

GREEN HAM AND EGGS: WHAT'S THE POLICY RECIPE FOR FEEDING A GROWING POPULATION ON A WARMING PLANET?

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“Those who dream of feasting wake to lamentation.”
—Chuang Tse: II¹

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I. INTRODUCTION

In 2013, after much experimentation and substantial investment,² the Dutch scientist Mark Post unveiled the first lab grown burger.³ That same year, the Chinese mega-meat company, Shuanghui (now the WH Group), bought Smithfield, the United States’ largest pork producer.⁴ Far from coincidence, these developments represent two disparate responses to a looming issue

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1. See URSULA K. LEGUIN, *THE LATHE OF HEAVEN* 126 (Scribner ed., Simon & Schuster 2008) (1971).

2. *World’s First Lab-Grown Burger is Eaten in London*, BBC NEWS: SCIENCE & ENVIRONMENT (Aug. 5, 2013), <https://www.bbc.com/news/science-environment-23576143>. Sergy Brin, co-founder of Google, was an underwriter of the research. *Id.*

3. *Id.*

4. *Smithfield Foods Goes Online to Sell U.S. Pork in China*, REUTERS: BUSINESS NEWS (Oct. 24, 2017), <https://www.reuters.com/article/us-china-smithfield-pork/smithfield-foods-goes-online-to-sell-u-s-pork-in-china-idUSKBN1CU07B>.

of great consequence: how to address the growing global demand for meat protein. In fact, feeding a burgeoning global population—9.8 billion by 2050⁵—with growing meat demands on a warming planet is a pressing matter of geopolitical import.

This article provides a brief overview of the sustainability and food security⁶ challenges posed by escalating meat demand and explores current strategies for addressing this issue. The essay concludes with thoughts on the role of law and policy in facilitating these strategies. In the final analysis, given the nature of such a complex social problem, there is no magic bullet solution. Rather, use of different strategies tailored to specific conditions, are necessary to tackle the challenge of mounting demands for protein worldwide.

II. THE FOOD SECURITY CHALLENGE

The U.S. Department of Defense (DoD), pre-Trump Administration, connected the dots between water scarcity, food security, and societal destabilization, reporting as follows:

DoD recognizes the reality of climate change and the significant risk it poses to U.S. interests globally. The National Security Strategy, issued in February 2015, is clear that climate change is an urgent and growing threat to our national security, contributing to increased natural disasters, refugee flows, and conflicts over basic resources such as food and water. These impacts are already occurring, and the scope, scale, and intensity of these impacts are projected to increase over time.⁷

Feeding an exploding population on a planet damaged by climate change is a dilemma rife with social justice implications and

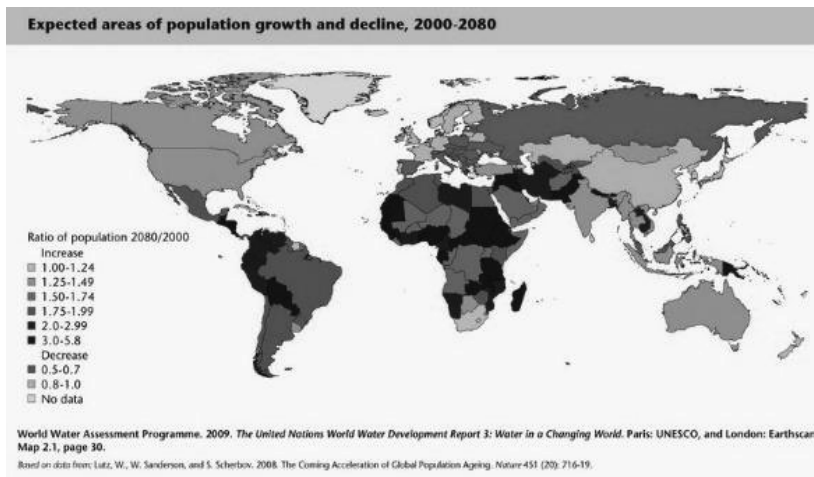
5. *World Population Projected to Reach 9.8 Billion in 2050, and 11.2 Billion in 2100*, U.N. DEPT OF ECON. & SOC. AFFAIRS (June 21, 2017) [hereinafter U.N., *World Population*], <https://www.un.org/development/desa/en/news/population/world-population-prospects-2017.html>.

6. Food security exists “when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.” U.N., FOOD & AGRIC. ORG., AN INTRODUCTION TO THE BASIC CONCEPTS OF FOOD SECURITY 1 (2008), <http://www.fao.org/docrep/013/a1936e/al936e00.pdf>.

7. U.S. DEP’T OF DEF., 8-6475571, NATIONAL SECURITY IMPLICATIONS OF CLIMATE-RELATED RISKS AND A CHANGING CLIMATE 3 (2015), <https://archive.defense.gov/pubs/150724-congressional-report-on-national-implications-of-climate-change.pdf?source=govdelivery> (citation omitted).

geopolitical consequences.⁸ Indeed, the Food and Agriculture Organization of the United Nations (FAO) in its 2016 Report, *The State of Food and Agriculture: Climate Change, Agriculture and Food Security*, cautioned that “[u]nless action is taken now to make agriculture more sustainable, productive and resilient, climate change impacts will seriously compromise food production in countries and regions that are already highly food-insecure.”⁹

Based on FAO estimates, food production will need to increase sixty percent over 2006 levels by 2050, driven by population and income growth,¹⁰ with the greatest population growth occurring generally in the Global South, such as Sub-Saharan Africa and swaths of Southeast Asia.¹¹ Critically, the highest crop yield declines due to climate change are likewise in the Global South.¹² The two maps below show this overlap. The Global South is similarly anticipated to experience the greatest decline in fish stocks due to warming waters and other climate change impacts.¹³ By contrast, the least populated regions on Earth will likely have the most gains in crop yield.¹⁴ In sum, this marked imbalance signals an oncoming global food security train wreck.



8. See U.N., FOOD AND AGRIC. ORG., *THE STATE OF FOOD AND AGRICULTURE: CLIMATE CHANGE, AGRICULTURE AND FOOD SECURITY* at xi (2016), <http://www.fao.org/3/a-i6030e.pdf>.

9. *Id.* at v.

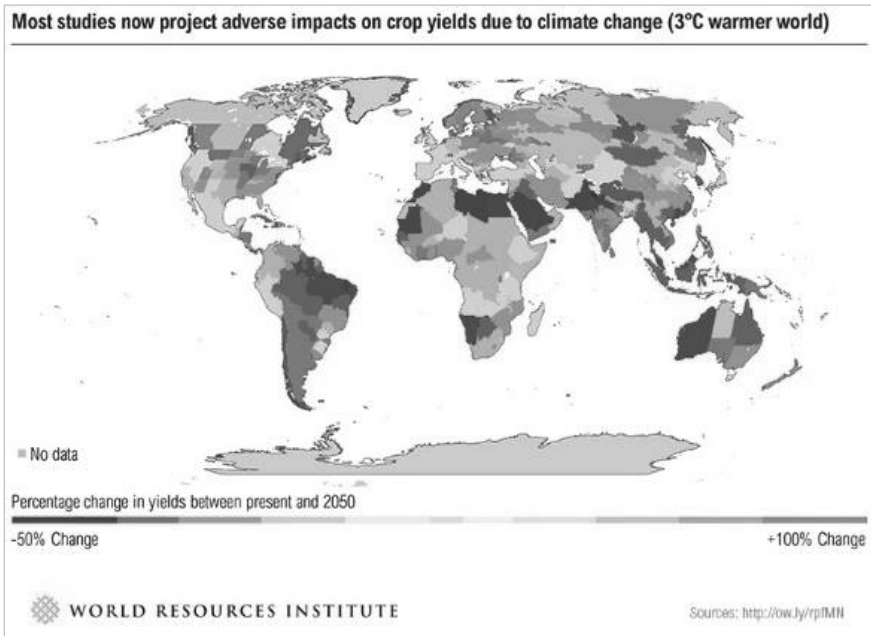
10. *Id.* at 4.

