Partnering Towards Sustainable Food Systems: Sustainable Animal Protein

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Abstract

Background

As the world population continues to grow and climate change reshapes our global ecosystems, how we shift our food systems to economically, sustainably and nutritiously provide food must continually evolve to align and forecast the means to meet these challenges. Specifically, an area of importance is animal protein production, demand and consumption. While for some segment of the population, eating less animal protein is perceived as the best way to reduce their environmental impact, demand is expected to grow in the coming years and it will continue to be a major part of the food system. The necessity for more sustainable animal protein production is imminent.

Solutions

Major points of emphasis in addressing this commitment are improvements in technology, innovation in systems management and reductions in food loss and waste to lessen the environmental impact of animal protein sources. Many global efforts are already taking place and it is important to learn from the stories of success, impacts of failure and connections with organizations across all levels of the food system.

Call to Action

In an ongoing effort to adopt these changes, more stakeholders are encouraged to join in further involvement through working groups within the World Business Council of Sustainable Development (WBCSD), Food Systems Dialogues (FSD), the U.S. Farmers & Ranchers

Alliance's (USFRA) network and others, like Bayer, to participate in workshops and dialogues (online and face to face when possible) that are to be hosted over the coming months and to continue to connect with the growing network of involved parties in preparation for the upcoming Global Food Summit in 2021.

Introduction

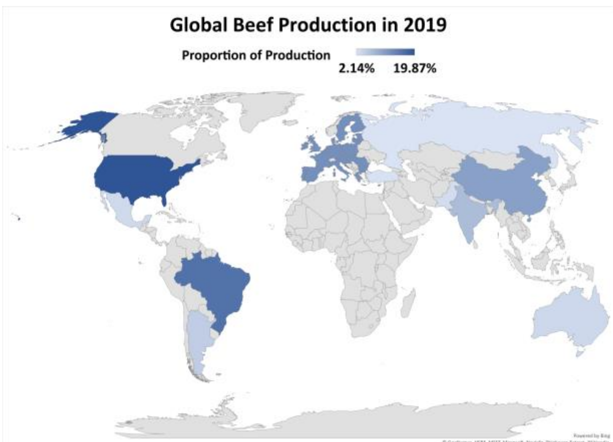
By 2050, the global population is expected to reach 9.8 billion, requiring a 70 percent increase in food production, in a business-as-usual (BAU) scenario [i]. At the same time, climate change poses serious risks for agriculture and food systems. Despite these challenges, there is huge potential to set a path for achieving sustainable future food systems and to build momentum for action across all sectors of society. Agriculture has a unique capability to spur innovation and provide climate-smart solutions and vital ecosystem services. In 2015, the agriculture sector, led by the WBCSD, presented an action plan to achieve a 50% reduction of emissions from the sector by 2030, while ensuring 50% more food be available at the same time [ii].

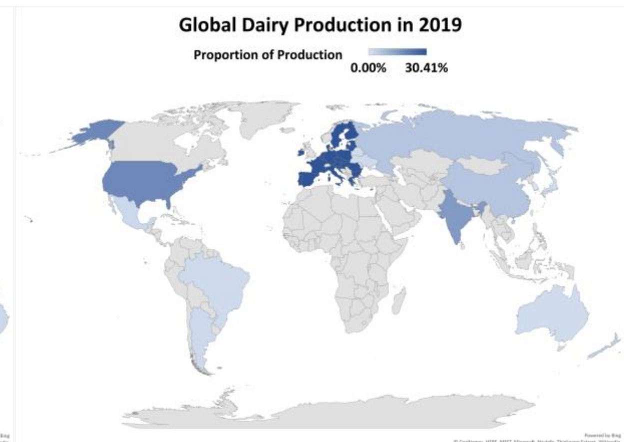
With currently available technology, we are on a trajectory to reduce agricultural greenhouse gas (GHG) emissions by 50%, but by harnessing further innovation and investment, the sector's emissions could become net-negative, up to a 147% decrease in CO2e emissions, according to sources such as the National Academies of Science, Engineering and Medicine (NASEEM), among others [iii]. These estimates are conservative and miss many of the opportunities with animal protein production and the added potential benefits from decreased food waste too. The solutions offered by agricultural ecosystems offer an unprecedented opportunity to deliver environmental, social and economic benefits across society and the economy. By stepping up our investment in more sustainable, climate-resilient agriculture, we can better secure our and our forthcoming generations' futures, to confront our global challenges. The USFRA has identified a set of major pathways to best transition to sustainable food systems of the future, two of them, (1) agriculture as a solution for ecosystem services and (2) mitigation and adaptation, are at the heart of this paper; which seeks to explore their relationship with the potential of animal agriculture to address climate change [iv].

