3976-3984, http://dx.doi.org/10.1016/j.biombioe.2011.06.001
92. Svanes, E. and Aronsson, A. K. S., 2013. Carbon footprint of a Cavendish banana supply chain, The International Journal of Life Cycle Assessment, 18(8), 1450-1464, https://doi.org/10.1007/s11367-013-0602-4
93. Thomassen, M. A., van Calker, K. J., Smits, M. C. J., Iepema, G. L., and de Boer, I. J. M., 2008. Life cycle assessment of conventional and organic milk production in the Netherlands, Agricultural Systems, 96, 95-107, doi:10.1016/j.agsy.2007.06.001
94. Tidaker, P., Mattsson, B., and Jonsson, H., 2007. Environmental impact of wheat production using human urine and mineral fertilisers – a scenario study, Journal of Cleaner Production, 15, 52-62, doi:10.1016/j.jclepro.2005.04.019
95. Van der Werf, H. M. G., Kanyarushoki, C., and Corson, M. S., 2009. An operational method for the evaluation of resource use and environmental impacts of dairy farms by life cycle assessment, Journal of Environmetnal Management, 90, 3643-3652, doi:10.1016/j.jenvman.2009.07.003
96. Vazquez-Rowe, I., Villanueva-Rey, P., Moreira, M. T., and Feijoo, G., 2012. Environmental analysis of Ribeiro wine from a timeline perspective: Harvest year matters when reporting environmental impacts, Journal of Environmental Management, 98, 73-83, doi:10.1016/j.jenvman.2011.12.009
97. Vegnoni, E., Franca, A., Breedveld, L., Porqueddu, C., Ferrara, R., and Duce, P., 2015. Environmental performances of Sardinian dairy sheep production systems at different input levels, Science of the Total Environment, 502, 354-361, http://dx.doi.org/10.1016/j.scitotenv.2014.09.020
98. Verge, X. P. C., Dyer, J. A., Desjardins, R. L., and Worth, D., 2008. Greenhouse gas emissions from the Canadian beef industry, Agricultural Systems, 98, 126-134, doi:10.1016/j.agsy.2008.05.003
99. Verge, X. P. C., Dyer, J. A., Desjardins, R. L., and Worth, D., 2009. Greenhouse gas emissions from the Canadian pork industry, Livestock Science, 121, 92-101, http://dx.doi.org/10.1016/j.livsci.2008.05.022
100. Verge, X. P. C., Dyer, J. A., Desjardins, R. L., and Worth, D., 2011. Long-term trends in greenhouse gas emissions from the Canadian poultry industry, J. Appl. Poult. Res., 18, 210-222, doi: 10.3382/japr.2008-00091
101. Veysset, P., Lherm, M., and Bebin, D., 2011. Productive, environmental and economic performances assessments of organic and conventional suckler cattle farming systems, Org. Agr., 1, 1-16, DOI 10.1007/s13165-010-0001-0
102. Villanueva-Rey, P., Vazquez-Rowe, I., Moreira, M. T., and Feijoo, G., 2014. Comparative life cycle assessment in the wine sector: biodynamic vs. conventional viticulture activities in NW Spain, Journal of Cleaner Production, 65, 330-341, http://dx.doi.org/10.1016/j.jclepro.2013.08.026
103. Vinyes, E., Gasol, C. M., Asin, L., Alegre, S., and Munoz, P., 2015. Life cycle assessment of multiyear peach production, Journal of Cleaner Production, 104, 68-79, http://dx.doi.org/10.1016/j.jclepro.2015.05.041
104. Wallman, M., Cederberg, C., and Sonesson, U., 2011. Life cycle assessment of Swedish Lamb Production, Swedish Farmers' Foundation for Agricultural Research.
105. Wang, C., Li, X., Gong, T., and Zhang, H., 2014. Life cycle assessment of wheat-maize rotation systems emphasizing high crop yield and high resource use efficiency in Quzhou County, Journal of Cleaner Production, 68, 56-63, http://dx.doi.org/10.1016/j.jclepro.2014.01.018
106. White, R. R., Brady, M., Capper, J. L., Johnson, K. A., 2014. Optimizing diet and pasture management to improve sustainability of U.S. beef production, Agricultural Systems, 130, 1-12, http://dx.doi.org/10.1016/j.agsy.2014.06.004