11. See U.N., *World Population*, *supra* note 5.

12. U.N., FOOD & AGRIC. ORG., *THE STATE OF FOOD AGRICULTURAL COMMODITY MARKETS* 19, 21–22 (2018), <http://www.fao.org/3/I9542EN/i9542en.pdf>.

13. See generally William W. L. Cheung et al., *Projected Changes in Global and National Potential Marine Fisheries Catch Under Climate Change Scenarios in the Twenty-First Century*, in *IMPACTS OF CLIMATE CHANGE ON FISHERIES AND AQUACULTURE* 63–85 (Manuel Barange et al., eds., 2018), <http://www.fao.org/3/I9705EN/i9705en.pdf>.

14. See *5 Ways Climate Change Will Affect You: Crop Changes*, NAT'L GEOGRAPHIC, <https://www.nationalgeographic.com/climate-change/how-to-live-with-it/crops.html> (last visited Feb. 17, 2019).



Complicating the food security puzzle is a high correlation between wealth and meat consumption. Although high-income countries currently consume the most animal protein,¹⁵ the growth in meat demand will come from developing countries, as the purchase of Smithfield by China portends.¹⁶ In this regard, the World Health Organization of the United Nations (WHO) has reported:

There has been an increasing pressure on the livestock sector to meet the growing demand for high-value animal protein. The world's livestock sector is growing at an unprecedented rate and the driving force behind this enormous surge is a combination of population growth, rising incomes and

15. See, e.g., Richard Waite, *2018 Will See High Meat Consumption in the U.S., but the American Diet is Shifting*, WORLD RES. INST. (Jan. 24, 2018), <https://www.wri.org/blog/2018/01/2018-will-see-high-meat-consumption-us-american-diet-shifting>.

¹⁶ See *supra* note 4 and accompanying text.

urbanization. Annual meat production is projected to increase from 218 million tonnes in 1997-1999 to 376 million tonnes by 2030.¹⁷

Further, the increasing consumption of meat, milk and eggs comes at the expense of staple foods.¹⁸

Currently, the FAO predicts global meat production will double by 2050, largely in developing countries.¹⁹ However, even if it were technically possible to meet the projected demand for high quality protein with animal meat, the consequences, as discussed below, would be environmentally disastrous.

III. "LIVESTOCK'S LONG SHADOW"²⁰

The global environmental footprint of livestock production is enormous. For example, livestock production uses upwards of eighty percent of agricultural land through grazing and crops for feed,²¹ but "produces less than [twenty percent] of the world's supply of calories."²² Despite the trend toward consolidation and intensification, livestock grazing remains the largest use of land at twenty-six percent of the Earth's surface, with over-grazing being a key cause of land degradation.²³ Further, land conversion to expand livestock operations drives deforestation, especially in the rainforests of Latin America,²⁴ while the crops grown to feed livestock result in serious biodiversity losses.²⁵

The agriculture sector is also a major source of greenhouse gas (GHG) emissions, contributing nineteen to twenty-nine percent of

17. *Global and Reg'l Food Consumption and Trends: Availability and Changes in Consumption of Animal Products*, U.N., WORLD HEALTH ORG., https://www.who.int/nutrition/topics/3_foodconsumption/en/index4.html (last visited Feb. 25, 2019).

18. *Id.*

19. *Meat & Meat Products*, U.N., FOOD & AGRIC. ORG (Apr. 26, 2016), <http://www.fao.org/ag/againfo/themes/en/meat/home.html>.

20. See LIVESTOCK, ENV'T & DEV. (LEAD) INITIATIVE, *LIVESTOCK'S LONG SHADOW: ENVIRONMENTAL ISSUES AND OPTIONS* (2006) [hereinafter *LIVESTOCK'S LONG SHADOW*], <http://www.fao.org/docrep/010/a0701e/a0701e.pdf>.

21. Isabelle Weindl et al., *Livestock and Human Use of Land: Productivity Trends and Dietary Choices as Drivers of Future Land & Carbon Dynamics*, 159 *GLOBAL & PLANETARY CHANGE* 1, 1 (2017), <https://www.sciencedirect.com/science/article/pii/S0921818117301480>.

22. Hannah Ritchie, *How Much of the World's Lands Would We Need in Order to Feed the Global Population with the Average Diet of a Given Country?*, *OUR WORLD IN DATA* (Oct. 3, 2017), <https://ourworldindata.org/agricultural-land-by-global-diets>.

23. *LIVESTOCK'S LONG SHADOW*, *supra* note 20, at xxi.

24. *Id.*

25. See generally WORLD WILDLIFE FUND, *APPETITE FOR DESTRUCTION* (2017), https://www.wwf.org.uk/sites/default/files/2017-11/WWF_AppetiteForDestruction_Full_Report_Web_0.pdf.

total emissions.²⁶ Livestock production alone is responsible for 14.5% of global GHG emissions,²⁷ the majority of which are in the form of methane produced by livestock digestion and manure decomposition.²⁸ Methane is a particularly noxious GHG because it warms the atmosphere about eighty-six times more potently than carbon dioxide.²⁹ Significantly, the World Resources Institute (WRI) estimates that agriculture emissions will grow fifteen percent above 2010 levels by 2030, mainly due to increased demand as populations expand and dietary preferences change in developing countries.³⁰ Although agriculture plays a weighty role in the Earth's declining environment, the sector has only recently been included in substantive international climate talks.³¹

IV. STRATEGIES

Cellular agriculture, of which Mark Post's lab-grown burger is representative,³² has newly captured the imaginations of investors and inventors alike as the answer to the meat protein conundrum. Yet, the increasing meat demand has been met with several strategies bearing varying degrees of efficacy and attendant ramifications. These strategies may be indicated as the needs of a community or country require, arguably falling into six general categories: production method, efficiency, reduction, substitution, disruption, and family planning.

A. Production method

America's dominant method of meat production, concentrated animal feeding operations (CAFOs), is characterized by the production of thousands or millions of animals (in the case of

26. *Direct Agricultural Food Emissions*, CGIAR RESEARCH PROGRAM ON CLIMATE CHANGE, AGRIC. AND FOOD SEC., <https://ccafs.cgiar.org/bigfacts/#theme=food-emissions&subtheme=direct-agriculture> (last visited Feb. 25, 2019).

27. Pierre J. Gerber et al., *Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities*, U.N., FOOD & AGRIC. ORG., at xii (2013), <http://www.fao.org/docrep/018/i3437e/i3437e.pdf>.

28. See Stephen Russell, *Everything You Need To Know About Agricultural Emissions*, WORLD RES. INST. (May 29, 2014), <https://www.wri.org/blog/2014/05/everything-you-need-know-about-agricultural-emissions>.

29. Gayathri Vaidyanathan, *How Bad of a Greenhouse Gas is Methane?*, SCI. AM. (Dec. 22, 2015), <https://www.scientificamerican.com/article/how-bad-of-a-greenhouse-gas-is-methane/>.

30. Russell, *supra* note 28.

31. Georgina Gustin, *2017: Agriculture Begins to Tackle Its Role in Climate Change*, INSIDE CLIMATE NEWS (Jan. 4, 2017), <https://insideclimatenews.org/news/03012017/agriculture-climate-change-paris-agreement-global-warming-drought>.

32. See *World's First Lab-Grown Burger*, *supra* note 2.

poultry) in large facilities with minimal labor inputs in a highly controlled, industrialized process.³³ This production system is “efficient” in the sense of concentrated land use and uniformity of production with resultant economies of scale benefits.³⁴ However, industrial meat production externalizes its full costs, such as harms to both the environment and human health, including water and air pollution, antibiotics resistance from overuse, and the inhumane treatment of animals.³⁵ In the United States, lack of transparency in the food system and regulatory gaps hinder progress on addressing these harms.³⁶ Nevertheless, with rising meat demand, the global trend is toward the vertically integrated intensification of livestock production.³⁷

At the same time, about 600 million of the world’s poor, primarily in sub-Saharan Africa and South Asia, depend on small scale livestock farming for food and livelihoods.³⁸ Meat protein is both an important source of total calories globally and is “crucial in combatting micronutrient deficiencies (hidden hunger) in women and children.”³⁹ The FAO has recognized the importance of livestock production for millions of poor farmers to help drive the United Nation’s Sustainable Development Goals (SDGs) to end poverty (SDG1) and achieve zero hunger (SDG2).⁴⁰ However, these small mixed crop farmers and pastoralists tend to have low livestock

33. U.S. ENVTL. PROT. AGENCY, REGULATORY DEFINITIONS OF LARGE CAFOS, MEDIUM CAFO, AND SMALL CAFOS, https://www3.epa.gov/npdes/pubs/sector_table.pdf (last visited Feb. 13, 2019).