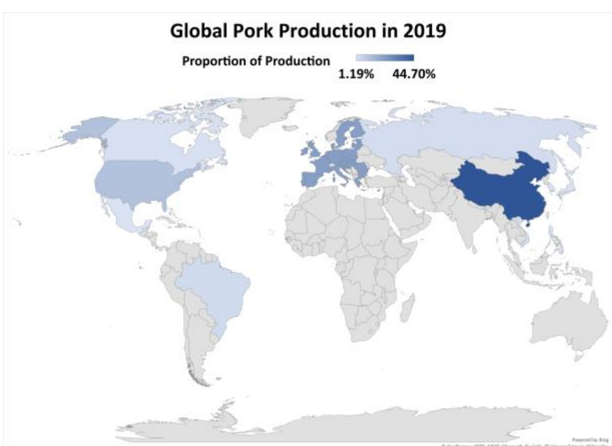
Status Quo:

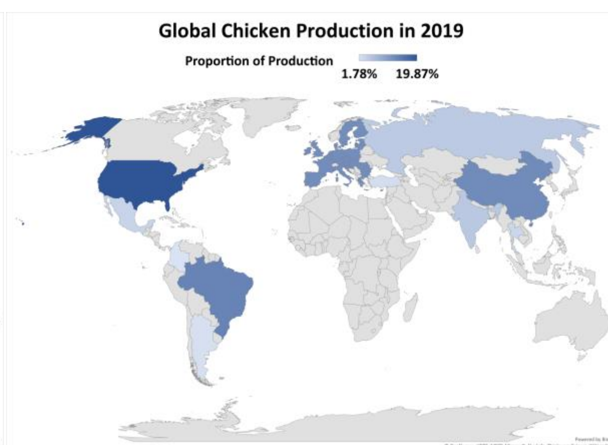
Despite the increased market for plant-based food options, plant-based diets such as veganism and vegetarianism have remained relatively constant in major animal product consuming countries, like the U.S., over the past five years [v]. While people are consuming more vegan and vegetarian foods, animal products are not going away any time soon. In fact, they are expected to increase by nearly 70% in the coming years [vi]. A combination of increases in income, urbanization and population growth in more countries around the world, all strongly link to continual growth in demand for animal-based proteins [vii]. There is great potential to mitigate a massive environmental impact as livestock alone accounts for 14.5% of all GHG emissions, globally [viii]. Given this current trajectory, coupled with the ecosystem changes occurring due to climate change, the importance of increasing both supply and demand of sustainable animal protein sources has become more apparent than ever before.

Currently, the U.S. is the largest consumer and producer of both beef and chicken. For both those meat options, Brazil, China and the European Union (E.U.) combine to round out the top four producers and consumers, globally. Production and consumption of pork, is led by China and followed by the E.U. then the U.S. The U.S., China, The E.U. and Brazil are home to about 32% of the global population but combine to produce between 59% and 82% and consume 59.96%, 52.58% and 78.21% of beef, chicken and pork, respectively [ix]. The largest dairy producers are the E.U., the U.S., India, China and Russia, who combine to produce 77.7% of all cow's milk globally [x]. This data is visualized below. Total fishery production is driven by China, Indonesia and India, who contribute 57.82% of the global seafood supply, with China alone consuming 37.57% of all seafood [xi] [xii]. As demand continues to grow worldwide, it is important to prioritize solutions feasible for these countries in terms of both production and consumption. The scope of this transformation can be broken down into a few target areas; innovations in technology and systems management of animal protein sources and adjustments in food loss and waste.*









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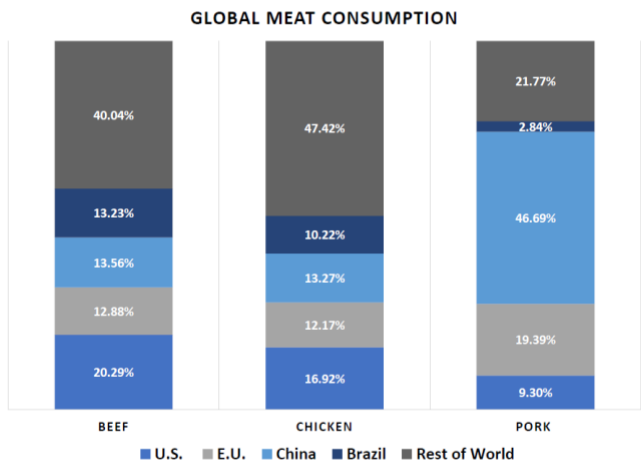
* It should be noted that due to the background, expertise and potential for direct involvement of the authors of this paper (not degree of importance), land-based animal protein solutions were prioritized over seafood



Scope: Technology, Processes and Systems Management

The primary sources of emissions from livestock production are enteric fermentation, downstream manure management, soil maintenance of the land used for animal feed crops and nitrous oxide emissions released because of fertilizers on the utilized agricultural land [xiii]. The primary greenhouse gases of concern are methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) [xiv].