107. White, R. R., Brady, M., Capper, J. L., McNamara, J. P., and Johnson, K. A., 2015. Cow-calf reproductive, genetic, and nutritional management to improve the sustainability of whole beef production systems, J. Anim. Sci., 93, 3197-3211, doi:10.2527/jas2014-8800
108. Wiedemann, S. G., Ledgard, S. F., Henry, B. K., Yan, M., Mao, N., and Russell, S. J., 2015. Application of life cycle assessment to sheep production systems: Investigating co-production of wool and meet using case studies from major global producers, Int. J. Life Cycle Assess., 20(4), 463-476, DOI 10.1007/s11367-015-0849-z
109. Williams, A. G., Audsley, E., and Sandars, D. L., 2006. Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities, Defra Research Project IS0205, Bedford: Cranfield University and Defra. Available on www.silsoe.cranfield.ac.uk, andwww.defra.gov.uk
110. Williams, A. G., Audsley, E., and Sandars, D. L., 2010. Environmental burdens of producing bread wheat, oilseed rape and potatoes in England and Wales using simulation and system modelling, Int. J. Life Cycle Assess, 15, 855-868, DOI 10.1007/s11367-010-0212-3
111. Yousefi, M., Khoramivafa, M., and Mondani, F., 2014. Integrated evaluation of energy use, greenhouse gas emissions and global warming potential for sugar beet (Beta vulgaris) agroecosystems in Iran, Atmospheric Environment, 92, 501-505, http://dx.doi.org/10.1016/j.atmosenv.2014.04.050
112. Zervas, G. and Tsiplakou, E., 2012. An assessment of GHG emissions from small ruminants in comparison with GHG emissions from large ruminants and monogastric livestock, Atmospheric Environment, 49, 13-23, https://doi.org/10.1016/j.atmosenv.2011.11.039
113. Zhu, B., Kros, J., Lesschen, J. P., Staritsky, I. G., and de Vries, W., 2016. Assessment of uncertainties in greenhouse gas emission profiles of livestock sectors in Africa, Latin America, and Europe, Regional Environmental Change, 16(6), 1571-1582.

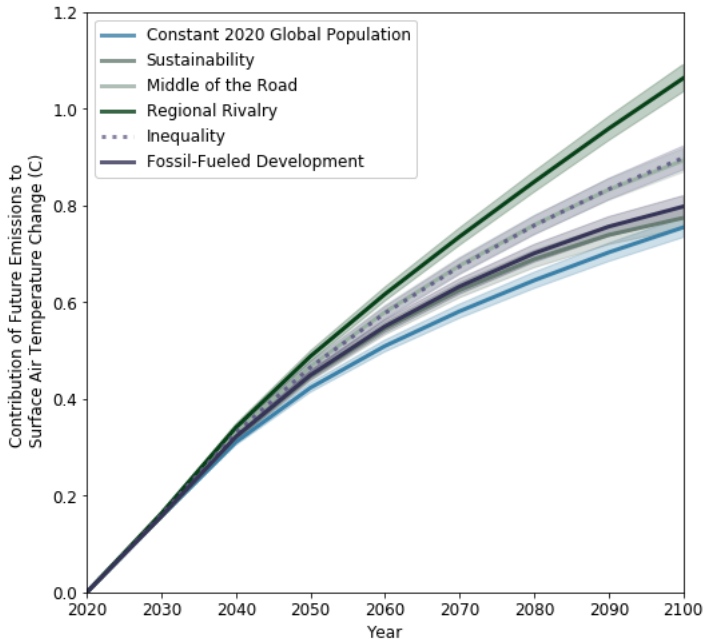

Figure S1: Contribution of future emissions to surface air temperature change associated with sustained food consumption rates starting in 2020 and continuing through the end of the century based on five population projections. The population projections are compatible with the following Shared Socioeconomic Pathways (SSPs) as outlined in Riahi et al. 2017: Regional Rivalry, Inequality, Middle of the Road, Fossil-Fueled Development, and Sustainability (corresponding to SSP3, SSP4, SSP2, SSP5, and SSP1, respectively). The future warming associated with consumption from a constant 2020 global population is also provided for reference. Emissions for all sectors other than agriculture are represented by RCP4.5. Final 2100 contribution to surface air temperature change is higher for the RCP4.5 scenario than RCP8.5 scenario due to the logarithmic relationship between CO_2 radiative efficiency and concentration. Shading represents 95% confidence intervals based on all ensemble members. Inequality (SSP4) scenario identified by dotted line in order to better visualize overlapping scenarios.

