
# The Future of Protein: Nourishing the World Sustainably

## Policy and Information Package

# BRIEF No.6

# Climate Change and Biodiversity

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December, 2019

**Acknowledgements:** This project was made possible thanks to funding received from the University of Ottawa's Office of the Vice President-External (Alex Trebek Forum for Dialogue); along with the Faculty of Social Sciences, the School of Political Studies, the Centre for International Policy Studies; and a Connections Grant from the Social Sciences and Humanities Research Council of Canada.

## Introduction

This policy brief discusses the theme of '**climate change and biodiversity**' as it pertains to the future production and consumption of protein foods. The livestock sector supply chain currently accounts for about 14.5% of global emissions.[1] Furthermore, a recent high-profile report from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) found that activities relating to unsustainable agricultural production are a leading cause of biodiversity decline globally.[2] The current agri-food system is not sustainable, however changes to the protein subsystem can help humanity address the global crises of climate change and biodiversity decline.

As noted in Brief No. 1 (Introduction), we make an important distinction between Animal-Sourced Protein Foods (**ASPFs**), Plant-Sourced Protein Foods (**PSPFs**), and Novel Proteins Food Products (**NPFPs**) and further we track the discussion surrounding each theme as it is primarily tackled by three main pathways addressing the future of protein (see Brief No. 1 for further details):

a. The **REPAIR** pathway aims to 'fix' existing problems relating to the protein agri-food subsystem, primarily through an approach prioritizing technological innovations and improvements.

i. The **REPLACE** approach seeks a broader overhaul of the protein subsystem, prioritizing the replacement of ASPFs with PSPFs and NPFPs as the dominant protein source in the human diet, in addition to the introduction of new food commodities and consumption practices.

i. The **RESTORE** 'school' aims to address the problem by 'restoring' a holistic balance between humans and nature within the protein subsystem. This includes an emphasis on maximizing biodiversity, biomimicry, and natural resilience in the production process, all supported socio-economically through reformed consumption practices.

In this brief, we tackle the following core questions:

- ➔ *How can we mitigate the environmental impacts of producing protein-rich foods?*
- ➔ *How might global environmental change shape their production in turn?*
- ➔ *How do the three pathways interpret climate change and biodiversity in the future of protein?*

## Toward Sustainable Proteins

The three pathways propose different solutions that each seek to tackle the same problem by coming at it from different angles. Each pathway accepts that the current system of protein production is not sustainable for our future climate change and biodiversity needs, but also accepts that humans need to continue to enjoy nutritious and culturally fulfilling diets, of which protein must be an integral part.

The **REPAIR pathway primarily sees this being accomplished through technological improvements that can be made largely at the production level**. This can be through improved efficiencies on the farm with regards to advanced heavy equipment, new fuel standards, increased electrification, and on-farm renewable power generation through methane-capture, etc. This can also be achieved through genetic manipulation (improving either crop yields and digestive efficiencies in ruminants), as well as producing livestock which generate more meat and dairy with less in the way of required inputs.

The **REPLACE camp has garnered significant visibility in recent years through the publicity received around new protein alternative products (like 'plant-based meats' and 'dairy', or insect powders, etc.)**. This school largely suggests that by replacing ASPFs with various PSPFs a more healthy and sustainable balance will be achieved – particularly because conventional animal-based agricultural systems are resource intensive. This camp sees a shift in consumer behaviours as the most effective way forward by shifting the balance toward plant-based proteins (as advocated, for example, in the recently updated Canada Food Guide, and the EAT Lancet study).[3]

Finally, the **RESTORE** camp sees current production and consumer patterns as having strayed significantly from what can be interpreted as genuine sustainability. Rather than replacing or repairing the protein subsystem, this camp **feels consumers need to be brought back closer to the source of their food production, and that food production itself ought to regenerate nature** – via contributing to natural resiliency, improved biodiversity and incorporating animals and plants into natural farm ecosystems. For some this includes a return to more traditional practices, while for others in this system the idea is to use the latest scientific knowledge about ecology to inform modern agricultural practices which are more in line with natural ecosystem function.