34. JAMES M. MACDONALD & WILLIAM D. MCBRIDE, U.S. DEPT. OF AGRIC., THE TRANSFORMATION OF U.S. LIVESTOCK AGRICULTURE SCALE, EFFICIENCY, AND RISKS iii (2009), https://www.ers.usda.gov/webdocs/publications/44292/10992_eib43.pdf?v=0.

35. See PEW COMM’N ON INDUS. FARM ANIMAL PROD., PUTTING MEAT ON THE TABLE: INDUSTRIAL FARM ANIMAL PRODUCTION IN AMERICA 3 (2008), https://www.pewtrusts.org/~media/assets/2008/pcfifap_exec-summary.pdf. Regarding antibiotic resistance, in particular, see Michael J. Martin et al., *Antibiotics Overuse in Animal Agriculture: A Call to Action for Health Care Providers*, 105 AM. J. PUB. HEALTH 2409, 2409 (2015), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4638249/>.

36. See Georgia Gustin, *Factory Farms Get Bigger, Pollution Grows, but Regulators Don’t Even Know Where They Are*, INSIDE CLIMATE NEWS (Oct. 21, 2016), <https://insideclimatenews.org/news/19102016/cafo-epa-regulations-factory-farms-get-bigger-pollution-grows-environmental-impact-methane>; David N. Cassuto, *The CAFO Hothouse: Climate Change, Industrial Agriculture and the Law*, ANIMALS & SOC’Y INST. 1, 1(2010), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1646484.

37. U.N., FOOD & AGRIC. ORG., WORLD AGRICULTURE: TOWARDS 2015/2030 – AN FAO PERSPECTIVE 160 (2008), <http://www.fao.org/docrep/005/y4252e/y4252e07.htm>.

38. SWEDISH FAO COMM., SUSTAINABLE GLOBAL LIVESTOCK DEVELOPMENT FOR FOOD SECURITY AND NUTRITION INCLUDING ROLES FOR SWEDEN 10 (2016), https://www.slu.se/globalassets/ew/org/andra-enh/uadm/global/pdf/rapport_fao_livestock-tillg_webbsan.pdf.

39. *Id.* at 9.

40. *Id.*

productivity.⁴¹ Consequently, needed improvements to livelihoods and environmental sustainability can be made through targeted policy and technology interventions related to animal health, feed, and genetics.⁴² Sustainable intensification, producing more crops and livestock with the same resource inputs, is a key strategy being used in developing countries to help meet the SDG goals.⁴³

Domestically, how livestock should be raised—whether on a small farm or in a CAFO—is one of the most hotly debated issues between environmentalists and the agriculture industry. Industry touts the production efficiency and food safety benefits of industrial agriculture as a model to feed the world.⁴⁴ In contrast, environmentalists, “good food” groups, and social justice advocates have decried the multiplicity of harms associated with CAFOs.⁴⁵ Diversified, smaller farms are often held up as a model for sustainability when externalities are accounted for and local economies considered.⁴⁶ The debate encapsulates fiercely held beliefs about multiple aspects of our food system, including social justice, animal welfare, and environmental sustainability, as well as production efficiency and consumer cost.

This controversy obscures a fundamental reality: neither approach can produce enough meat protein to meet future demand sustainably, given associated resource use⁴⁷ and resulting GHG emissions.⁴⁸ For example, WRI predicts that with increased demand for meat and dairy, agriculture alone could consume the emissions budget required to keep global warming below the international

41. See *id.* at 33 (discussing lack of tenure, poor access to land and water, substandard access to markets, and vulnerability to pests and climatic events as obstacles to increasing productivity in small-holder mixed farming systems).

42. *Id.* at 9.

43. *Policy Support and Governance: Sustainable Intensification of Agriculture*, U.N., FOOD & AGRIC. ORG. (2019), <http://www.fao.org/policy-support/policy-themes/sustainable-intensification-agriculture/en/>.

44. See Jayson Lusk, *Why Industrial Farms Are Good for the Environment*, N.Y. TIMES (Sept. 23, 2016), <https://www.nytimes.com/2016/09/25/opinion/sunday/why-industrial-farms-are-good-for-the-environment.html>.

45. See *Why Are CAFO's Bad?*, SIERRA CLUB: MICHIGAN CHAPTER (2019), <https://www.sierraclub.org/michigan/why-are-cafos-bad>.

46. See Kelsey Nowakowski, *Why We Need Small Farms*, NAT'L GEOGRAPHIC (Oct. 12, 2018), <https://www.nationalgeographic.com/environment/future-of-food/photos-farms-agriculture-national-farmers-day/>; see also generally Regenerative Organic Certification (2018), <https://regenorganic.org/>.

47. LIVESTOCK'S LONG SHADOW, *supra* note 20, at xxi. As previously mentioned, livestock production is the largest user of land and is a significant cause of deforestation. *Id.*

48. See, e.g., Richard Waite & Daniel Vennard, *Without Changing Diets, Agriculture Alone Could Produce Enough Emissions to Surpass 1.5°C of Global Warming*, WORLD RES. INST. (Oct. 17, 2018), <https://www.wri.org/blog/2018/10/we-cant-limit-global-warming-15c-without-changing-diets>; see also Fredrik Hedenus et al., *The Importance of Reduced Meat and Dairy Consumption for Meeting Stringent Climate Change Targets*, 124 CLIMATIC CHANGE 79, 80 (2014), <https://link.springer.com/article/10.1007%2Fs10584-014-1104-5>.

two-degree Celsius goal,⁴⁹ a target that the International Panel on Climate Change recently predicted is inadequate to avert serious damage from climate change.⁵⁰

The aforementioned takeover of Smithfield by Shuanghui/WH Group⁵¹ illustrates both how meat production is being consolidated globally and how industrialization is being used as strategy, albeit short-range, to meet swelling consumer demand. Of significance, the United States Treasury Department reviewed the deal for potential national security implications, likely the first time the foreign purchase of a U.S. food company triggered such review.⁵² In fact, China facilitated Shuanghui's acquisition of Smithfield through its government-controlled bank, consistent with its strategy to purchase foreign agricultural assets to feed its large population.⁵³ China's policies also support the rapid intensification and consolidation of its agriculture sector in its country, mirroring the evolution of the American agricultural sector: fewer farmers with larger landholdings, mechanized production, and increased profits.⁵⁴

Globally, seventy-five percent of livestock production growth is predicted to be through confined operations, largely in developing countries.⁵⁵ Long-range, however, any production efficiencies gained by such economies of scale are ultimately bound by the hard ceiling of our environmental limits, both in terms of finite resource inputs and the imperative to drive down GHG emissions.⁵⁶ Accounting for the negative environmental impacts of confined animal production systems, such as water pollution, has the potential to improve their overall sustainability and moderate demand. In the United States,

49. Waite & Vennard, *supra* note 48.

50. See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, GLOBAL WARMING OF 1.5°C (Valerie Masson-Delmotte et al. eds., 2018), https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf.

51. See *supra* note 4.

52. Helena Bottemiller, *Government Extends Review of Smithfield-Shuangui Deal*, FOOD SAFETY NEWS (July 25, 2013), <https://www.foodsafetynews.com/2013/07/government-extends-review-of-smithfield-shuangui-deal/>; Simon Montlake, *U.S. Senate Hearing on Smithfield Foods Poses Challenge to CFIUS*, FORBES (July 9, 2013, 11:49 PM), <https://www.forbes.com/sites/simonmontlake/2013/07/09/u-s-senate-hearing-on-smithfield-foods-poses-challenge-to-cifus/#476cc1676c6b>.

53. Nathan Halverson, *How China purchased a prime cut of America's pork industry* REVEAL NEWS (Jan. 24, 2015), <https://www.revealnews.org/article/how-china-purchased-a-prime-cut-of-americas-pork-industry/>.