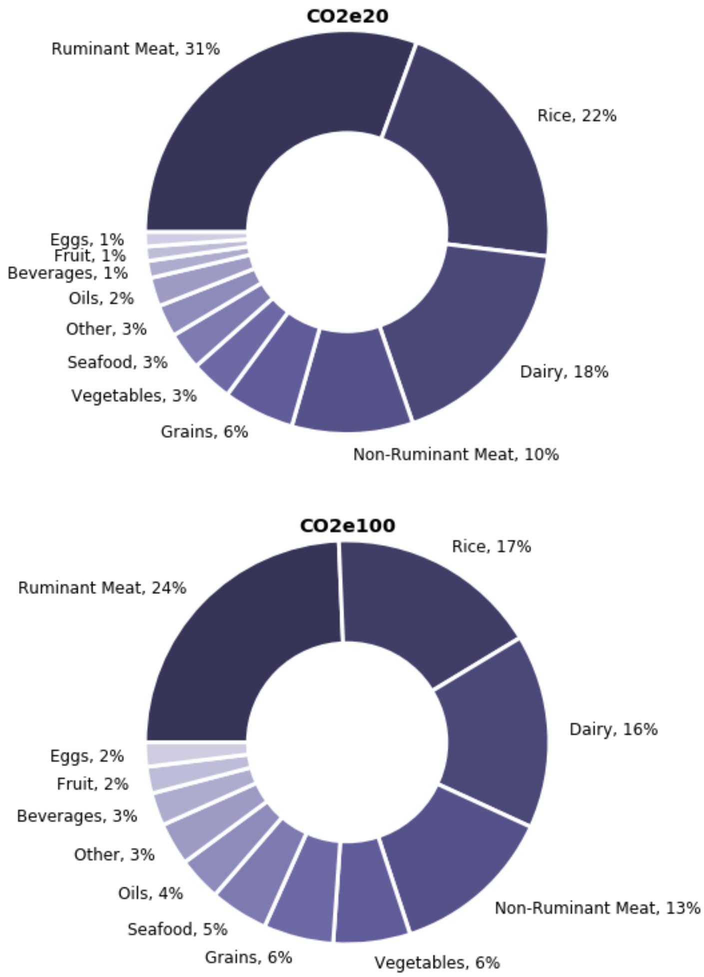

Figure S2: Relative contribution of each food group to future climate change, measured by annual emissions in CO_2e20 and CO_2e100.

