The Future of Protein: Nourishing the World Sustainably

Policy and Information Package

BRIEF No.7
Innovation and Investment in the Agri-Food Sector

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February 2020

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 '**innovation and investment in the agri-food sector**' as it pertains to the future production and consumption of protein foods. Innovation is key to achieving food security, but there remain myriad roadblocks and barriers to both the development and the implementation of developing agricultural technologies, practices and methodologies.[1] In many places new products, processes and technologies already exist, but having them effectively scaled-up and scaled-out remains an ongoing challenge, especially in the developing world.[2] At the same time, there remains widespread resistance to certain types of innovation, particularly when these threaten longstanding traditions or cultural values.[3]

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 Protein 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.

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

c. 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, as supported socio-economically through consumption practices.

In this brief, we tackle the following core questions:

- ➔ *How can innovation and investment in agri-food help tackle environmental problems associated with the production and distribution of protein foods, while helping sustainable production models scale up?*
- ➔ *How do the three pathways interpret agri-food innovation and investment in the future of protein?*

Toward Sustainable Proteins

All three pathways see **innovation and investment as a clear and necessary way forward for the agri-food sector**. The three pathways accept that there will be a growing worldwide demand for food and that a sizeable part of this growth will be for protein-rich foods. For this brief what sets the three pathways apart is the way they define "innovation" and the way they see investment as a tool to help scale up sustainable agri-food production.

Those in the **REPAIR** camp envision innovation and investment in what might be viewed as the most traditional sense. This camp sees innovation as a natural force involved in the evolution of civilization, since the advent of sedentary life or before. The repairists thus see the agri-food sector becoming sustainable through the use of **technological innovations including apps, drones, farm machinery, genetic manupulation, and more**. They point to the massive increases in crop and animal product yields that have already been witnessed, and see a bright future for technology as an important tool going forward.

Like the repair camp, supporters of the **REPLACE** pathway suggest that innovation and investment are pivotal, yet they do not see technological improvements to the *existing* system as sufficient or even desirable. Rather, they see as necessary **replacing many of the political, social and organizational components** of the current system. The replace camp sees the need to provide access to new markets, credit or extension services to marketing PSFPs and NPFSs.

Finally, the **RESTORE** camp recognizes the need for both technological and socio-political innovation as important elements in the sustainable scale up of both ASPF and PSFP production. However, it **takes a broader societal approach to a reorganization of the system in order to establish a healthy balance.** This is envisioned to be achieved through government investments and supports, civil society, farmer organizations, research bodies and the private sector who are all seen to have important roles to play in enabling innovation and investment to flourish in the agricultural sector in a way that reimagines the entire system from farm to table in 'agro-ecological' terms. There is in part an embrace of new technologies, but the restore camp also seeks to deploy the 'timeless wisdom' of traditional knowledge in new innovative ways.

In short, various types of proposals (which in some cases contradict one another) are made by advocates calling for innovation and investment in agri-food, including:

- Foster collaboration between scientists, experts in nutrition, biology, chemistry, engineering and analytics across the globe.
- Use existing organizations at all levels to create platforms for participatory dialogue among a diverse range of actors.
- Place particular emphasis on investment to support and scaling up of ideas from smallholder and family farms.
- Invest in and encourage research superclusters to develop new technologies and benefit from economies of scale.

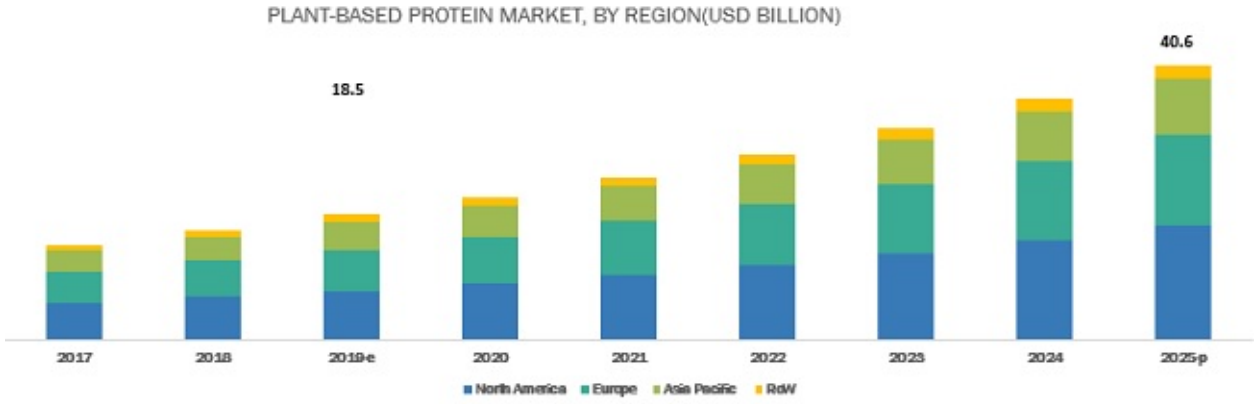
- Bring small, medium and large enterprises, academic institutions and not for profit organizations together to work with governments to generate bold new multi-sector ideas and partnerships.
- Strengthen ties including; North-South, North-North, and South-South. Technology and resource sharing should be maximized across public and private spheres as well as across regions.
- Foster private sector investments in a variety of solutions including NPFSs, feed alternatives to lower methane emissions from livestock, food additives to improve taste in healthy foods and in vitro meat produced in labs among others, supports to help farmers introduce new sustainable practices, and introduce new systems to curtail food waste, etc.
- Private sector development must come with public sector improvements to remove red tape that slows the advancement and implementation of existing innovations.

