The New Protein Economy: policy directions

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Acronyms used in this paper.

ADB	Asian Development Bank
BCG	Boston Consulting Group
BH	Blue Horizon
EY	Ernst & Young
FAIRR	Farm Animal Investment Risk and Return
FAO	Food and Agricultural Organisation of the United Nations
GFI	Good Food Institute
GHG	Greenhouse Gas
GGR	Greenhouse Gas Removal
IDB	Inter-American Development Bank
ILO	International Labour Organisation
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
LEAP	Livestock, Environment and People
NPE	New Protein Economy
OECD	Organisation for Economic Co-operation and Development
R&D	Research and Development
SDGs	Sustainable Development Goals
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

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Executive summary

In March 2022, global food prices reached their highest ever levels. Data from the Food and Agriculture Organisation (FAO) shows that food commodities (cooking oils, cereals and meats) cost one third more than they did a year ago. The consequences of this surge are already being felt by vulnerable individuals and communities around the world. No immediate respite seems in prospect.

This report is being published during one of the most precarious periods in the history of the modern global food system. The 2022 invasion by Russia of Ukraine has wreaked havoc on the lives and livelihoods of millions of people. The direct consequences of this act are already being acutely felt by countries in North and East Africa, the Middle East, and Europe. Policymakers worldwide, scrambling to respond, are having to navigate international geopolitics while remaining conscious of their national interest. While all the long-term consequences of this crisis are unknowable, it is already apparent that the invasion has triggered some fundamental changes, for example in the energy policies of several European countries.

It is our contention that current events also present a catalytic opportunity to reform and improve how integrated global food systems operate. When this paper was originally conceived in 2021, our thesis was that investments in the green recovery following COVID-19 could provide the impetus for growth in what we call the 'new protein economy'. And while this remains an important driver, it is possible that the price shocks being experienced in 2022 provide an even more powerful lever for policy changes that could support a shift towards a more sustainable food system through increasing the share of protein derived from 'alternative' sources such as plant-based analogues and cultured meat.

In this report, we make the case for investments in the new protein economy that create a positive stimulus in the short-term along with enduring economic, environmental, and societal co-benefits in the longer run. We explicitly acknowledge that differences between countries, for example in terms of national income, the share of agriculture in the economy, as well as socio-cultural practices, means that the transition to a sustainable food system will require a range of context-specific interventions.

We set out the case for activist government policies to accelerate transitions to the new protein economy and highlight key areas where these policies could be implemented. But the economic, social and cultural fabric of individual countries is not the same, and after briefly describing how this heterogeneity would influence the new protein economy, we propose some adaptive interventions for country archetypes based on (i) meat consumption per capita, (ii) agricultural dependence of GDP, and (iii) the income category of a country. We briefly outline a framework to synthesise the economic, environmental and social impacts of interventions across different country archetypes.

The purpose of this report is to a catalyse a discussion around the unexpected opportunity that recent disruptive events may have provided to drive change in global food systems. Policymaking is difficult and we offer no panacea to the very real challenges associated with systems change. But we believe that the reward is worth the effort, particularly when considering the consequences of maintaining the status quo. Ultimately, we offer up a nascent framework to help policymakers contextualise the interventions that are available to them, recognising that any meaningful country-level analysis will require more layers than this.

1. Introduction

While the COVID-19 pandemic highlighted the fragility of parts of our food system (O'Callaghan and Mudrock, 2021; FAIRR, 2020) it also presents a transformative opportunity for countries to challenge path dependency and the status quo. There is at least the prospect that a coalition of the willing could contribute to a green global recovery through national policies that are more aligned with the trajectory of net zero emissions (Hepburn et al., 2020) than they were prior to the pandemic. And while investment opportunities in areas such as renewable energy, low carbon transport and green manufacturing are widely documented, less has been written about the green post-pandemic recovery opportunities associated with transforming our food systems (Green Alliance, 2020).

Green recovery opportunities in agriculture exist on both the supply-side (e.g. ecosystem regeneration, skill building and retraining, investments in sustainable farming) and the demand-side (behavioural and societal change). In this paper, we make the case for investments in the 'new protein economy' (NPE), that create a positive stimulus in the short-term along with enduring economic, environmental, and societal co-benefits in the longer run. In essence, the NPE constitutes a shift towards a more sustainable food system through increasing the share of protein derived from 'alternative' sources such as plant-based analogues and cultured meat.

The market for alternative proteins is growing rapidly, driven by innovation and increased consumer awareness of the health, animal welfare, and environmental concerns associated with conventional animal protein. In September 2021, the United Nations hosted the Food Systems Summit which described a global food system transformation that underpinned the critical role of food in achieving net zero emissions and meeting the Sustainable Development Goals (SDGs). In this paper, we explicitly recognise that differences between countries, for example in terms of national income, the share of agriculture in the economy, as well as distinct socio-cultural practices, means that the transition to a sustainable food system will require a range of context-specific interventions.