## The Issue in Brief

There are a number of complex challenges facing protein production which generate environmental impacts, exacerbating anthropogenic climate change and biodiversity decline. Here are some illustrative examples:

- Typically, producing ASPFs is more resource intensive than producing PBPFs. For instance, producing 1 kg of beef typically requires – on average – eighteen times more land, ten times more water, nine times more fuel, twelve times more fertilizer and ten times more pesticides in comparison to producing 1kg of kidney beans.[4]
- Livestock (especially cattle) are large producers of GHG emissions, specifically methane (CH4), which is around 28 times more powerful than carbon dioxide on a weight-by-weight basis.[*] The Environmental Defence Fund suggests that about 25% of anthropogenic climate change is caused by methane emissions.[5] Globally, enteric fermentation from ruminant livestock accounts for about 27% of methane emissions; while another 3% is from manure management and another 5% from other agricultural sources.
- While new technologies which improve efficiency are available across the board in the agricultural sector, uptake is often slow due to the high investment costs and low revenues for many farmers. As incomes rise in developing countries per capita consumption of ASPFs is increasing, and this increase is not likely to stop in the near term.[6]
- Changing the habits of consumers is generally difficult, especially with something like food that is such an integral part of an individual's every day practices and their identity, linked closely with cultural practices.
- Biodiversity plays an important role in maintaining ecosystem productivity, stability, sustainability as well as other ecosystem services that are integral for human and non-human planetary well-being. Biodiversity loss is being experienced at an alarming rate as a result of habitat loss and degradation, excessive nutrient load, air and water pollution, over-exploitation and unsustainable use of natural resources, invasive species and above all climate change.[7]
- Global climate change is similarly occurring at an alarming rate due to increased GHG emissions. This has caused global mean temperatures to rise close to 1°C since the mid-1800s; has seen global mean sea levels rise 12-22 cm during the last century, and is causing increasingly erratic rainfall globally leading to increased drought in some areas as well as worsening flooding in others; all while extreme weather events have become more common and more severe.[8]
- Global food production threatens to contribute to irreparable harm to the Earth's climate and biodiversity as well as ecosystem stability, and it presently serves as the single largest

[*] At the same time, Methane is a fairly short-lived gas, only remaining in the atmosphere for less than a decade as compared to CO2 which remains there for hundreds of years on average.

contributor to environmental degradation (pushing the Earth beyond its planetary boundaries).[9]

- As a recent IPCC report makes starkly clear, compounding the issues of trying to feed the world's growing populations that are demanding growing and increasingly complex diets, as the problem of climate change worsen, crop yields in many parts of the world are being threatened due to the effects of changing weather patterns and extreme weather events.[10]

## Rising global ASPF demand and complexity in protein agri-food systems

The production of protein-rich foods serves as one of the most pressing challenges for the global environment. While there are many who have long turned away from traditional meat-based diets for various ethical and health reasons, it appears more people are choosing to reduce ASPFs (especially beef) consumption for environmental reasons.[11] At the same time, however, growing populations, rising affluence and urbanization are translating into increased demand for meat and meat products, particularly in developing countries.[12] Since 1961 the per capita supply of vegetable oils and meat has more than doubled and the supply of food calories has increased by about one third. Beyond these increases 25-30 percent of food produced is lost or wasted.[13]

While projections vary, the UN Food and Agriculture Organization (FAO) suggests global demand for animal proteins will have to increase by 70 percent to feed a population that is estimated to reach close to 10 billion by 2050.[14] Much of this growth can be attributed to rapidly expanding modern forms of intensive livestock production, often referred to as industrial livestock organizations (ILOs). However, 70 percent of the food eaten in the world is actually produced by small farmers, of which there are around one billion who manage to feed the majority of the world.[15] We therefore cannot attribute the environmental issues related to protein production to one system of production, or one type of commodity alone. **Rather, this must be seen as a complex issue with manifold moving parts that all interact and demand similarly dynamic solutions.**