The Issue in Brief

The food production system faces a number of compound challenges that can be addressed in a variety of ways through innovation and investment. Here are some illustrative examples:

- According to the FAO, no other sector holds as much potential to reduce GHGs as the agricultural sector. Innovation and investment in feeding livestock are explicitly recognized in this.[4]
- Economic development, especially across the developing world, will likely see a continued increase in the demand for ASPFs.[5] While some suggest efforts to curb ASPF demand are important, others argue that an increase in supply will be needed and that it must be produced in a more sustainable fashion than the current system provides.[6]
- Innovation is key to achieving food security, but there remain myriad roadblocks and barriers to both the development and implementation of developing agricultural technologies, practices and methodologies.[7]
- In many places, new products, processes and ways of organization already exist but having them effectively scaled-up and scaled-out to reach more producers on a larger scope remains an ongoing challenge, especially in the developing world.[8]
- There remains widespread resistance to certain types of innovation that often stems from misunderstanding the nature of innovations, or simply cultural desires to maintain certain traditional techniques and practices.[9]
- There is a need for ever-improved plant-based protein with better taste and functionality that is suitable for a use in a wide range of food applications and available in a wider array of products.[10]
- There has been major expansion of investment in plant-based meat alternative products, and the size of the market is expected to continue growing (see Figure 7.1). While one obvious beneficiary has been consumers seeking particular tastes and textures, there are some concerns about the possibility that the plant-based investment boom could lead to a cutthroat market which sees some winners while other firms, investors and employees will pay dearly, or alternatively that it could lead to a collapse of traditional livestock sector (leaving numerous farmers, ranchers, and agri-food producers in the lurch).[11]
- Finally, there is increasing concern about the corporate agglomeration of control over the burgeoning plant-based market.[12]

Figure 7.1. The Growing Plant-Based Protein Market



Source: Markets and Markets, 2019.[13]

Considerations:

Defining Innovation
The Food and Agricultural Organization (FAO) defines **agricultural innovation** as;

> *the process whereby individuals or organizations bring new or existing products, processes or ways of organization into use for the first time in a specific context in order to increase effectiveness, competitiveness, resilience to shocks or environmental sustainability and thereby contribute to food security and nutrition, economic development or sustainable resource management.*[14]

Innovation could thus focus on improving existing practices and management techniques of the in the agri-food system or developing entirely new technologies or new products that have not traditionally been a part of people's diets. Innovations may centre on production or consumption, or both. Many important innovations can be developed on-farm through traditional and local knowledge developed through trial and error and generations of experience. Each region has vastly different realities and certain practices and techniques will work in one place but not for another. There are endless innovations that can be accomplished through management options that reduce the vulnerability of soil to degradation, erosion and loss of moisture including, for instance:

- Improved techniques in water retention and micro-irrigation
- Restoring degraded lands using drought-resilient native plants
- New applications in agro-forestry
- Other agroecology and ecosystem-based adaptation practices.[15]
- Growing green manure crops and cover crops
- Reduced/zero tillage or conservation tillage
- Maintenance of ground cover through improved grazing management.[16]

Reducing Waste

An important application of innovation will be to find ways to reduce food waste, including circular production systems wherein waste becomes a useable input. From 2010-2016 8-10% of total anthropogenic GHG emissions came from global food waste (about 25-30% of all food produced is lost or wasted each year).[17] This can be mitigated through innovations in:

- Improved harvesting techniques
- On farm storage
- Infrastructure
- Transport
- Packaging
- Retail
- Marketing
- Education to help reduce food loss and waste along the entire supply chain.[18]

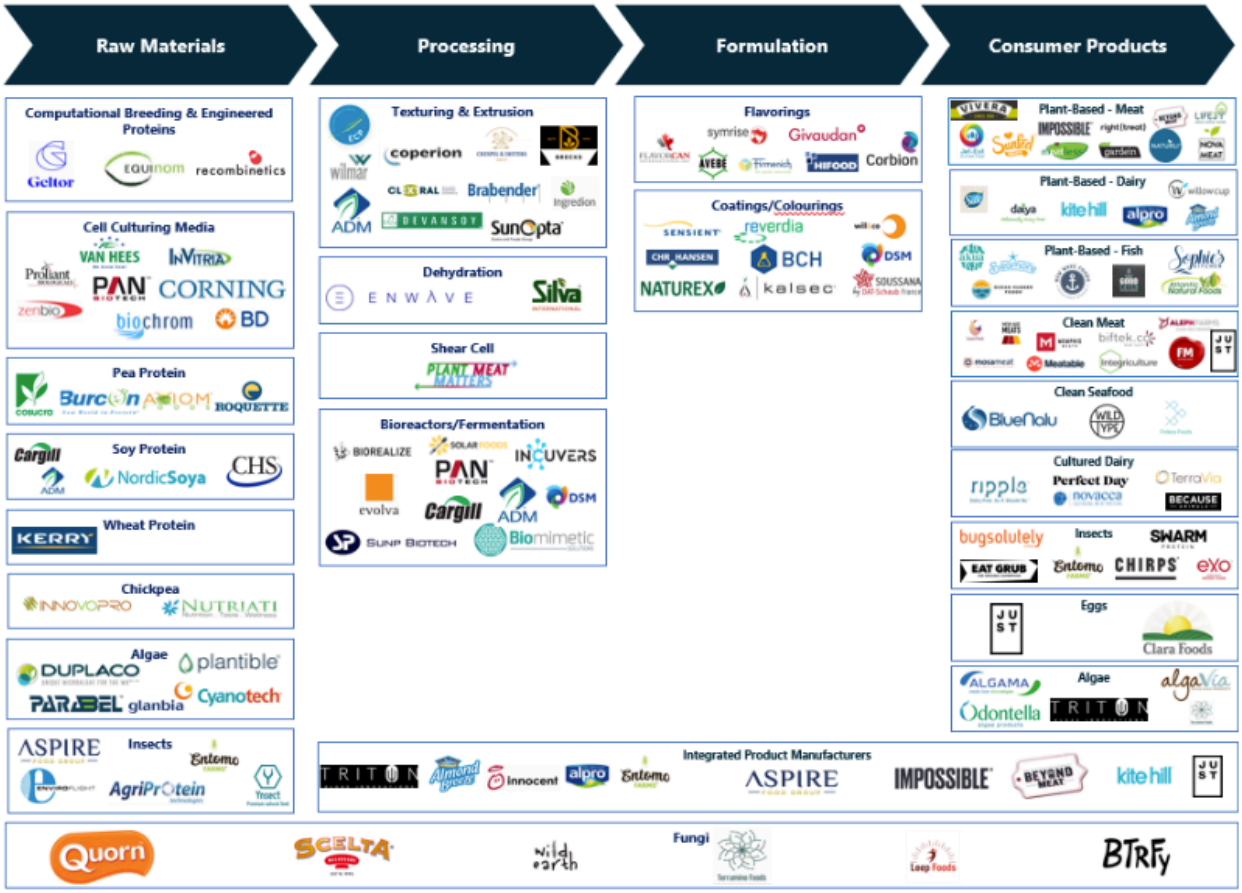
Big Protein

Private sector companies such as Tyson, Cargill and Maple Leaf Foods have sought to lead in efforts to become more sustainable through large-scale innovation and investment. They have done so by improving the way they source their current meat products, but have also developed growing lines of plant-based meat-alternative products to give consumers more choice and allow them to eat greener without feeling as though they are sacrificing meat completely from their diets.[19] What was once a small number of US-based meat packing firms cornering the global market for animal protein has now become a number of firms jostling for power in a quickly agri-food system. Much of the private sector sees these very models not as and/or but plus/and solutions. For example, most of these companies report not having seen any decrease to the growth in demand for their meat products but have simultaneously enjoyed growth in their new lines of protein products added on top of existing ones to meet the ever-growing demand for both ASFP *and* PSFP protein.[20] To-date, however, these numbers are difficult to verify, with reports varying widely depending on sources.