Food Group *(Emissions Magnitude in CO_2e100/kg food group*)*	Food Item	Percent Gas Contribution			Citation	Notes
		CO_2	CH_4	N_2O		
Grains *(1.3)*	Barley	53	2	44	Christoforou et al. 2016	No land use change
		47	2	51	Fallahpour et al. 2012	Irrigated barley; no land use change
		51	1	48	Fallahpour et al. 2012	Rainfed barley; no land use change
		65	2	33	Kramer et al. 1999	Spring/winter barley; land use change included
		57	3	40	Nemecek et al. 2011	Land use change included
	Maize	91	2	7	Bartl et al. 2012	Hard maize; land use change included
		53	2	45	Christoforou et al. 2016	No land use change
		63	1	36	Grassini and Cassman 2012	No land use change
		57	6	37	Murphy and Kendall 2013	Maize/stover; no land use change
		70	2	28	Nemecek et al. 2011	Land use change included
		69	0	31	Soni and Salohke 2013	No land use change
		99	1	0	Wang et al. 2014	Summer maize; no land use change
	Rye	73	2	25	Nemecek et al. 2011	Land use change included
	Sorghum	55	2	43	Christoforou et al. 2016	Sweet sorghum; no land use change
	Wheat	35	0	65	Aryal et al. 2015	Land use change included
		74	5	21	Biswas et al. 2008	No land use change
		55	2	43	Christoforou et al. 2016	No land use change
		49	4	47	Fallahpour et al. 2012	Irrigated wheat; no land use change
		48	4	48	Fallahpour et al. 2012	Rainfed wheat; no land use change
		92	0	8	Koga et al. 2016	Winter wheat; no land use change
		50	0	50	Korsaeth et al. 2012	Winter wheat; no land use change
		55	1	44	Kramer et al. 1999	Spring/winter wheat; land use change included
		56	0	44	Lillywhite et al. 2007	Winter wheat; no land use change
		54	3	43	Nemecek et al. 2011	Land use change included
		100	0	0	Soltani et al. 2013	No land use change
		29	0	71	Tidaker et al. 2007	No land use change
		95	5	0	Wang et al. 2014	Winter wheat; no land use change
		19	1	80	Williams et al. 2010	No land use change
	Misc.	78	0	22	Aguilera et al. 2015	Cereals; no land use change
	AVERAGE	62	2	36		
Rice *(3.8)*	Rice	9	88	3	Aguilera et al. 2015	No land use change
		28	71	1	Brodt et al. 2014	Land use change included
		2	97	1	Harada et al. 2007	No land use change
		31	66	3	Hokazono et al. 2009	No land use change
		26	69	5	Nemecek et al. 2011	Land use change included
		50	34	16	Pathak et al. 2013	No land use change
		27	63	10	Soni and Salohke 2013	No land use change
		5	86	9	Arunrat and Pumijumnon 2017	No land use change
	AVERAGE	24	63	13		
Fruits *(0.6)*	Apples	79	2	19	Bartyl et al. 2012	Land use change included
		86	3	11	Cerutti et al. 2013	No land use change
		90	0	10	Lillywhite et al. 2007	No land use change
		76	2	22	Nemecek et al. 2011	Land use change included

		21	0	79	Keyes et al. 2015	No land use change
	Avocado	50	1	49	Astier et al. 2014	No land use change
		57	2	41	Bartyl et al. 2012	Land use change included
	Bananas	76	2	22	Nemecek et al. 2011	Land use change change included
		75	0	25	Soni and Salokhe 2013	No land use change
		88	7	5	Svanes and Aronsson 2013	No land use change
	Cherry	25	4	71	Litskas et al. 2011	No land use change
	Lemons	56	0	44	Martin Gorriz et al. 2014	No land use change
	Melon	35	23	41	de Figueiredo et al. 2015	No land use change
		96	1	3	Kehagias et al. 2015	No land use change
		58	0	42	Martin Gorriz et al. 2014	No land use change
	Oranges	42	2	56	Bartyl et al. 2012	Mandarin oranges; land use change included
		53	0	47	Martin Gorriz et al. 2014	Mandarin oranges; no land use change
		54	0	47	Martin Gorriz et al. 2014	No land use change
		79	3	18	Nemecek et al. 2011	Land use change included
	Peaches	63	2	35	Bartyl et al. 2012	Land use change included
		99	1	0	Michos et al. 2012	No land use change
		73	6	21	Nemecek et al. 2011	Land use change included
		85	5	10	Nikkhah et al. 2017	No land use change
		99	0	1	Vinyes et al. 2015	No land use change
	Strawberries	61	1	38	Bartyl et al. 2012	Land use change included
		98	0	2	Lillywhite et al. 2007	No land use change
	AVERAGE	69	2	29		
Vegetables *(0.9)*	Almonds	67	5	28	Nemecek et al. 2011	Land use change included
	Artichoke	59	0	41	Martin Gorriz et al. 2014	No land use change
	Asparagus	70	5	25	Bartyl et al. 2012	Land use change included
	Beans	96	0	4	Koga et al. 2016	Adzuki beans; no land use change
		65	2	33	Kramer et al. 1999	French beans; no land use change
	Beet	86	0	14	Koga et al. 2016	Sugar beet; no land use change
		57	1	42	Christoforou et al. 2016	Sugar beet; no land use change
		68	0	32	Lillywhite et al. 2007	Sugar beet; no land use change
		55	3	42	Nemecek et al. 2011	Sugar beet; land use change included
		58	20	22	Yousefi et al. 2014	Sugar beet; no land use change
	Broccoli	50	0	50	Martin Gorriz et al. 2014	No land use change
	Cabbage	92	0	8	Koga et al. 2016	No land use change
	Carrot	85	0	15	Lillywhite et al. 2007	No land use change
		75	4	22	Nemecek et al. 2011	Land use change included
	Cashew	38	0	62	de Figueiredo et al. 2015	No land use change
	Cassava	84	0	16	Soni and Salokhe 2013	No land use change
	Cauliflower	60	0	40	Lillywhite et al. 2007	No land use change
	Chestnuts	75	5	20	Rosa et al. 2017	No land use change
	Cucumber	59	6	35	Khoshnevisan et al. 2014	No land use change
	Hazelnuts	71	5	24	Nemecek et al. 2011	Land use change included
	Lettuce	97	0	3	Lillywhite et al. 2007	No land use change