54. Michael Schuman, *China's Small Farms Are Fading. The World May Benefit.*, N.Y. TIMES (Oct. 6, 2018), <https://www.nytimes.com/2018/10/05/business/china-small-farms-urbanization.html>

55. Philip K. Thornton, *Livestock Production: Recent Trends, Future Prospects*, 365 PHIL. TRANSACTIONS ROYAL SOC'Y B 2853, 2856 (2010), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2935116/>.

56. See *supra* notes 47–50 and accompanying text.

for example, consumer demand for sustainably produced meat, corporate supply chain sustainability programs, and third party certification schemes have become levers to help improve environmental outcomes and animal welfare where the government has failed to regulate.⁵⁷ Setting aside concerns regarding global livestock expansion, there remains an ongoing sustainable development imperative to support improved livestock farming sustainability for small farmers and pastoralists as an important food security strategy.

B. Efficiency

A key industry metric of livestock production is yield: the amount of feed required to produce a pound of meat, also known as the feed conversion ratio or feed conversion efficiency.⁵⁸ Poultry has the most efficient feed conversion ratio followed by pigs and then last, cattle.⁵⁹ Depending on the data source, beef cattle require anywhere from six to twelve pounds of feed for every pound of live weight.⁶⁰ In the United States, livestock and poultry yields have been increased through targeted nutrition, genetic selection, and the use of antibiotics and growth hormones. For instance, from the 1950s to 2005, broiler chicken growth increased a stunning 400%, chiefly due to genetic selection which increased meat yield from the breast muscle.⁶¹ These genetic changes in broiler characteristics have also had negative impacts on the birds' health and have raised animal welfare concerns.⁶²

Not as striking, the feed to conversion ratio has also improved for hogs. Smithfield claims a feed conversion ratio of 2.5 pounds of feed to grow a pound of meat, a yield increase from a four to one

57. See NIELSEN, SUSTAINABLE SHOPPERS BUY THE CHANGE THEY WISH TO SEE IN THE WORLD (2018), <https://www.nielsen.com/us/en/insights/reports/2018/the-education-of-the-sustainable-mindset.html>.

58. *Feed:Meat Ratios*, A WELL-FED WORLD, <https://awfw.org/feed-ratios/> (last updated Oct. 26, 2015).

59. *Id.* Notably, recent research indicates that aquaculture, which is becoming an increasingly important source of protein globally, has a similar feed conversion ratio to poultry. Jillian P. Fry et al., *Feed Conversions Efficiency in Aquaculture: Do we Measure it Correctly?*, ENVTL. RES. LETTERS (2018).

60. *Id.*

61. Martin J. Zuidhof et al., *Growth, Efficiency, and Yield of Commercial Broilers from 1957, 1978, and 2005*, 93 POULTRY SCI. 2970, 2980–81 (2014), <https://academic.oup.com/ps/article/93/12/2970/2730506>.

62. Massimiliano Petracci & Claudio Cavani, *Muscle Growth and Poultry Meat Quality Issues*, 4 NUTRIENTS 1, 2 (2012), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3277097/>.

ratio within the past couple of decades.⁶³ Over the same time period, cattle yield efficiency has stayed relatively flat, likely because ruminants are not as efficient as monogastric animals, and cattle have not been selected for feed efficiency.⁶⁴

Even if one puts aside the animal welfare and biodiversity⁶⁵ concerns related to genetic selection or modification of livestock and poultry, gains through yield improvements likely have biological limits. In this regard, there is some scientific evidence that the limits of production efficiency gains through genetic selection for broiler chickens have mostly been reached.⁶⁶

As previously discussed, in low incomes countries many people rely on livestock for the multiple amenities they provide, including food security.⁶⁷ Importantly, interventions related to nutrition, animal health, and genetics have the potential to close yield gaps and improve sustainability in developing countries.⁶⁸ A report funded by the Bill and Melinda Gates Foundation found that livestock yield data is needed in developing countries to identify and close yield gaps, explaining that:

Estimates of livestock yield gaps are not available and these are necessary for developing feasible scenarios of how the production of different livestock commodities might evolve in the future, how systems might change and what would be the resource use implications and their costs, both for donors and for public and private entities in target countries.⁶⁹

63. SMITHFIELD FOODS, 2017 SUSTAINABILITY REPORT 74 (2019), <https://www.smithfieldfoods.com/custom-report/pdf/smithfield-2017sustainabilityreport-02-02-2019-111927.pdf>.

64. See Dan W. Shike, *Beef Cattle Feed Efficiency*, DRIFTLESS REGION BEEF CONF. 3, 3 (2013), <https://web.archive.org/web/20190102133416/https://lib.dr.iastate.edu/cgi/viewcontent.cgi?referer=https://en.wikipedia.org/&httpsredir=1&article=1027&context=driftlessconference>.

65. Jan Overney, *Dwindling Genetic Diversity of Farm Animals Is a Threat to Livestock Production*, PHYS.ORG (Oct. 16, 2015), <https://phys.org/news/2015-10-dwindling-genetic-diversity-farm-animals.html> (reporting on the loss of genetic diversity in farm animals).

66. Craig W. Tallentire et al., *Artificial Selection for Improved Energy Efficiency is Reaching its Limits in Broiler Chickens*, NATURE: SCIENTIFIC REPORTS 1 (Jan. 18, 2018), <https://www.nature.com/articles/s41598-018-19231-2>.

67. Jan Philipsson et al., *Use of Livestock Resources for Food Security in the Light of Climate Change*, SWEDISH INT'L AGRIC. NETWORK INITIATIVE 1–2 (Apr. 2017), https://www.slu.se/globalassets/ew/org/andra-enh/uadm/global/rapporter/livestock_resources_for_food_security_in_light_of_climate_change_layout_final_cmyk.pdf.

68. See, e.g., Mario Herrero et al., *Understanding Livestock Yield Gaps for Poverty Alleviation, Food Security and the Environment*, THE LIVEGAPS PROJECT 2–3 (2016) (a study on closing yield gaps in India and Ethiopia), <https://research.csiro.au/livegaps/wp-content/uploads/sites/37/2015/08/Herrero-et-al.-2016.-Understanding-livestock-yield-gaps-for-poverty-alleviation-food-security-and-the-environment.pdf>.

69. *Id.* at 2; For additional analysis on the report, see also Susan MacMillan, *How closing livestock yield gaps can enhance incomes, food security and the environment in*

The report went on to conclude that this information is required in order to design appropriate technology interventions and, relatedly, inform investment decisions to help improve livestock yield.⁷⁰ Indeed, improving production efficiencies is highly site-specific given on-the-ground circumstances such as availability of quality feed, water, and land, which are highly variable and subject to competing demands.⁷¹ Climate change, moreover, will generally exacerbate current resource limitations, especially the availability of water and feedstocks in developing countries, as well as give rise to new pathogens impacting farmed animal health.⁷² For example, breeding programs for long term climate hardiness to improve overall productivity⁷³—as opposed to solely focusing on maximizing yield—have been identified as a key strategy in places like Sub-Saharan Africa.⁷⁴

C. Reduction

Reduction as a strategy to address the problem of surging global meat demand has two main sub-strategies, with some overlap, particularly for middle to high-income countries: 1) reduction of food waste; and 2) reduction in consumption. Globally, the FAO estimates that each year a whopping one-third, or 1.3 billion tonnes, of all food for human consumption is wasted or lost.⁷⁵ The amount of food wasted in a year could feed nearly two billion people.⁷⁶ Not surprisingly, wealthy countries are the largest source of food loss, with North America and Oceania, followed closely by Europe, wasting the most.⁷⁷ Over the last several years, attending to food

Ethiopia and India, INT'L LIVESTOCK RESEARCH NEWS (Jun. 6, 2018), <https://news.ilri.org/2018/06/06/how-closing-livestock-yield-gaps-can-enhance-incomes-food-security-and-the-environment-in-ethiopia-and-india/>.

70. Herrero et al., *supra* note 68, at 4–5.

71. Thornton, *supra* note 55, at 2861.

72. *See id.* at 2861–64.