According to the Global Recovery Observatory, governments of the world's fifty largest economies deployed approximately US$15 trillion through fiscal support packages in 2020 to offset the downturn due to the COVID-19 pandemic. However, less than one-fifth of this amount was allocated to investing in the recovery, and of that, only 18% was explicitly directed towards a green recovery (O'Callaghan and Mudrock, 2021). In this ongoing period of recovery, there is a need for governments to design policy measures that will support socioeconomic development in the context of a green recovery (Global Alliance, 2020; UNEP, 2020). Investing in the NPE can directly support a green recovery given its environmental and economic impact (Parodi et al., 2018; Poore and Nemecek, 2018; Godfray et al., 2018; Deleidi et al., 2019). Societal benefits associated with the NPE can include improved food security, reduced vulnerability to climate change, positive health outcomes through decreased diet-related diseases, and improvements in animal welfare (Sexton et al., 2019; Funke et al., 2021; Treich, 2021). We propose that aligning policy with enterprise and capital to stimulate growth of the NPE could present a catalytic opportunity to transition to food systems that are more sustainable, resilient, and equitable in the long-run.

No large-scale systemic change of this type is possible without structural shifts in the global economy. At the national or subnational scale, there are different implications from these shifts. Domestic economies that are highly exposed to traditional agricultural practices may face high frictional costs, for example. Other challenges may include limited infrastructure or capacity, and a reluctance to depart from existing practices. This risks the possibility of exclusion from alternative protein sectors (Newton and Blaustein-Rejito, 2021). Adaptive policy measures are necessary, therefore, to address the cyclical, structural, and frictional impediments to change.

2. The New Protein Economy

Although alternative proteins currently represent just 1% of the total protein market (FAIRR, 2021), double-digit growth rates mean that alternative protein sales are forecast by the consultancy McKinsey to reach US$18 billion by 2025 (2020: US$ 2.5 billion). Sales of plant-based meat alternatives in the US market alone exceeded $1 billion in 2020 and accelerated sharply during the COVID-19 pandemic (210 Analytics, 2020).

Market research suggests that current growth trajectories could be sustained if there is a supportive regulatory, policy, and investment environment. A recent report from Boston Consulting Group (2021) projects that the alternative proteins market could make up between 11% and 22% of the overall protein market by 2035. Assuming average revenues of $3/kg, this amounts to an annual market of around US$300 billion (BH and BCG, 2021). And a paper by EY (2021) forecasts the alternative meat market share in the US could exceed 40% by 2040 - even in the absence of policy-driven tailwinds. If appropriate regulatory drivers are incorporated into conventional protein production, then these baseline forecasts could easily be surpassed.

2.1 The Alternative Proteins Mix

The NPE consists of both novel sources of alternative proteins which are still under development (e.g. cellular agriculture) alongside more established sources which have been consumed for millennia (e.g. plant-based proteins). At present, alternative proteins can be broadly categorised as: plant-based proteins, insects, and 'cellular agriculture'[1]. Cellular agriculture includes cultured meat, mycoproteins and bacterial proteins as well as precision fermentation[2] (Sexton et al., 2019). The characteristics of these three categories is considered in turn.

Plant-based proteins such as soya, beans, peas, and nuts are already widely consumed in lower-income countries (LICs) where animal-protein is largely unaffordable. In addition, plant protein concentrates and isolates have also been used to create meat-analogues (i.e. meat-

[1] This does not imply equal stages of production or consumption of the alternative proteins. For example, plant-based alternatives are more widely consumed in comparison to edible insects.

[2] Precision fermentation uses microbial hosts as "cell factories" for producing specific functional ingredients.

free products which are processed to mimic the texture, taste, and gustatory experience of meat) which have increasingly gained popularity (Boukid, 2020; Newton and Blaustein-Rejto, 2021). According to EY (2021), plant-based meat in the US may reach sensory and price parity by 2024. By definition, meat analogues are highly compatible with existing food habits yet have approximately one-tenth the greenhouse gas (GHG) impact of meat and a fraction of land and water use (Carmichael, 2019).