		53	0	47	Martin Gorriz et al. 2014	No land use change
	Onion	75	0	25	Lillywhite et al. 2007	No land use change
		67	3	30	Nemecek et al. 2011	Land use change included
	Peas	62	2	36	Nemecek et al. 2011	Land use change included
	Peppers	76	4	20	Nemecek et al. 2011	Land use change included
	Pidgeonpea	73	0	27	Pratibha et al. 2015	No land use change
	Potatoes	29	1	70	Bartyl et al. 2012	Land use change included
		55	2	43	Christoforou et al. 2016	No land use change
		97	0	3	Koga et al. 2016	No land use change
		62	1	37	Kramer et al. 1999	No land use change
		84	0	16	Lillywhite et al. 2007	No land use change
		68	4	28	Nemecek et al. 2011	Land use change included
		48	2	50	Norton et al. 2008	Land use change included
		48	2	50	Williams et al. 2006	No land use change
		47	2	51	Williams et al. 2010	No land use change
	Pumpkin	67	3	30	Nemecek et al. 2011	Land use change included
	Soybeans	39	0	61	Castanheira and Freire 2013	Land use change included
		60	3	37	Mohammadi et al. 2013	No land use change
		90	1	9	Nemecek et al. 2011	Land use change included
		65	0	35	Soni and Salokhe 2013	No land use change
	Spinach	53	3	44	Nemecek et al. 2011	Land use change included
	Tomatoes	25	0	75	He et al. 2016	No land use change
		58	7	35	Khoshnevisan et al. 2014	No land use change
		78	5	17	Nemecek et al. 2011	Land use change included
	Misc.	65	13	22	Aguilera et al. 2015	Legumes; no land use change
		33	6	61	Aguilera et al. 2015	Open air vegetables; no land use change
		84	2	14	Aguilera et al. 2015	Greenhouse vegetables; no land use change
		88	0	12	Soni and Salokhe 2013	Vegetables; no land use change
		67	2	31	Kramer et al. 1999	Vegetables; no land use change
	AVERAGE	65	3	32		
Ruminant Meat *(33.6)*	Beef	5	82	13	Alemu et al. 2016	No land use change
		7	68	25	Basarab et al. 212	No land use change
		5	85	10	Cardoso et al. 2016	No land use change
		2	82	17	Cederberg et al. 2009	No land use change
		3	83	14	Mazzetto et al. 2015	No land use change
		8	54	38	Phetteplace et al. 2001	No land use change
		3	92	5	Ridoutt et al. 2011	No land use change
		7	67	26	Verge et al. 2008	No land use change
		11	69	20	Veysset et al. 2011	Land use change included
		5	84	11	White et al. 2014	No land use change
		9	85	6	White et al. 2015	No land use change
		13	65	23	Zhu et al. 2015	Land use change included
	Lamb	14	47	39	Lillywhite et al. 2007	No land use change
		10	64	26	Wallman et al. 2011	No land use change
		4	85	11	Wiedemann et al. 2015	No land use change
	Misc.	13	60	27	Zhu et al. 2015	Sheep and goat; land use change included
		58	34	8	Zervas and Tsiplakou 2011	Cattle and buffaloes; land use change included