## GHG emissions and scarce resources

The livestock sector is the world's largest user of agricultural land, through the use of feed crops, pasturelands and other uses. The natural resources that are needed to sustain agriculture, including water and land, are becoming increasingly scarce and of degraded qualities while agriculture itself is often leading to these declines.[16] Agriculture is also a major contributor to global greenhouse gas emissions (GHGs). Current statistics put emissions by global livestock alone at 14.5% and this is almost sure to rise significantly in the coming decades due to some of the factors mentioned above, as well as others.[17] Many estimates suggest that GHG emissions from agriculture could rise to above 50 percent of global GHG emissions of which meat and dairy will comprise 70 percent.[18] Adding to the complexity, much of agricultural emissions are methane and the IPCC recognizes there's a certain amount of methane that's inevitable. That's why **the 1.5C report says we need to reduce CO2 to zero (and below) whereas CH4 only needs to be reduced to a level which can be naturally absorbed by the Earth system.**[19] One of the most important questions of our time, then, is how can we mitigate the environmental impacts of producing protein-rich foods?

## Considerations

*Current ASPF system has become unbalanced*

The current production of ASFPs has become unsustainable. The global food system, including within farm gate and agricultural land expansion, contributes 16-27% of total anthropogenic GHG emissions. Outside farm gate emissions represent another 5-10% of total anthropogenic emissions.[20] Agriculture also accounts for 70 percent of global freshwater use.[21] These figures pose significant challenges for combatting global climate change and fighting the loss of biodiversity - major systemic changes are needed to achieve important climate goals.

It is sometimes argued that growing animals for human caloric intake is inefficient as it takes about five to seven kilograms of grain to produce one kilogram of beef. Each of those kilograms also takes energy and water to produce, process and transport.[22] One study found that by producing a similar caloric value as beef in the form of plant-based proteins it would be possible to feed around 190 million extra people from US agriculture alone. Switching beef to poultry production between 120 and 140 million more people could be fed, placing it not that far behind the plant-based diet (however, we caution that different protein foods feature different nutritional compositions and may not be wholly interchangeable in terms of total net protein – see Brief 3).[23]

There is a large amount of land across the world being used to produce crops like corn, soy and wheat, which dominate production especially in many western countries. These are then fed in large quantities to animals to yield protein rich foods.[24] This process has become increasingly mechanized and people have become increasingly distant and dislocated from the sources of their food.[25]

*Shifting from reducing harm to producing positive impacts*

Many proposed solutions to the protein sustainability problem seek only to do less harm. Arguably, however, humans can use protein production to *improve* the health of agricultural lands and have a net positive impact on the environment. For example, many researchers have focused on improving soil quality as a key tool to support biodiversity and climate mitigation. Healthy soils provide countless ecosystem services such as filtering water and holding water to regulate floods and droughts as well.[26] Soils are the largest carbon sink, holding two to three times as much carbon as the atmosphere. Unfortunately, in large part due to agriculture, but also through deforestation and other anthropogenic impacts, agricultural soils have been degraded worldwide which has caused a dangerous loss of soil carbon to the atmosphere. Improving agricultural soils is thus one of the most important ways to turn the protein subsystem into a tool for ecological remediation.

*Shifting demands, shifting supply, shifting challenges*

Historically, the realities discussed above mixed with ever-changing population and environmental pressures have led to a variation of agricultural techniques and crop products. These types of shifts in agricultural foci should be seen as potentially natural and beneficial, but can also be examined through a critical lens: Canada, for example, has seen a massive expansion in the production of lentils in recent decades. This expansion has been promoted by the government, and as exports have risen the sector has been protected.[27] Lentils are part of the growing call for an increase in PSPFs that has been on the rise world-wide and which Canada has directly written into the newest food guide [as discussed in Brief no. 5]. However, in some places where lentil production has been successful, it has increased the incidence of various practices like monocropping, tillage, and pesticide use.[28] Combined with the absence of crop rotation, these practices can cause the soil to become depleted of certain nutrients, while also having adverse impacts on local wildlife and resulting in GHG emissions. Monocrops further tend to bring in certain types of pests, weeds, and animals which can create new problems and further require more inputs to manage. This can affect biodiversity greatly by promoting certain species which can be detrimental to others.[29] Thus, as 'solutions' are found to one problem many others can be created. Policy makers must be particularly cautious because the agri-food system is complex and often tackling one problem can lead to another.