Edible insects have long been part of the human diet, predominantly consumed by ethnic groups in South and Southeast Asia, Africa, South America, and Mexico as a cheap and sustainable source of protein (Sexton and Glover, 2015). Products are now becoming available more globally. For example, in 2018, Sainsbury's became the first supermarket chain in the UK to stock edible insects in order to promote sustainable food sources (Taylor, 2018). Insects can be farmed for consumption in their entirety or used in powder form as flour (Morrisy-Swan, 2018). French company Ynsect produces a range of protein powders derived from mealworms that are already being used in some brands of energy bars and pasta. A variety of feedstocks can be used to produce insects, including "waste" food that isn't suitable for human or vertebrate feed. According to *Meticulous Research*, the edible insects market is projected to rise at an annual growth rate of 26.5% to reach $4.63 billion by 2027 (de la Hamaide, 2021).

Cultured meat involves producing meat by in vitro culture of animal cells, rather than from slaughtered animals (Treich, 2021). Although the growth medium is still being explored, cultured meat has the potential to revolutionise food systems by providing the same product without the negative externalities (Treich, 2021). The first cultured meat burger was manufactured for consumption in 2013 (Mattick et al., 2015b) and dozens of companies (e.g. Memphis Meats, Mosa Meat, BlueNalu etc.) are now working to commercialise production and bring their products into the market in the near-term, at least at a small scale (Rubio et al., 2020). In December 2020, Singapore became the first country to gain regulatory approval for cultured meat. This enabled the first-ever commercial sale of cultured chicken produced by US start-up Eat Just, served at a restaurant in Singapore (Bennett, 2021). Lab-grown meat products have also reached markets in Israel and Israeli bio-tech company Future Meat has launched the "world's first industrial cultured meat facility" with capacity to produce 500 kg of lab-grown meat a day (de Sousa, 2021). The cultured meat industry spans over 75 companies (de Sousa, 2021) and a recent paper by McKinsey & Co (2021) states that the market for cultured meat could reach $25 billion by 2030.

Additional forms of alternative proteins include mycoproteins which are a meat-replacement derived from fungi (e.g. products produced by Quorn and Nature's Fynd), algae which are protein-rich aquatic plants (e.g. spirulina and duckweed), and proteins derived from bacteria (e.g. produced by Solar Foods). Quorn is also looking to derive protein from food waste (e.g. crop leftovers) as a "solution to the twin problems of climate change and food wastage" (Morrison, 2021).

2.2 The Barriers to and Benefits of Alternative Protein Sources

Alternative proteins potentially offer widespread economic, social, and environmental benefits. However, challenges that need to be overcome include affordability, emissions intensity, consumer acceptance, and capital investment.

Although the price of plant-based alternatives can be up to 13 times lower than that of animal meat (Rubio et al., 2020), many novel alternative protein sources currently require a high retail price point. The first cultured meat burger was unveiled in 2013 at a manufacturing cost of $350,000 (Mattick et al., 2015b). Although production costs have fallen dramatically and are projected to reach $22 per kg by 2022, they are still high compared to the cost of beef at $10.4 per kg (Kateman, 2020). However, alternative protein production stands to benefit from reductions in the cost of renewable energy, further R&D, and from economies of scale (Specht, 2021). Provided they are scalable, proteins derived from cellular agriculture (e.g. cultured meat and bacterial proteins) also have the potential to become cheaper than animal-based proteins (Tubb and Seba, 2019; Godfray, 2019). According to McKinsey & Co. (2021), roughly 75% of costs of cultivated meat could be eliminated via increased scale and refined manufacturing processes while an additional 25% could be reduced by strengthening R&D, resulting in a cost of $11 per kg. Similarly, a recent study by GFI (2021) shows that cultured meat could be cost-competitive with animal protein by 2030, with production costs being as low as $5.7 per kg. In today's marketplace, there is evidence that consumers are willing to pay extra for products that they believe are healthier and more sustainable (McKinsey & Co., 2021).

A number of alternative protein production processes (e.g. cultured meat, bacterial protein, growth of microalgae) are energy intensive (Tuomisto, 2019; Collett et al., 2020; Lynch and Pierrehumbert, 2019). For example, cultured meat production requires 12kWh per 100g protein (Parodi et al., 2018). In some cases, GHG emissions from lab-based meat may accumulate and overtake emissions associated with cattle production (Lynch and Pierrehumbert, 2019). As such, emission savings will depend on the carbon intensity of the electricity supply. A recent study by GFI (2021b) found that the carbon footprint of cultured meat production drops by 80% if renewable energy sources are used. Cultivated meat produced using decarbonised energy reduces global warming impacts by 17%, 52%, and 85 - 92% compared to conventional chicken, pork, and beef production, respectively (GFI, 2021b). Ultimately, investment in renewable energy sources is critical to realising the full potential of the NPE and ensuring a net gain in GHG emissions reduction.