		60	25	15	Zervas and Tsiplakou 2011	Sheep and goat; land use change included
		34	39	27	Steinfeld et al. 2006	Land use change included
	AVERAGE	14	68	18		
Non-Ruminant Meat *(11.7)*	Chicken	61	14	25	de Silva et al. 2014	No land use change
		67	5	28	Zhu et al. 2015	No land use change
	Pork	53	32	15	Bava et al. 2017	Land use change included
		57	27	16	Cherubini et al. 2014	Land use change included
		30	9	61	Dolman et al. 2012	No land use change
		54	17	29	Gonzales Garcia et al. 2015	No land use change
		70	29	1	Gutierrez et al. 2016	No land use change
		47	30	23	Boakye et al. 2014	Land use change included
		24	52	23	Verge et al. 2009	No land use change
		61	28	11	Zervas and Tsiplakou 2011	Land use change included
		32	31	37	Zhu et al. 2015	No land use change
	Misc.	39	5	56	Verge et al. 2009	Poultry; no land use change
		48	0	52	Zervas and Tsiplakou 2011	Poultry; land use change included
	AVERAGE	49	22	29		
Seafood *(5.6)*	Freshwater Fish	75	6	19	Gronroos et al. 2006	Trout; no land use change
		75	5	20	Burchspies et al. 2011	Salmon; no land use change
		85	5	10	Boissy et al. 2011	Trout and salmon; no land use change
	Pelagic Fish	84	14	2	Burchspies et al. 2011	Mackerel and herring; no land use change
		100	0	0	Astuti and Hadiyanto 2018	Mackerel; no land use change
	Demersal Fish	94	3	3	Burchspies et al. 2011	Cod; no land use change
		99	0	1	Garcia et al. 2019	Sea bass; no land use change
		99	0	1	Garcia et al. 2016	Gilthead seabream; no land use change
	Mussels	93	8	2	Iribarren et al. 2010	Canned; no land use change
	AVERAGE	89	5	6		
Dairy *(3.1)*	Milk	25	49	26	Bos et al. 2014	No land use change
		11	65	24	Cederberg et al. 2004	No land use change
		5	81	14	Cunha et al. 2016	No land use change
		28	49	23	Fantin et al. 2012	No land use change
		9	70	21	Flysjo et al. 2011	No land use change
		3	64	33	Geough et al. 2012	No land use change
		23	66	11	Guerci et al. 2013	No land use change
		10	65	25	Jayasundara and Wagner Riddle 2013	No land use change
		41	41	18	Lillywhite et al. 2007	No land use change
		14	70	16	Mathot et al. 2014	No land use change
		20	63	17	O'Brien et al. 2012	Land use change included
		12	66	23	O'Brien et al. 2014	Land use change included
		29	49	22	Penati et al. 2013	No land use change
		19	51	31	Thomassen et al. 2008	No land use change
		10	67	23	Van der Werf et al. 2009	No land use change
		30	57	13	Vegnoni et al. 2015	No land use change
		72	19	9	Cederberg et al. 2012	Land use change included
	Misc.	10	65	25	Phetteplace et al. 2001	Dairy; no land use change
		29	46	25	Rivas et al. 2015	Dairy; no land use change