*Entrepreneurial solutions*

New agri-food firms are having a great deal of early success, particularly plant-based protein substitutes which seek to replace traditional resource intensive meat products with more eco-friendly ones that do not demand a large shift in consumer behavior. The products are developed to mimic meat while still providing similar nutrients at a comparable cost.[30] This approach is widely touted by REPLACE proponents, as it is generally quite difficult to shift consumer behavior especially with something as ingrained as ASPFs in people's diets (particularly in wealthy nations).

Similarly, various forms of insect foods are entering the marketplace, whether these are sold as crunchy snacks or in the form of protein powder to be added to recipes and diets to give a boost of more environmentally conscious nutrients – specifically protein – to supplement dietary needs.[31] This approach is symbolized by Greenpeace's demand to reduce meat and dairy consumption by 50 percent based on the current consumption levels by 2050.[32]

*Technological solutions*

Another of the major solutions to reduce the impacts of meat production on climate change and biodiversity is through technological innovation. This can take on variety of forms but seeks ultimately to improve production efficiency from farm to table. While jurisdictions around the world have been active in developing technologies to make vehicles, motors, and power generation more efficient, particularly in terms of electrification, this side of the question is often left out when discussing improving agricultural emissions.

While cattle often get blamed for the large amounts of methane they emit, a great deal of carbon dioxide is also produced from the farm equipment used to plow, harvest, transport, clean, sort, and perform a number of other activities. By improving farm machinery, fuel standards and working to increasingly electrify farms as a source of power where possible, huge gains can be made right at the source of the emissions without shifting other behavior patterns.

Farms similarly possess the land necessary for virtually limitless potential to produce clean renewable wind and solar electricity that can be used at point of production to maximize efficiency. Solar currently produces only about 1% of Canada's total electricity output and wind produces about 2% while almost all of the generation for both of these comes from Ontario. While solar farms and micro wind production have both been on the rise in the country they still remain relatively insignificant in comparison to overall national energy generation which proponents see as a major untapped resource.

Scientists are consistently developing new ways to reduce GHGs through various genetic breakthroughs. They have found ways to produce more ASFPs with less methane and other GHG emissions as a result. These include:

- *Feeding strategies:* Reduction of methane has been seen by tweaking the diet of livestock, for example by increasing the level of dietary fat by feeding a diet of crushed oilseeds, or dried corn. These have been shown to reduce methane emissions by up to 20 percent.
- *Feed additives:* By using plant extracts such as condensed tannins, saponins, essential oils, yeast, bacterial direct fed microbials and enzymes fiber digestion in cattle can be improved and has been shown to reduce methane output by up to 6 percent which shows promise for developing even better techniques.
- *Feed conversion efficiency:* By focusing on food input to milk output it is possible to minimize methane emissions in the dairy sector. Thus, by finding more easily digestible food that produces more milk and by breeding beef and dairy cattle selected for high conversion efficiency we can produce more with less inputs and less negative externalities.
- *Biodigesters:* These are airtight containers in which anaerobic digestion of manure, biosolids, food waste, other organic wastewater streams or a combination of these feedstocks occur. The process produces commodities such as biogas (a blend of methane

and carbon dioxide) which can be used to generate electricity, animal bedding, and fertilizer.