Enteric fermentation is the microbial fermentation process that takes place in the stomach of ruminant livestock species (cattle, buffalo, sheep, goats, and camels) to help break down coarse plant materials into soluble products that can be utilized by the animals. Methane is released as a waste product by the bacteria that break down the feed and it is excreted through exhalation, belching, manure and within the intestinal tract [xv]. This process makes beef, dairy and lamb potential areas to focus solutions related to enteric fermentation [xvi]. Cattle, for dairy, beef and inedible outputs such as manure, account for 65% of the emissions associated with livestock, followed by pig meat at 9%, buffalo milk and meat at 8% and chickens and eggs at 8% [xvii]. Animal manure is most commonly stored in open pit lagoons, and these concentrations of liquid manure release significant amounts of methane over time too [xviii]. How this manure is then treated and managed, greatly influences the overall environmental impact that livestock have across the globe.

Currently, global agricultural land is estimated to be about 1.87 billion hectares, covering about 37% of the total land mass of the world [xix] [xx]. From the crops grown on this land, 27% of those calories are utilized for animal feed [xxi]. With such a significant proportion of global land use dedicated to animal-based proteins, an especially important aspect of this relationship is the health of the soil. Soil is the largest land-based carbon sink that exists and agricultural soil's ability to continue to sequester carbon from the atmosphere remains a major area of influence related to sustainable animal protein production [xxii].

With soil in mind, it's important to highlight the role that fertilizers play as well. The World Resources Institute (WRI) estimates that 94% of fertilizer related emissions result from nitrogen-based fertilizers, with nearly half of the emissions ensuing from synthetic fertilizer use and the other half a combination of manure, crop residues, runoff and microorganism releases [xxiii].

Nitrogen runoff from fertilizers can also contribute to contamination of local water sheds and disrupt nearby marine ecosystems [xxiv]. Given the demand for greater animal protein production that is expected over the next few decades (and thus increased fertilizer use), how fertilizer application is managed to support feed crop growth is drastically important.

Scope: Food Loss and Waste

In addition to the production related impacts, it is important to consider the inefficiencies that result from food loss (any food that is lost in the supply chain between the producer and the market) and waste (a more specific subset of food loss associated foods fit for human consumption going to waste) when addressing the consumption of animal-based foods [xxv]. Astonishingly, if it were a country, food waste would be the third largest GHG emitter, globally, behind China and the U.S. [xxvi]. This is because close to one third of all food produced for human consumption goes to waste and within that, animal protein sources carry some staggering wastage statistics [xxvii]. Loss and waste for meat and dairy is estimated in to be in excess of 20% of what is produced and fish and seafood around 35% for all levels of the value chain [xxviii]. Animal product food waste is greater at the production level in less economically developed countries, while in developed nations, it occurs more often at the consumption stage [xxix]. In the U.S., 31% of available seafood, 21% of meat and poultry, 21% of eggs and 20% of dairy products are wasted at the consumer facing level (retail, food service and at home) [xxx]. Meat constitutes around 4% of the total global foods wasted, but 20% of the food waste carbon footprint and 78% (combined with milk) of the land use associated with food waste [xxxi]. Given how far downstream most of this food waste occurs at, its footprint entails the aforementioned production processes, alongside transport, storage and total land use utilized to produce the food and does not even include the emissions generated if sent to a landfill after. Wasting so much food at this stage of the value chain is inefficient on all accounts necessary to provide it to the consumer and its extent further enhances the degradation that agriculture has on the environment.

Solutions

Technology, Processes and Systems Management

With the environmental impact that animal protein production has, sustainable practices at all stages of the supply chain are necessary. At perhaps the earliest production stage, dietary manipulation and feed additives are emerging areas of interest related to methane emissions resulting from enteric fermentation. Studies have shown that supplementing grains with high quality forage (meaning it has a high soluble carbohydrate content and lower fiber content) is a promising and approachable method to reduce ensuing methane emissions while continuing to produce the same quantity and quality of food [xxxii]. Beyond that, additives such as the 3-nitrooxypropan (3-NOP) molecule have been tested in recent years and early results boast a 30% reduction in methane through inhibition of the fermentation process occurring in the ruminant animals' stomachs, all while not showing any evidence of harm to the animal or decrease in quality of the food produced [xxxiii]. That work is supplemented by ongoing research at the University of California Davis that reported that adding a certain strain of seaweed, asparagopsis, may even be able to reduce methane emissions by greater than 50% [xxxiv]. Further away, gene editing to breed livestock that release less methane is beginning to be explored as well [xxxv]. These initial successes should encourage further research and help to identify even more opportunities to curb emissions at this stage.