New Food Products

As hinted above, joining the traditional Big Food firms are dozens of new start-ups and companies involved in building an entirely new global market for plant-based proteins – at all stages of the commodity chain, from producing raw materials, processing, formulation and selling and developing novel products (see Figure 7.2). One example of these is *DSM* whose website suggests it "is a global purpose-led, science based company specializing in Nutrition, Health and Sustainable Living."[21] Their strategy is to use all the scientific and innovation power at their disposal to tackle some of the world's greatest challenges. One such avenue they have been actively pursuing is developments in turning inedible by-products of food production into valuable food protein. The company set up a project called 'Proteins of the Future' and what emerged was a new technology that enabled them to turn inedible agricultural by-products from rapeseed oil extraction, into valuable protein products for a wide variety of food uses.

Figure 7.2. The New Protein Corporate Landscape



A number of these firms are involved in producing cell-cultured meats. Such 'in vitro meat' has been proposed as humane and more environmentally friendly than meat derived from traditionally-raised livestock. The basic process involves culturing muscle tissue in a liquid form on a large enough scale to produce edible food products for consumers. The production process is completely controlled and thus can be manipulated along the way to produce a variety of outcomes (which is one of its greatest advantages). Thus far, the major limitations of in vitro meat production have been its ability to meet nutrient requirements as well as at sufficient scale to make it effective in contributing to sustainability.[22]

Some from the replace camp believe that as a result of this rapidly advancing precision biology that has resulted in huge strides in precision fermentation allowing us to program microorganisms to produce almost any complex organic molecule, the cattle industry will soon be bankrupt. They claim the quality of lab engineered proteins will continue to rise, eventually making it superior in every key attribute to ASPFs – including more nutritious, healthier, better tasting and more convenient, along with almost unimaginable variety. They predict this will massively reduce demand for livestock products and suggest that by 2030 the industry could be virtually bankrupt and demand for NSPFs continues to grow.[23]

Innovations for Health

People are increasingly looking for healthier alternatives, but at the end of the day taste still plays a major factor in decisions. Innovations have been made in creating healthy food additives to make foods that are low in sugar, salt, or saturated fat, more gastronomically pleasing. This also goes for foods that have additional fibers or plant proteins included that might alter the eating experience to maintain good taste, flavour and mouthfeel.[24]

Methane Inhibitors, Biogas Digesters, and more

Of course, as much as the plant-based and novel proteins markets are growing, these are eclipsed by the sheer size and global scale of ASPF production. The globalization and expansion of industrial livestock production means there are now hundreds of millions more farm animals now that there were half a Century ago (in fact, there are about three times as many farm animals living at any given time as there are people).[25] For those in the Repair camp, this inevitably means that innovations will play a central role in reducing the footprint of ASPF production.

One of the key sites of investment is in methane inhibiting technologies in cattle. The digestion process of cattle emits methane gases which contribute to 4% of all total global GHG emissions – making it a serious individual contributor to climate change from the farm. *DSM* (the corporation active in the plant-proteins market as well, as above) has created a feed supplement that is easily added to the regular diet of cattle which can reduce methane emissions from beef and dairy production by 30%.[26] Other firms are seeking to develop technologies with even greater reductions in methane from feed additives. Toxicologists, analytical chemists and external research institutes have conducted extensive testing and found this reduction to come with no apparent adverse effects to animal welfare, feed or consumption performance. Other firms still are experimenting with specialized halters or digital nose rings, which can be worn by cattle, designed to capture up to 80% of the emitted methane and oxidise it – effectively neutralizing a considerable portion of its warming potential.[27]

Biodigesters and advanced manure management systems are also being introduced as a new technology to reduce emissions in dairy operations in particular. These collect manure from the barn floor, capture methane from the resulting slurry (which is then burned to produce electricity), and produces waste solids which can be re-used for various purposes (including fertilizer and bedding).[28] Given that methane from manure management is responsible for about 5.2% of the livestock sector's emissions, capturing the methane and using it for renewable power generation offers additional GHG savings to methane-inhibiting feed additives or methane-oxidation devices.