73. *2016 Global Agricultural Productivity Report: Sustainability in an Uncertain Season*, GLOBAL HARVEST INITIATIVE 24, 33 (2016), <https://www.globalharvestinitiative.org/gap-report-gap-index/2016-gap-report/>.

74. Philipsson et al., *supra* note 67, at 1–4.

75. *Food Loss and Food Waste*, U.N., FOOD & AGRIC. ORG. (2019), <http://www.fao.org/food-loss-and-food-waste/en/>.

76. Zach Conrad et al., *Relationship Between Food Waste, Diet Quality, and Environmental Sustainability*, 13 PLOS ONE 1, 2 (2018) (citing Matti Kummu et al., *Lost Food, Wasted Resources: Global Food Supply Chain Losses and Their Impacts on Freshwater, Cropland, and Fertiliser Use*, 438 SCI. TOTAL ENV'T 477, 477–89 (2012), <https://www.sciencedirect.com/science/article/pii/S0048969712011862?via%3Dihub>).

77. Jenny Gustavsson et al., *Global Food Losses and Food Waste*, U.N., FOOD AND AGRIC. ORG 1, 5 (2011), <http://www.fao.org/docrep/014/mb060e/mb060e00.pdf>.

waste has gained traction as a low hanging fruit strategy that reduces environmental impacts, including agriculture's significant carbon footprint, while feeding the hungry.⁷⁸

In middle to high-income countries, most food is wasted at the point of production and consumption,⁷⁹ while in low-income countries, food loss tends to occur along the supply chain due to limitations in refrigeration facilities, marketing, and handling.⁸⁰ Thus, the interventions used to reduce food waste and loss vary between different economies and the source of loss.⁸¹ The Environmental Protection Agency's "Food Recovery Hierarchy" (Hierarchy) summarizes the intervention points in the supply chain to reduce food waste in North America.⁸² In order of optimality, the Hierarchy places at the top the source reduction strategy to reduce waste, that is, reducing the amount of food produced in the first place, followed by diverting food waste to feed hungry people, then feeding animals, with diversion to industrial uses and composting as the last two strategies.⁸³

Notably, the type of food that is lost complicates the ability to confront food waste. Somewhat counterintuitively, Americans who have the healthiest diets, those rich in fruits and vegetables, generate the most waste.⁸⁴ The FAO estimates that fifty two percent of fresh fruits and vegetables are wasted in North America, compared to meat and milk loss of twenty-two percent and twenty percent, respectively.⁸⁵ Because fruit and vegetable production is generally input-intensive, but uses less land than commodities or livestock, the environmental impacts from this category of food waste take the form of excess pesticide use and water wastage.⁸⁶ As discussed further below, switching to a plant-based diet and away from the "western" diet of heavily processed foods and meat is a strategy with the potential for multiple benefits, including reducing

78. See, e.g., *27 Solutions to Food Waste*, REFED (2019), <https://www.refed.com/?sort=economic-value-per-ton>; Yerina Mugica et al., *San Francisco Composting: From Fork to Farm and Back*, NAT. RES. DEF. COUNCIL 1–2 (Nov. 2017), <https://www.nrdc.org/sites/default/files/food-matters-san-francisco-composting-cs.pdf>.

79. Gustavsson et al., *supra* note 77, at v.

80. *Id.*

81. See *id.* at 10–14.

82. See *Sustainable Management of Food: Food Recovery Hierarchy*, U.S. ENVTL. PROT. AGENCY, <https://www.epa.gov/sustainable-management-food/food-recovery-hierarchy> (last visited Feb. 28, 2019).

83. See *id.*

84. Conrad et al., *supra* note 76, at 1.

85. Dana Gunders, *Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill*, NRDC ISSUE PAPER 1, 5 (2012), <https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf>.

86. Conrad et al., *supra* note 76, at 1.

food's environmental footprint.⁸⁷ But, the potential climate benefits cannot fully be realized when a high percentage of these plant-based foods are wasted.

Reducing food waste entails a cost-effective and practical set of strategies but alone, reduction cannot meet expanding global calorie needs.⁸⁸ According to WRI, reducing food waste could provide around twenty percent of the sixty percent calorie increase needed to feed the world population by 2050, leaving a significant delta of unmet calorie demand.⁸⁹

The second reduction strategy, eating less meat and/or reducing the calories consumed overall, involves behavior changes that are ripe for high-income countries because of the access to high-quality protein alternatives and the health co-benefits.⁹⁰ In the United States, calorie intake has risen twenty-three percent from 1970 to 2010, exceeding the total calories needed for a healthy adult.⁹¹ Concurrently, obesity has achieved epidemic proportions with forty percent of adults and 18.5% of children in the country now meeting the definition of obese.⁹² As we try to solve the global meat puzzle, it is important to note that this increase in calories has come from processed grains, sugars, and oils—not necessarily meat.⁹³ In general, Americans are consuming less milk, eggs, and beef, but more cheese and poultry.⁹⁴ Consumption of fresh fruits and vegetables have also declined, below what the U.S. Department of Agriculture (USDA) Dietary Guidelines recommend.⁹⁵ Still, according to the Organization for Economic Cooperation and Development (OECD), Americans are the largest consumers of meat

87. Waite & Vennard, *supra* note 48.

88. See generally Sebastian Sterl et al., *What's on the Table? Mitigating Agricultural Emissions While Achieving Food Security*, CAT DECARBONISATION SERIES (2018), https://climateactiontracker.org/documents/68/CAT_2018-01-23_DecarbAgriculture_CATAnalysis.pdf.

89. Brian Lipinski et al., *Reducing Food Loss and Waste 2–3* (World Res. Inst., Working Paper, Installment 2 of Creating a Sustainable Food Future, 2013), <https://www.wri.org/publication/reducing-food-loss-and-waste>.

90. See generally Marco Springmann et al., *Analysis and Valuation of the Health and Climate Change Cobenefits of Dietary Change*, 113 PNAS 4146 (2016), <https://www.pnas.org/content/pnas/113/15/4146.full.pdf> (discussing the benefits of shifting diets).

91. Drew DeSilver, *What's on your table? How America's diet has changed over the decades*, PEW RESEARCH CTR. (Dec. 13, 2016), <http://www.pewresearch.org/fact-tank/2016/12/13/whats-on-your-table-how-americas-diet-has-changed-over-the-decades/>.

92. *National Obesity Rates & Trends*, THE STATE OF OBESITY, <https://stateofobesity.org/obesity-rates-trends-overview/> (last visited Feb. 28, 2019).

93. DeSilver, *supra* note 91.

94. *Id.*

95. *2015-2020 Dietary Guidelines for Americans*, U.S. DEP'T OF HEALTH & HUMAN SERVS. & U.S. DEP'T OF AGRIC. 38 (8th ed. 2015) [hereinafter *2015-2020 Dietary Guidelines*], <https://health.gov/dietaryguidelines/2015/guidelines/chapter-2/current-eating-patterns-in-the-united-states/>.

globally, at 214 pounds per capita annually, followed closely by Australia.⁹⁶ In sum, the expansive number of calories at play in the average American diet invites the opportunity for calorie reduction as a whole, as well as a shift to a plant-based, nutrient-dense diet with multiple societal benefits.

D. Substitution

The idea of embracing a plant-based diet is as old as the Greek philosopher Pythagoras, who, in addition to his work on mathematical theorems, was an early proponent of vegetarianism.⁹⁷ In the climate change era, shifting to a plant-based diet and consuming next-generation meat protein alternatives are becoming more widely accepted as necessary to feed the growing global population sustainably.⁹⁸ To that end, WRI, in conjunction with the United Nations Environment Program and other organizations, has launched the “Cool Food Pledge,” a platform to help institutional dining facilities shift to plant-based foods with a lower environmental footprint, thereby slashing GHGs.⁹⁹ In addition, organizations like the Good Food Institute (GFI), founded in 2016, have begun to advocate for plant-based meat alternatives and “clean meat.”¹⁰⁰ Philanthropies are also supporting plant-based meat alternatives by funding research such as Open Philanthropy’s backing of Impossible Foods, creator of the plant-based “juicy” Impossible Burger.¹⁰¹

Perhaps because of the confluence of these advocacy efforts with profit motive, plant-based substitutes for meat and plant-based diets have recently gone mainstream and are now big business. A 2018 study by Nielsen commissioned by the Plant-Based Foods Association found that the retail sales for plant-based foods intended to replace meat, dairy, and eggs had grown over eight

96. Rob Smith, *These Are the Countries That Eat the Most Meat*, WORLD ECON. FORUM (Aug. 29, 2018), <https://www.weforum.org/agenda/2018/08/these-countries-eat-the-most-meat-03bdf469-f40a-41e3-ade7-fe4ddb2a709a/>.