		15	65	21	Samson et al. 2012	Dairy; no land use change
		22	58	22	Sandrucci et al. 2014	Dairy; no land use change
		20	62	17	Boakye et al. 2014	Dairy; no land use change
		15	64	21	Saunders and Barber 2007	Dairy; no land use change
		51	36	13	Muhammad Taufiq et al. 2016	Dairy (modern and local practices); land use change included
		64	24	12	Nilsson et al. 2010	Dairy; land use change included
		36	44	20	Zhu et al. 2015	Average of cow and sheep/goat milk; land use change included
	AVERAGE	22	59	19		
Eggs *(4.5)*	Eggs	57	3	40	Dekker et al. 2011	No land use change
		39	5	56	Cederberg et al. 2012	Land use change included
		56	5	39	Zhu et al. 2015	Land use change included
		43	6	51	Williams et al. 2006	Land use change included
		21	4	75	Dekker et al. 2008	Land use change included
		34	16	50	Verge et al. 2009	Land use change included
	AVERAGE	41	7	52		
Oils *(4.5)*	Castor	72	0	28	Pratibha et al. 2015	No land use change
	Linseed	69	3	28	Nemecek et al. 2011	Land use change included
	Olive oil	89	3	8	Rinaldi et al. 2014	No land use change
	Palm oil	95	0	5	Castanheira et al. 2014	Land use change included
		86	1	13	Nemecek et al. 2011	Land use change included
		17	67	16	Stichnothe and Schuchardt 2011	No land use change
		27	48	25	Schmidt 2007	No land use change
	Peanut oil	78	3	20	Nemecek et al. 2011	Land use change included
	Rapeseed	65	3	32	Nemecek et al. 2011	Land use change included
	AVERAGE	61	13	26		
Beverages *(5.7)*	Wine	100	0	0	Fusi et al. 2014	No land use change
		75	13	12	Neto et al. 2013	No land use change
		58	0	42	Vazquez Rowe et al. 2012	No land use change
		85	0	15	Vazquez Rowe et al. 2014	No land use change
	Coffee	76	0	24	Noponen et al. 2012	Land use change included in some portions
		30	0	70	Segura and Andrade 2012	Land use change inclusion cannot be identified
		55	0	45	Oelbermann 2014	Land use change included in some portions
	Beer	95	0	5	Shin and Searcy 2018	No land use change
	AVERAGE	72	2	26		
Other (*6.5*)	Sugar	31	47	22	Mashoko et al. 2010	No land use change
		81	2	17	Nemecek et al. 2011	Sugar cane; land use change included
		67	0	33	Ramjeawon 2004	Sugar cane; no land use change
	AVERAGE	60	16	24		

Table S1: List of percent contribution toward total CO_2e100 from CO_2, methane, and nitrous oxide for individual food items based on previous studies. The notes column indicates specific types of food analyzed and whether land use change is included in the analysis. Values presented here reflect an average of individual estimations (354 in total) provided by each source, and precede an adjustment to account for land use change. The average for each gas species is highlighted in grey. Values have also been adjusted to reflect the most up-to-date estimations of GWP for CO_2, CH_4, and N_2O (1, 34, and 298, respectively).

*The total emissions in kg CO_2e100/kg food group consumed calculated based on data from Poore and Nemecek 2018 are provided in italics below each food group name. We note that they use GWP100 values from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) (2007).

Scenario		Population Projection				
		SSP1, Sustainability	**SSP2,** Middle of the Road	**SSP3,** Regional Rivalry	**SSP4,** Inequality	**SSP5,** Fossil-Fueled Development
Baseline Contribution to Warming from Food Consumption	**Total Warming (°C in 2100)**	0.67	0.77	0.91	0.77	0.69
Production Improvement Scenario Avoided Warming	**Warming Reduction (°C in 2100)**	0.15	0.18	0.21	0.18	0.16
	Percent Reduction (% in 2100)	23	23	23	23	23
Healthy Diet Scenario Avoided Warming	**Warming Reduction (°C in 2100)**	0.14	0.16	0.19	0.16	0.15
	Percent Reduction (% in 2100)	21	21	21	21	21
50% Retail-Level Food Waste Reduction	**Warming Reduction (°C in 2100)**	0.02	0.02	0.02	0.02	0.02
	Percent Reduction (% in 2100)	3	2	3	2	3
50% Consumer-Level Food Waste Reduction	**Warming Reduction (°C in 2100)**	0.03	0.04	0.04	0.04	0.03
	Percent Reduction (% in 2100)	5	5	5	5	5
All Mitigation Scenarios	**Warming Reduction (°C in 2100)**	0.29	0.33	0.40	0.34	0.30
	Percent Reduction (% in 2100)	44	44	44	44	44

Table S2: Table outlining the net reduction and percent reduction of the total contribution to future warming associated with each mitigation scenario for the set of five population projections.