Sustainable manure management also offers a dearth of opportunities for impactful change. Fractionation of livestock manure helps greatly with the precision of its potential downstream usages. Separating into nutrients necessary for growing such as nitrogen, phosphorous and potassium can help distribute them back to fields in more specific proportions [xxxvi]. With most emissions from manure management a result of liquid manure storage, environmentally sustainable alternatives to open pit lagoons can be utilized as well. Covered lagoons offer an opportunity to siphon out the natural gas to be utilized instead of emitted or burned off into carbon dioxide, which is less harmful to the environment than the methane that would otherwise be released [xxxvii]. Additionally, anaerobic digestors allow for the manure slurry to be processed and turned into energy on site by using microbes to break down the waste and capture the released gases to generate electricity; again, significantly reducing the environmental impact [xxxviii].

Climate smart agriculture practices have highlighted promising results in increasing the capacity for agricultural soil to become an even greater carbon sink too. Reducing tillage, or soil disturbance, can reduce losses through soil erosion and nutrient runoff [xxxix]. No till and conservation tillage farming offer the opportunity to reduce soil erosion, recycle nutrients and improve water retention on agricultural land, thus increasing both its ability to sequester carbon and maintain its fertility [xl]. Furthermore, planting cover crops during off seasons for growing livestock feed crops helps to improve soil resilience, provide continued sustenance for the animals and can help protect the soil's longevity [xli]. Crops like rye, radishes and wheat are commonly used options for cover crops. Rotational grazing and other forms of regenerative pasture management are under research, development and adoption by farmers across the world as well, with Brazil already heralded as a major leader in these practices [xlii] [xliii].

Through more precise application of fertilizers, nitrous oxide emissions can be reduced too. With the expansion of real time soil data through technology, such as Bayer's Climate FieldView, Farmers Edge's FarmCommand and Yara International's Adapt-N, fertilizers can be applied more strategically when and where they are necessary [xliv] [xlv] [xlvi]. This makes it more likely for nitrogen to be assimilated by the plants, reducing the risk of loss to the air, surface waters or into local aquifers [xlvii]. Crops with higher yields will absorb more nutrients in an applied area and breeding cultivars that produce better yields has been credited with much of the progress in nitrogen uptake efficiency that has been achieved already [xlviii]. Alternative technologies applied to fertilizers, known as enhanced efficiency fertilizers, are also being tested to slow nitrification and other biological nitrogen conversion processes down in the soil, which would allow the nitrogen to stay in the soil longer to be utilized during the critical points at which the plants need nutrient replenishment [xlix]. This is area with potential for improvement still and trials are underway to breed grain cultivars that have a greater propensity for natural biological nitrification inhibition, which could cut down the need for as much fertilizer to be applied during the growing process [l]. With one third of the environmental footprint of fertilizers a result of manufacturing and transport, decreasing total use in addition improving supply chain efficiencies would have a massive ecological impact on the feed crop production system [li]. Given the recency of many of these innovations, the potential for continual improvements in fertilizer application and nitrogen management remains tremendous.

Food Loss and Waste

Although food loss in animal production is so low, when it occurs it is usually due to animal mortality. Even then, most of these animals are turned into feed or non-edible products [lii].

For those harmed by disease, selective breeding is used to reduce impairment and gene editing technologies such as CRISPR boast encouraging compounded improvements in this space as well [liii]. It is worth mentioning that in terms of animal proteins, seafood sticks out as an outlier at this stage. It's estimated that at least 8% of all fish that are caught are thrown back into the sea, often injured or dead; these are known as bycatch [liv]. One study estimates that U.S. bycatch alone could provide enough protein to meet the dietary needs of 1.6 to 2 million people a year [lv].This highlights incredible potential to feed more of the world with these "trash fish". Development of more precise fishing equipment to avoid additional bycatch harm is an important avenue as well.

Animal proteins have relatively low wastage rates in processing and distribution where parts used for non-food products or desired in different cultures are redistributed efficiently. The main sources of waste in distribution are related to improper storage and handling as well as inefficiencies in transportation [lvi]. As a result, improvements in proper cold chain management and transportation could make these sectors even better equipped to prevent waste.