97. Tori Avey, *From Pythagorean to Pescatarian – The Evolution of Vegetarianism*, PBS (Jan. 28, 2014), <http://www.pbs.org/food/the-history-kitchen/evolution-vegetarianism/>.

98. Dan Hancox, *The unstoppable rise of veganism: how a fringe movement went mainstream*, GUARDIAN (Apr. 1, 2018), <https://www.theguardian.com/lifeandstyle/2018/apr/01/vegans-are-coming-millennials-health-climate-change-animal-welfare>.

99. *The Cool Food Pledge*, WORLD RES. INST., <https://www.wri.org/our-work/project/cool-food-pledge> (last visited Feb. 28, 2019).

100. See generally GOOD FOOD INST., <https://www.gfi.org/> (last visited Feb. 28, 2019).

101. Connie Loizos, *Impossible Foods Just Raised \$75 Million for its Plant-Based Burgers*, TECHCRUNCH (Aug. 1, 2017), <https://techcrunch.com/2017/08/01/impossible-foods-just-raised-75-million-for-its-plant-based-burgers/>.

percent in the last year.¹⁰² Additionally, the industry is projecting that plant-based meat alternatives could compromise a third of all protein by 2054.¹⁰³ Heightened consumer interest in the connection between food, health and wellness, and sustainability has been cited as a reason for the rising demand.¹⁰⁴

E. Disruptive Technology

“Remaking meat is one sector of the food industry that is ripe for innovation and growth.”¹⁰⁵

—Bill Gates

Mark Post created the first lab grown burger using a technology originally pioneered in regenerative medicine to grow replacement organs.¹⁰⁶ In this process, stems cells are harvested from cattle, placed in a growth medium in which the cell multiplies into strands, and then the strands are “exercised” in a bioreactor to grow muscle tissue.¹⁰⁷ Alternatively called “clean meat” or “cultured meat,”¹⁰⁸ the process to grow such meat has even coined a new term: “cellular agriculture,” meaning creating animal products from cells grown outside the animal.¹⁰⁹

102. Becky Schilling, *The Future of Plant-Based Foods*, SUPERMARKET NEWS (Sept. 21, 2017) <https://www.supermarketnews.com/consumer-trends/future-plant-based-foods>; *Plant-Based Foods Growing at 20 Percent, Data Shows*, FOOD NEWSFEED: INDUSTRY NEWS (July 30, 2018), <https://www.foodnewsfeed.com/content/plant-based-foods-growing-20-percent-data-shows>.

103. Schilling, *supra* note 102.

104. Julia B. Olayanju, *Perspectives on Factors Driving New Trends in the Food & Drink*, FORBES (Oct. 1, 2018, 12:26 PM), <https://www.forbes.com/sites/juliabolayanju/2018/10/01/perspectives-on-factors-driving-new-trends-in-the-food-drink/#174ab33878cd>.

105. As quoted in Cristina S. Diniz, *Change Ahead: Can Factory Farming Compete Against Technology?*, MEDIUM (Oct. 1, 2017), <https://medium.com/@cristinadiniz/change-ahead-can-factory-farming-compete-against-technology-feb01d9c8b2d>.

106. See Neil Stephens et al., *Blood, Meat, and Upscaling Tissue Engineering: Promises, Anticipated Markets, and Performativity in the Biomedical and Agri-Food Sectors*, 13 BIOSOCIETIES 368, 371–72 (2018), <https://link.springer.com/article/10.1057/s41292-017-0072-1>.

107. Tom Ireland, *The Artificial Meat Factory – the Science of your Synthetic Supper*, SCI. FOCUS (Aug. 25, 2017, 12:00 AM), <https://www.sciencefocus.com/future-technology/the-artificial-meat-factory-the-science-of-your-synthetic-supper/>.

108. More recently, there is some indication that “clean meat” companies have agreed to use a new term “cellular meat” for purposes of interacting with conventional meat companies and regulators. Elaine Watson, *Cultured Meat Cos Agree to Replace Term ‘Clean Meat’ with ‘Cell-Based Meat’ and Form Trade Association*, FOODNAVIGATOR – U.S. (Sept. 10, 2018), <https://www.foodnavigator-usa.com/Article/2018/09/10/Cultured-meat-cos-agree-to-replace-term-clean-meat-with-cell-based-meat-and-form-trade-association#>.

109. *Cellular Agriculture*, NEW HARVEST, https://www.new-harvest.org/cellular_agriculture (last visited Feb. 28, 2019).

Flash forward a mere few years after Professor Post's big reveal¹¹⁰ and Silicon Valley investors and philanthropies have bet big on the potential of cultured meat. Start-up Memphis Meats, for example, has raised millions in capital from both industry and philanthropists, including Bill Gates, Cargill and Richard Branson, to bring its cultured poultry and beef products to market by 2021.¹¹¹ Similarly, the Rockefeller Foundation, which in the last century helped hatch the "Green Revolution,"¹¹² is looking again to technology to "feed the world," in hopes that such innovations as cellular agriculture might also reduce the climate footprint of meat protein.¹¹³

The emergence of this new market has also led to food safety and transparency concerns, with echoes of the genetically modified organism (GMO) debate, as well as tensions with the traditional meat industry.¹¹⁴ Non-governmental organizations (NGOs) like GFI and New Harvest have been founded for the purpose of facilitating, on multiple fronts, the development and growth of food created through cellular agriculture. In August 2018, for example, GFI and others filed suit against the State of Missouri to prevent the enforcement of a law supported by the beef industry that would ban products created through cellular agriculture from being labeled "meat."¹¹⁵

Tellingly, each industry has a preference for the ultimate regulatory forum for the products of cellular meat. Pro-cellular agriculture meat organizations and companies have engaged preemptively in the development of the regulation framework for cellular agriculture products, with a general preference for

110. Nicole Kobie, *Meatless Meat: the Startups Ditching Animals from Meat*, WIRED U.K. (Aug. 2, 2017), <https://www.wired.co.uk/article/lab-grown-plant-based-meat-substitutes-impossible-foods-beyond-meat>.

111. Jacob Bunge, *Cargill Invests in Startup That Grows 'Clean Meat' From Cells*, WALL ST. J. (Aug. 23, 2017), <https://www.wsj.com/articles/cargill-backs-cell-culture-meat-1503486002>.

112. *But see* Carmen G. Gonzalez, *Trade Liberalization, Food Security and the Environment: The Neoliberal Threat to Sustainable Rural Development*, 14 TRANSNAT'L L. & CONTEMP. PROBS. 419, 440–43 (2004), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=987150, for a critique of some of the Green Revolution's negative unintended consequences to poor farmers in developing countries.

113. Kevin O'Neil, *Is Protein a Key to Feeding Ten Billion?*, THE ROCKEFELLER FOUND. (June 28, 2017), <https://www.rockefellerfoundation.org/blog/protein-key-feeding-ten-billion/>.

114. *See, e.g.*, Walter Johnson et al., *Burgers Grown in a Lab Are Heading to Your Plate. Will You Bite?*, WASH. POST (Sept. 9, 2018), https://www.washingtonpost.com/national/health-science/burgers-grown-in-a-lab-are-heading-to-your-plate-will-you-bite/2018/09/07/1d048720-b060-11e8-a20b-5f4f84429666_story.html?utm_term=.362978b4cc68.