- *Management practices:* Management practices include regenerative and holistic practices as well as breeding for highly reproductive cows, resulting in fewer replacement heifers needed. Lowering head of cattle per farm is an obvious way to reduce methane emissions.
- *Computer software:* Agriculture and Agri-Food Canada has developed the Holos greenhouse gas calculator which allows farmers to envision and test more efficient ways of production. It estimates carbon dioxide, nitrous oxide and methane emissions allowing farmers to observe how changes in their practices can affect emissions.[33]

Beyond reducing emissions from ASFPs there are many technological improvements that can reduce GHG emissions from PSFPs as well such as;

- 'no-till' technology which reduces carbon loss from the soil as well as the many subsequent issues caused by tilling including loss of ground water, loss of soil nutrients and increased erosion.
- 'Precision agriculture' technologies that are able to identify weeds, determine how much water/fertilizer is needed by a given plant and directly apply required fertilizers, pesticides, herbicides, irrigation all using technology rather than broadcasting these chemicals across the field.[34]

*Changing culture: from farm to foodie*

Regenerative agriculture falls under the pathway of 'restoring meat' and promotes practices that seek to regenerate soil health and build soil carbon. There are important ethical and welfare focuses for regenerative farming as well as seen in Policy Brief no. 4. However, this brief focuses on it as a way to not only reduce the harm of protein production on environmental climate change and biodiversity but also looking at ways it can be utilized to actually improve various ecological, social and even political economic areas.[35] Regenerative practices include:

- No tilling (as turning soil upside causes a range of problems from severing roots to enabling carbon dioxide leakage, etc.).
- Planting perennials (as their roots remain in the ground and grow deeper year after year to maintain soil quality and ground water).
- Integrating tree crops in agricultural systems (as their roots go deep and can provide food crops such as tree nuts which also supply a good source of protein).[36]

Similar to regenerative agriculture are holistic management practices which involve an elaborate process that determines when, where and how best to move cattle and other livestock on land in order to optimize the recovery time of grasses, soil regeneration and according to local climatic conditions, as well as the land owner's specific goals. Holistic management is an adaptive methodology that involves a detailed planning process that acknowledge the plan will continuously evolved along the way, especially in the face of changing climatic conditions. The whole concept relies on mimicking nature to try and maintain the type of balance that successfully enabled large populations of ruminants to roam vast tracts of land without largescale degradation for centuries and in some cases millennia.[37]

Some evidence for the success of these holistic management practices include data that show that when cattle are on pasture there is 'methanotrophic' bacteria in the soil that develop that feed on methane.[38] This means that methane emissions are partly offset when cattle are grazed in healthy pastures (as opposed to what would generally occur in industrialized systems when cattle are in large barns or on barren sites; or even grass-fed cattle on overgrazed pastures).

Secondary feeding of grains produces an energy trade-off: While on one hand it is more 'efficient' in terms of animal weight-gain per a given amount of time, it is also much more energy-intensive as it requires feed to be farmed by heavily mechanized processes prior to being ingested by the livestock.[39] Manure must also then be collected in intensive feed operations, and dealt with in some way (either spread on fields as fertilizer, another similarly energy intensive activity), etc. In contrast, when on pasture ruminants eat from the ground and return excrements directly to the locations saving vast quantities of energy and GHG emissions while also greatly decreasing methane through methanotrophic bacteria.

## Towards Solutions:

Due to the complexity of the protein subsystem and its role in both contributing to and helping to solve environmental challenges such as climate change and biodiversity decline – it is advisable to avoid single bullet solutions. Far too often efforts to combat climate change have consisted individual consumer-based solutions - which alone are neither feasible for an entire society, nor will they suffice to realize the systemic change needed.[40] A recent study showed that even though animals make up near half of overall agricultural emissions in the US, even if the entire country switched to a vegan diet it would only reduce agricultural emissions by a little more than 25% (overall domestic emissions would be reduced by less than 3%).[41] Of course there would be other impacts to consider from such a shift – including the sourcing of fertilizer, leather and wool, as well as nutritional and cultural considerations – all of this implies the value in greening the production methods of existing protein foods.

Agriculture and specifically livestock for the purposes of meat and dairy production contribute a significant part to this global challenge. Rather than bullet point solutions that suggest grand umbrella actions that will solve the problem, systemic approaches are needed that factor in the breadth of political socio-economic factors that have got the food system to this point in the first place. This means that dynamic strategies are needed that incorporate the ability to constantly change as the complexities of the global landscape and the challenges posed by a changing climate will constantly evolve. As such, this systemic approach must be ready to adapt and transform to keep pace.