Waste at the retail level can mainly be attributed to more cultural and systemic issues. Cosmetic issues related to packaging damage or ineffectiveness are the source of a lot of grocery waste. Specifically, packaging for beef has shown to change the color in vacuum packaging, which can deter customers despite lasting longer [lvii]. Entire cartons are also disposed of for having just one cracked egg [lviii]. Companies such as Walmart have already developed in house strategies to remove the cracked eggs and sell or utilize the rest of cartons [lix]. Technology has the potential to alert customers of items nearing their optimal quality dates and can offer them at a discounted rate. Meat that is not sold in time can also be frozen and donated or diverted to animal feed, something grocery brand, Ahold USA, has begun to do already [lx]. In the U.S., food donations are protected by the Bill Emerson Good Samaritan act when done in good faith and other countries like France have even mandated that all edible grocery store food waste be donated if not sold [lxi] [lxii]. Further policies, both governmental and in store, to protect, financially incentivize and encourage donation and diversion of potentially wasted foods have the opportunity to erase massive inefficiencies at the retail level.

Food service vendors also have incredible capacity to reduce their waste footprint. A trend in increased portion sizes has also increased the potential for more food waste [lxiii] [lxiv]. Consequently, 17% of food goes uneaten at restaurants today, with 55% of that food not being taken home [lxv]. Smaller plates and tray free substructures in self-service dining establishments both result in lower levels of waste [lxvi]. The presence of smartphones and apps has allowed for some restaurants to sell leftover food for discounted prices and further expansion and accessibility of this is both possible and plausible. Some amount of food waste is inevitable (bones, egg shells, avocado pits, burnt food etc.) and with food safety concerns related to precooked food and food left on patrons' plates, diversion to animal feed, anaerobic digestion and compost are all conceivable solutions to plate waste in food service establishments (in order of priority according to the USDA's food recovery hierarchy) [lxvii].

At the top of the USDA's food recovery hierarchy is reduction at the source [lxviii]. Given that the household level is the largest stage at which food is wasted among the countries consuming the greatest amounts of animal based proteins, much of the solutions at this point are related to convenience, education and awareness. One major area for improvement is food quality date labeling. In the U.S., food date labels are not regulated by the Food and Drug

Administration (FDA) unless they're for infant formula. In fact, the FDA even encourages donations after the listed best quality date and publicly supports multi-company pledges to standardize date labels to the phrasing "best if used by" to be clearer about the intention of them [lxix]. This gap between consumer and industry knowledge is compounded by lack of awareness on the extent of the issue in all countries. Through better consumer education programs that highlight the scope of the issue and promote awareness of opportunities to better preserve, donate and compost food that would potentially go to waste, a sizeable portion of the animal protein waste footprint could be reduced at the household level.

Conclusion

As the world continues to grow and develop at an unprecedented rate, so will the demand for animal protein sources. Coupled with climate change and already limited resources, the necessity for sustainable animal protein is imminent. The solutions to shift to a more sustainable production system relate both to the lifecycle of the foods themselves and the habits of consumers in possession of this food. Technological innovations, smarter systematic procedures and continued research in addition to improved retail practices and consumer behaviors all play an important role in this transition. More advancements have been, and are being, developed in this space that deserve continual support and attention alongside what has been highlighted in this paper. The scope of this work was limited to prioritize solutions that best reflected the combined background, expertise and potential for impact from the authors and their respective organizations. Further solutions to be highlighted include innovations and systems management practices related to wild fisheries and aquaculture operations, agroforestry practices that synergistically provide food while maintaining natural forests and explorations into increased entomophagy and how to incorporate insects as a scalable and sustainable animal protein source into more people's diets across the planet. As the world continues to evolve, Bayer, the USFRA and the WBCSD hope to continue to lead the way in developing a more sustainable global food system.

Call to Action

With the technology and systems management improvements available, financial investment and incentivization, political and private sector support and grassroots prioritization are all necessary. Awareness and education need to be continually promoted to all parties along the value change related to sustainable livestock production and further research to better understand future challenges and solutions needs to continue. Bayer and the USFRA encourage their networks to continue to participate in workshops and dialogues such as those organized by the WBCSD and the FSD to provide content related to sustainable animal protein production leading up to the Global Food Systems Summit in 2021 (being organized in conjunction by the World Economic Forum (WEF) and U.N. groups such as the Food and Agriculture Organization (FAO), the World Food Programme (WPF) and the International Fund for Agricultural Development (IFAD)). In an effort to address the food demands of a growing world, we must stand together and support the food system transformation that is necessary and continue to create a healthier and more sustainable planet for our global community.

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