115. Matt Ball, *CFI Goes to Court for First Amendment*, THE GOOD FOOD INST. (Aug. 27, 2018), <https://www.gfi.org/gfi-goes-to-court-for-first-amendment>.

regulation by the U.S. Food & Drug Administration (FDA).¹¹⁶ By contrast, the National Cattlemen's Beef Association is vigorously defending the beef brand, in part by advocating for USDA regulation of the specific labeling of cellular agriculture products to distinguish those products from meat produced by animals.¹¹⁷

It is unclear, meanwhile, whether consumers will feel comfortable purchasing meat not grown conventionally—a recent survey found that only a third of respondents would be willing to buy lab-grown meat.¹¹⁸ How such technology-produced foods will be received by the general population as the availability of animal-produced meat becomes more precious, remains to be seen.

F. Family Planning

Voluntary family planning¹¹⁹ has been shown to be a cost-effective strategy to address food insecurity by helping women better space the timing of births and/or reduce the number of births.¹²⁰ When the United States Agency for International Development (USAID) began providing support for family planning and modern contraception aid in 1965, the average family size in the developing world was over six people.¹²¹ Now, in the countries where USAID focuses aid, the use of modern contraceptive methods has tripled to about thirty percent, and family size has dropped to 4.4 people.¹²² Moreover, family planning provides multiple socio-economic benefits, including the improvement of maternal child health, enhanced women's opportunities for education and employment, and a decrease in poverty.¹²³

Unfortunately, a startling dearth of access to family planning in the developing world persists. A report by the Guttmacher Institute

116. *Food and Drug Administration's (FDA) announcement regarding clean meat*, THE GOOD FOOD INST. (June 15, 2018) (statement of Jessica Almy, Dir. of Pol'y) <https://www.gfi.org/images/uploads/2018/06/GFIFDAStatementJune152018.pdf>.

117. Press Release, Nat'l Cattlemen's Beef Ass'n, NCBA Lays Out Principles for Regulating Fake Meat (Apr. 10, 2018), <https://www.beefusa.org/newsreleases.aspx?NewsID=6628>.

118. Johnson et al., *supra* note 114.

119. The World Health Organization defines "family planning" as the use of contraceptives to attain the desired number of births and to plan and space the timing of births. *Family Planning/Contraception*, U.N., WORLD HEALTH ORG. (Feb. 8, 2018), <https://www.who.int/news-room/fact-sheets/detail/family-planning-contraception>.

120. Reid Hamel, *Notes on Family Planning, Food Security, and Environmental Protection for USAID's New Administrator: Everything Old is New Again*, CTR. FOR STRATEGIC & INT'L STUDIES (Nov. 9, 2017), <https://www.csis.org/analysis/notes-family-planning-food-security-and-environmental-protection-usaids-new-administrator>.

121. *Family Planning and Reproductive Health*, U.S. AGENCY FOR INT'L DEV., <https://www.usaid.gov/what-we-do/global-health/family-planning> (last visited Feb. 28, 2019).

122. *Id.*

123. *Id.*

and the United Nations Population Fund estimated that 222 million women in developing countries lack modern family planning.¹²⁴ In highlighting evidence from low and middle income countries that voluntary family planning is effective at combatting food insecurity, USAID has noted that fulfilling contraceptive needs in developing countries could result in significant reduction in population growth—about 400 million less people than the United Nations’ medium growth projection.¹²⁵

V. A ROLE FOR LAW AND POLICY

In 2015, the panel of public health experts that periodically advises the federal government on revisions to the Dietary Guidelines for Americans (“Guidelines”) recommended, for the first time, including sustainability as part of ensuring a food secure future for Americans.¹²⁶ In doing so, the advisory committee connected healthier diets rich in vegetables, whole grains, and nuts to better environmental outcomes, and, consequently, improved the chances for future food security, a precondition of a healthy diet.¹²⁷ The immediate backlash from the livestock industry and its allies in Congress was swift and decisive.¹²⁸ The 2015 Guidelines were adopted by the federal government without sustainability considerations.¹²⁹

Despite the omission of sustainability considerations from the 2015 Guidelines, the recommendation itself marks an important turning point in their evolution. Fundamentally, the contentious debate over the 2015 Guidelines reflects the continuing importance of the government’s role in what we eat. Taking the long view (meaning beyond the Trump Administration), federal governance mechanisms have the ability to positively guide societal behaviors

124. Ellen Smith & Rhonda Smith, *Family Planning Improves Food Security: Evidence from Studies in Low and Middle-Income Countries*, HEALTH POL’Y PROJECT 1 (2015), https://www.healthpolicyproject.com/pubs/692_FPFoodSecurity.pdf (citing Susheela Singh & Jacqueline E. Darroch, *Adding it Up: Costs and Benefits of Contraceptive Services Estimates for 2012*, GUTTMACHER INST. (2012), https://www.guttmacher.org/sites/default/files/report_pdf/adding-it-up-adolescents-report.pdf).

125. Smith & Smith, *supra* note 124, at 2.

126. *Sustainability in the 2015 Dietary Guidelines: What the Advisory Committee Really Said, and Why USDA and HHS Should Listen*, JOHNS HOPKINS CTR. FOR A LIVABLE FUTURE (2015), https://www.jhsph.edu/research/centers-and-institutes/johns-hopkins-center-for-a-livable-future/_pdf/about_us/FSPP/DGA/DGA%20Myths%20and%20Facts.pdf.

127. *Id.*

128. Allison Aubrey, *New Dietary Guidelines Will Not Include Sustainability Goal*, NPR: THE SALT (Oct. 6, 2015, 6:16 PM), <https://www.npr.org/sections/thesalt/2015/10/06/446369955/new-dietary-guidelines-will-not-include-sustainability-goal>.

129. *Id.* For the Guidelines’ recommendations in their entirety, see *2015-2020 Dietary Guidelines*, *supra* note 95.

to enhance the likelihood of a sustainable, food secure future. Furthermore, as the world's largest economy with tremendous global influence, it is imperative that our government do so. What follows are examples of law and policy mechanisms to effectuate, where appropriate, the strategies presented in the sections above.

A. Guidelines and Policy Frameworks

The Dietary Guidelines exemplify the potential of overarching guidelines or policy frameworks to influence food consumption. In particular, the Guidelines inform policy and program development for federal food, nutrition, and health programs.¹³⁰ Ultimately, the purpose of the Guidelines is to help individuals choose a healthy diet in order to maintain overall health and reduce chronic disease.¹³¹ The 2015 Guidelines adjusted advice on cholesterol and sodium intake from previous 2010 Guidelines, and recommended further reductions in added sugar consumption based on national data showing a public health need to further reduce intake of these empty calories.¹³² The advice regarding consuming lean, red, and processed meats, however, remained basically unchanged from the 2010 Guidelines.¹³³ Importantly, if the advisory committee's recommendation to include considerations of sustainability in dietary choices had been included in the Guidelines, the advice regarding meat consumption would have been strikingly different. The advisory committee clearly recognized the import of dietary choices on the environment, and, therefore, future food security. Accordingly, the committee recommended "a diet higher in plant-based foods, such as vegetables, fruits, whole grains, legumes, nuts, and seeds, and lower in calories and animal-based foods is more health promoting and is associated with less environmental impact than is the current U.S. diet."¹³⁴

Inclusion of sustainability in the next iteration of the Guidelines, due around 2020, could have significant positive environmental impact by moving billions of dollars in public spending on food and nutrition programs toward a plant-based diet, as well as influencing individual consumer behavior.

130. *2015-2020 Dietary Guidelines*, *supra* note 95, at 5.

131. *Id.* at 5–6.

132. Kris Sollid, *New Dietary Guidelines: What Changed & What Stayed the Same*, INT'L FOOD INFO. COUNCIL FOUND.: FOOD INSIGHT (Dec. 11, 2015), <https://www.foodinsight.org/new-dietary-guidelines-americans-2015-changes>.

133. *Id.*

134. Press Release, *My Plate, My Planet: Food For A Sustainable Nation*, Environmental and Health Leaders Show Support for Historic Inclusion of Sustainability Language in 2015 Dietary Guidelines (Mar. 24, 2015), https://foodpolitics.com/wp-content/uploads/My-Plate-My-Planet-press-release_final.docx.