One dairy farm concept in the Netherlands has taken innovation to the next level. It has introduced the idea of a small floating micro-dairy as a means to produce protein foods in urban areas that do not take away from urban land requirements and which are resilient to flooding and sea level rise. The three storey structure, with 35 dairy cows, floats in the Port of Rotterdam, and includes a processing plant on upper floors where the milk is pasteurized and made into yoghurt, supplying the neighbourhood.[29]

The Challenges of Scaling-up

The innovations and investments that have been discussed above have been making inroads toward providing more sustainable protein, yet one of the biggest challenges that remains with most of them is scale. As certain innovations are developed to try to replace older, unsustainable products and processes, demand is outstripping growth of the new more sustainable alternatives.[30] While each of the 'protein pathways' take different paths and see benefits for their own pathway and

negatives in the others, ultimately one does not necessarily undermine the other. That is, arguably there is merit to pursuing all pathways in order to attempt as many safe and diverse solutions as possible. The remainder of this brief considers how each pathway sees the future of innovation and investment in the protein subsector.

REPAIR:

Innovating technical solutions for success

Through what can be viewed as the more traditional approach to innovation and investment the **REPAIR** camp sees targeted investments as a way to develop more sustainable protein supplies for growing populations. Successful innovations are being introduced all the time as a direct result of targeted investment. However, those in the repair camp typically find that the approval process to get new products and innovations to market is slow. By ramping up these processes these technological fixes will continue to improve, scale up and hit markets sooner to realize broader success.

Improving equipment efficiency

While those concerned with environmental sustainability have long been pushing for improved efficiencies on our highways, farm equipment efficiency has often flown under the radar. Conventional farms use a great deal of energy through the extensive array of machinery and in order to power barns and greenhouses, etc. Improvements in efficiency on a range of equipment from tractors to combines, to trucks, all-terrain vehicles and even the efficient production and distribution of electricity are all important parts of creating more sustainable protein subsystem.

REPLACE:

No way around less meat

The **REPLACE** camp believes it will be virtually impossible to sustainably meet the growing demand for protein using traditional ASPFs. As such, it envisions a major scaling up of investment and innovation in the areas of PSPFs and NPFSs to replace at least a portion (if not more) of humanity's protein intake. They additionally call for continued investments in plant genomics and novel processing technology to increase the value of key crops such as canola, wheat and pulses that are coveted in high-growth markets.[31] These can supply high growth markets such as China and India. While both supply and demand of PSFPs has increased, especially in wealthier countries, most is currently produced as a side-stream during their processing into other food, and this processing can negatively influence the properties of protein. That is why there is still a great need for increased innovation and investment to replace existing protein and continuously improve the way they are produced.[32]

Protein alternatives that are better for the planet and our health

As mentioned above, the **REPLACE** camp sees less meat as necessary for the environment, but this camp also sees it as desirable for other reasons (as noted in prior briefs on health and ethics, in particular). Innovations have already begun with plant-based meat products as well as a growing industry for insect-based food products that are packed with protein.[33]

While not everyone is yet ready to give up meat and dairy, there is an ever-expanding line of products that are proliferating through many regions of the world and in others have always been an important dietary staple. Once products such as cricket protein powder expand to cricket based pasta, bread, chips, crackers and other products that are healthier than their traditional counterparts, there will be a much larger buy in from the public for this sustainable alternative that proponents argue is better for people's health.[34]

New innovations have made rapeseed protein edible for humans and can be used in a broad range of food products in areas such as: Clinical nutrition; sports nutrition; weight management; baby food; food for the elderly; specialist foods such as non-gluten and vegetarian alternatives. It is also GMO-free, gluten-free, and dairy-free as well as being hypo allergenic and great tasting.[35] Finally, implementing and scaling up an in vitro meat production to complement existing ASFPs will create additional opportunities for new types of more sustainable meat products to reach markets and expand.

RESTORE:

Innovation beyond 'technological fixes'

The **RESTORE** camp sees innovation and investment differently than the other two camps. The challenge is to rethink conventional farming, which has become 'linear' and 'extractive' – and remake it in nature's images (which is to say to make it regenerative and cyclical).[36] Innovations and investments will be required to produce enough high-quality sustainable proteins in a regenerative manner, whether it is through research and new practices in agro-forestry, mixed farming, soil carbon sequestration, mob grazing, biochar production, green fertilizer, etc., there is ancient wisdom available which can be applied to the modern era in order to produce wholesome healthy agri-food systems.[37]

The call of the foodie

The **RESTORE** camp does not see this pathway as simple or cost-free, but instead sees it as a societal shift that can regain the lost balance of the food industry from farm to table. Consumers everywhere as well as the public and private sectors are becoming increasingly aware of the imbalance that our current food system has incurred and have sought sustainable transition. This is seen with an ever-increasing demand for organic, seasonal, locally-produced products which support community development. This is part of the growing 'foodie' culture where people want not only to eat tasty and nutritious food, but just as important food they know is supporting resilient agro-ecosystems.[38]

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