**Solutions must at the same time remain simple and easily communicable**. Any effective pathway forward will undoubtedly require buy-in to a broad spectrum of populations and if they are too complex for average people to easily grasp, they will fail in place. Solutions must be navigable, transferable and have straightforward steps toward achieving clear and demonstrable goals. In this sense a clear link needs to be drawn towards costs, or people's actions and desired outcomes being achieved.

The remainder of this brief considers pathway-specific approaches to the problem of tackling climate change and biodiversity within the protein subsystem:

## REPAIR:

### A system that is broken, but fixable

This pathway argues that ASPFs will remain a major and growing part of global dietary needs and eliminating them is neither realistic nor desirable.[42] The system does not need to be "reinvented", but rather needs a systemic overhaul that sees improvements in the way things are done. Efforts at this have already been undertaken and need to be scaled up and pushed forward to improve on the success already achieved.

### Innovative solutions are the answer

Based mainly on a variety of technological solutions, the protein subsystem can be repaired, and a healthier balance can be achieved. Through improved efficiencies it will be possible to "produce more with less" (as has occurred previously before during the 'green revolution'). As a key example, numerous commercial enterprises are currently seeking to produce feed additives that will reduce methane emissions by upwards of 30% in ruminants – this would be a major gamechanger by reducing the largest category source of GHG emissions in the protein subsector.[43]

## REPLACE:

### No way around 'less meat'

The replace camp sees no sustainable solutions to the climate change and biodiversity issues posed by livestock production under the current system. The system that exists can neither be repaired or restored, but must be replaced. Because of the compound problems of growing population, resource shortages, deforestation, land degradation and climate change, restoring or repairing the system will not be enough.

**Current system = too much for too little**

The replace pathway argues that the production of ASPFs is simply too energy intensive and requires too much input for the output received in exchange and comes with too many negative externalities. This camp sees no pathway forward that does not include an overall reduction in the consumption of ASPFs. They agree with the steps the new Canada Food Guide and the EAT Lancet take toward encouraging plant-based diets that are not only healthier but more sustainable for the planet. Replacing meat can be as simple as foregoing it from diets or can include eating plant-based meat-like products that sees little in the way of change have to occur from habitual and consumption standpoint.[44] Changing dietary habits including more plant-based foods present major opportunities for climate adaptation and mitigation while generating significant co-benefits in terms of human health.[45]

## RESTORE:

**Returning to balanced equilibrium**

The restore camp sees the current system as having fallen precariously off course. However, through a holistic realignment with the principles of ecology, farming can be returned to a sustainable balance. This camp sees a need for "better meat" and acknowledges that this might come with a need for less meat overall as many of the agricultural techniques are less industrially productive (although this is one of the key internal debates within this pathway). Those is the restore camp see holistic and regenerative practices as being able to restore a healthy balance and through continued improvement to management practices and techniques productive intensity could even be maintained.[46] 25-30% of food produced is lost or wasted. Developing a systemic approach to cut this even in half would have a significant effect on reducing GHGs and protecting the environment while saving vast resources.[47] By implementing voluntary or persuasive instruments such as environmental farm planning, standards and certification for sustainable production, use of scientific, local and indigenous knowledge and collective action, consumers will increasingly reward better management techniques and begin to restore to food industry.[48]

**Reconnecting traditional, local, indigenous knowledge**

The restore camp tends to see an integral role for animals in a sustainable protein subsystem. The problem is not ASPFs, but instead the way the industrialization of animal agriculture has moved too far away from traditional and indigenous food systems in favour of large-scale export-driven production.[49] This industrialization has led to an ever-increasing gap between people and where and how their food is produced which has created a dangerous expanse that must be bridged. Practices to be supported include those centred on increasing soil organic matter, erosion control, improved fertilizer and manure management, improved crop management and grazing practices, and better use of varietals and genetic selection for heat and drought tolerance.[50] Many of these management techniques can enhance the adaptive capacities of rural communities as they seek to develop resiliency in the face of a changing climate and changing global environment.

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