By the same token, national policies have the potential to shape program spending and public behavior in a way that creates progressive change through program and funding alignment with food security and sustainability goals. Adoption of a national food policy or strategy could provide a successful framework to guide policy and funding decisions across the country. For example, spurred by strong civil-society support of the human right to food, Brazil's government led a multi-stakeholder process to develop a national framework to address hunger, culminating in the 2010 adoption of "The National Policy for Food and Nutritional Security."¹³⁵ Brazil's efforts resulted in cutting in half the number of people suffering from hunger between the years of 1990 to 2015.¹³⁶ A similar approach to addressing food security domestically has been advocated by those interested in promoting food sustainability, most notably by the Union of Concerned Scientists.¹³⁷

B. Programs and Financial Incentives

Governmental programs are a key means to achieve healthy food outcomes, both directly through funding (including international aid) and technical assistance, as well as indirectly by incentivizing private investment and support. The farm bill¹³⁸ demonstrates well how programs and financial incentives shape the American food and agriculture system, with impacts beyond our borders. An omnibus piece of legislation passed every four to five years, the farm bill authorizes food and farm programs and appropriates billions of dollars to implement them.¹³⁹ The farm bill programs principally rely on financial incentives such as cost share and loans to achieve its purposes—not regulation.¹⁴⁰

Abundant opportunity exists to reform the farm bill to help ensure a sustainable and food secure future and make better use of precious taxpayer dollars. Currently, the farm bill is a mishmash of programs covering food and farm policy, rural development, conservation, and research, which sometimes work at cross

135. BRAZIL'S FOOD AND NUTRITIONAL GOVERNANCE PLAN, INST. OF DEV. STUDIES 6–8 (2017).

136. *Id.* at 3.

137. See *USC Calls for a National Food Policy*, UNION OF CONCERNED SCIENTISTS, <https://www.ucsusa.org/publications/earthwise/ucs-calls-national-food-policy#.XC98G1xKhPY> (last visited Mar. 1, 2019).

138. See generally Agriculture Improvement Act of 2018, Pub. L. No. 115–334 (2018) (colloquially known as the "farm bill").

139. See RENEE JOHNSON & JIM MONKE, CONG. RESEARCH SERV., RS22131, WHAT IS THE FARM BILL? 1 (2018), <https://fas.org/sgp/crs/misc/RS22131.pdf>.

140. *Id.* at 2.

purposes.¹⁴¹ For instance, among other negative impacts, the current “farm safety net,” of which crop insurance is a main component, tends to reward risky commodity crop planting instead of incentivizing resilient and sustainable farming practices.¹⁴² Meanwhile, the farm bill conservation title provides billions in funding to help farmers reduce the environmental harms in part caused by unsustainable farming practices incentivized by the safety net in the first place.¹⁴³ These policies are designed to perpetuate commodity crops such as corn and soy and the livestock industry that consumes them.¹⁴⁴

A fundamental change to jumpstart the farm bill into a twenty-first century policy more aligned with addressing food security challenges would be to reorganize the farm bill around a food security and rural resilience framework. This type of framework would help provide a systems-approach to the legislation whereby policy proposals could be screened for how well they work together to support rural livelihoods, sustainable production, and equitable access to healthier, plant-based diets.

C. Regulation

Our food system would greatly benefit from regulatory reforms to make it transparent and accountable as to the costs and risks of various forms of food production. Food safety regulation developed by the accretion of laws, not through a holistic approach, has resulted in a confusing regulatory system divided among several agencies.¹⁴⁵ As our government evaluates how to regulate new food products like those derived from cellular agriculture or through genetic editing,¹⁴⁶ our society would benefit from a hard look at whether current agency regulatory roles and assessment of risks,

141. See generally *id.*

142. Laurie Ristino & Gabriela Steier, *Losing Ground: A Clarion for Farm Bill Reform to Ensure a Food Secure Future*, 42 COLUM. J. ENVTL. L. 59, 102 (2016).

143. *Id.* at 94–102.

144. See Michael Pollan, *Why did the Obamas Fail to Take on Corporate Agriculture?*, N.Y. TIMES (Oct. 5, 2016) <https://www.nytimes.com/interactive/2016/10/09/magazine/obama-administration-big-food-policy.html?mtrref=undefined>; Richard J. Jackson et al., *Agriculture Policy is Health Policy*, 4 J. HUNGER & ENVTL. NUTRITION 393, 396 (2009), <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3489137/>.

145. See generally Lisa Heinzerling, *Divide and Confound: The Strange Allocation of U.S. Regulatory Authority Over Food*, in FOOD AND DRUG REGULATION IN AN ERA OF GLOBALIZED MARKETS 125 (2015), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2507346.

146. As of this writing, the Food and Drug Administration appears to still be considering how to regulate the products of gene editing. See *Foods Derived from Plants Produced Using Genome Editing*, U.S. FOOD & DRUG ADMIN., <https://www.fda.gov/food/ingredientpackaginglabeling/geplants/ucm537109.htm> (last updated Nov. 2, 2018).

which generally regulate the final product and presume the safety of the production process, are sufficient to ensure long term food safety and sustainability.¹⁴⁷

Our system of environmental laws and regulations, passed before CAFOs came to dominate U.S. production, tends to exempt farmed animal production from their regulation of clean water and air.¹⁴⁸ Consequently, the environmental harms caused by agricultural production are largely externalized, and the full cost of meat and commodity production is not reflected in its cost to the consumer. Because of the legislative influence of the agriculture industry,¹⁴⁹ it is highly unlikely that environmental laws could be amended to fully regulate these harms. Nevertheless, we can greatly improve environmental outcomes by improving the efficacy of farm bill conservation programs, which expend billions for conservation practices on agricultural operations. Refining such programs would require measuring environmental impacts from agricultural operations such as air emissions and run-off so that conservation practices may be better targeted to address priority resource concerns, and then measuring the conservation outcomes of those practices.

Regrettably, after lobbying by the livestock industry, Congress recently amended a critical pollution law, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund Act), to exclude agriculture from hazardous emissions reporting.¹⁵⁰ Additionally, Congress declined to include a policy proposal in the 2018 Farm Bill that would have required the USDA to measure the environmental outcomes of its conservation programs in order to improve their performance.¹⁵¹ Common sense legal reform to address this lack of data and performance measurement should be a policy priority as part of a sustainable agriculture agenda.

147. See Emily Marden, *Risk and Regulation: U.S. Regulatory Policy on Genetically Modified Food and Agriculture*, 44 B.C. L. REV. 733, 733–36 (2003), for an overview of the principles that guide the regulation of biotechnology which illustrates this point.

148. Laurie Ristino, *Congress Just Gave Big Agriculture the Pollution Green Light*, THE HILL (Mar. 23, 2018, 2:20 PM), <https://thehill.com/opinion/energy-environment/379971-congress-just-gave-big-agriculture-the-pollution-green-light>; see also generally, J.B. Ruhl, *Farms, Their Environmental Harms, and Environmental Law*, 27 ECOLOGY L. Q. 263 (2000) (discussing the impact of CAFOs on regulating clean water and air).

149. See *supra* notes 126–129 and accompanying text.

150. *CERCLA and EPCRA Reporting Requirements for Air Releases of Hazardous Substances from Animal Waste at Farms*, U.S. ENVTL. PROT. AGENCY, <https://www.epa.gov/epcra/cercla-and-epcra-reporting-requirements-air-releases-hazardous-substances-animal-waste-farms> (last visited Mar. 1, 2019).

151. *2018 Farm Bill Drilldown: Conservation*, NAT'L SUSTAINABLE AGRIC. COAL., (Dec. 13, 2018), <http://sustainableagriculture.net/blog/2018-farm-bill-drilldown-conservation/>.

VI. CONCLUSION

Growing global meat protein demand is a grave and pressing social issue, given the food insecurity implications and climate change impacts of livestock production. In light of the extensive natural resource inputs required to raise livestock and the resulting environmental impacts, we simply cannot produce enough livestock to meet future needs. Instead, we must deploy a range of strategies to address high quality protein demand. There is no simple “recipe” to solve this complex social problem. Strategies tailored to the food demands of a particular community are necessary to provide for future food security where the needs are diverse and resource conditions are changing. Law and policy are vital to innovating and implementing these strategies to meet head-on what will surely be the catastrophic consequences of maintaining a business-as-usual approach to our food and agriculture system.