In terms of consumer acceptance, many consumers have deep cultural and psychological ties to conventional meat. Novel products challenge conventional notions of meat and could raise concerns about the perceived "unnatural" methods of food production (Godfray, 2019; Rubio et al., 2020). Poor regulation, transparency, and communications could further impede building consumer appeal and adoption of alternative protein products (Sexton et al., 2019). Without sufficient consumer demand the economies of scale needed for prices to fall and products to become cost-competitive with conventional meat (Treich, 2021; Rubio et al., 2020; Godfray, 2019) may not be realised. However, if these challenges surrounding consumer acceptance are overcome, a recent report by EY (2021) has stated that as cultivated protein technologies advance, cultured meat could surpass plant-based proteins in popularity by 2040.

The transition to a new protein economy requires significant capital investment. Many of the new technologies are R&D intensive and moreover are often being developed by companies that are themselves early-stage, pre-revenue ventures. Given the additional upfront challenges of consumer acceptance that are needed to achieve cost reductions through scale, many conventional sources of early-stage finance and investment, such as banks and venture capital, may not be accessible to businesses that are perceived as being too risky. Policy-driven incentives to invest in the transition are likely to be necessary; this could include incentives for incumbent firms to diversify or invest. There is the potential for corporate venturing to play a key role in the development of the NPE (Money and Cottee, 2021). Incumbent food companies often already have production facilities, R&D capabilities, distribution networks and insights into local consumer preferences the collectively could support an accelerated transition.

2.2.1 Economic Benefits of the NPE

The NPE has the potential to generate new jobs and income for those across the livestock industry as well as freeing up government subsidies related to animal agriculture. New jobs can be created by harnessing new economic opportunities associated with an emerging alternative protein sector and its supply chains (Newton and Blaustein-Rejto, 2021). Livestock farmers may diversify or transition into new sectors and new jobs may be created in alternative meat production facilities. Anecdotal examples include dairy farmers switching to growing oats for plant-based milk or chicken farmers repurposing their sheds for mushroom production (Newton and Blaustein-Rejto, 2021). A recent scenario-based study by ILO and IDB (2020) found that transitioning towards a net-zero economy will generate 22.5 million jobs in plant-based food production, renewable electricity, forestry, construction, and manufacturing, and 7.5 million fewer jobs in animal-based food production, fossil fuel electricity and extraction, and mining (implying a net gain of 15 million new jobs) by 2030 in Latin America and the Caribbean.

According to the decarbonisation scenario, a shift in diets and subsequent emergence of the plant-based food sector dominates this job creation by generating 19 million full-time jobs in 2030 (ILO and IDB, 2020). Similarly, the UK's National Food Strategy estimates that developing and manufacturing alternative proteins in the UK (rather than importing them) would generate approximately 10,000 new factory jobs and secure 6,500 jobs in farming.

Thus, for countries able to secure competitive advantage, investment in alternative proteins has been identified as having a long-run economic multiplier effect (UNEP, 2020). This is achieved through employment, wealth creation, innovation opportunities, knowledge spillovers (e.g. in regenerative sciences), and other positive externalities associated with the NPE (Deleidi, 2019; Tubb and Seba, 2019). Ultimately, the economic case for investment in the NPE serves as a critical lever for motivating public intervention.

Additionally, most existing agricultural policies support incumbent production systems, providing subsidies and market support measures to intensive meat and dairy farmers and the big corporations that profit from them (FAO, 2012; Changing Markets Foundation, 2020). The subsidies supporting animal agriculture could be reformed and funds could be reallocated towards the remuneration of environmental services, production of alternative protein sources, and investment in R&D. Such agricultural subsidy reform has potential to generate signification economic benefits and will be discussed in greater detail in Section 6.

2.2.2 Societal Benefits of the NPE

Social benefits associated with switching to alternative protein sources include improved food security and reduced vulnerability to climate change, improvements in animal welfare, and positive health outcomes through decreased diet-related diseases. There has been a significant body of research in recent years showing clear associations between the intake of red and processed meat and adverse health outcomes (Godfray et al., 2018; Papier et al., 2021; Sexton et al., 2019) including obesity (Popkin, 2002), heart disease (Westhoek, 2014), and even certain types of cancer (Amine et al., 2002; Pan et al., 2012; McMichael et al., 2007). As such, the NPE can offer significant individual and public health co-benefits by minimising the incidence of diet-related disease and generating indirect cost savings for public health budgets (Carmichael, 2019). For example, the World Economic Forum (2019) found that incorporating meat alternatives (e.g. beans and lentils) into diets could reduce diet-related mortality by 5-7%. Additionally, in the UK, lowering average meat intake to two to three servings per week could prevent 45,000 diet-related deaths and save the NHS £1.2 billion per year (Scarborough et al., 2010).

Moreover, opportunities for improved food security and accessibility are possible because some alternative proteins are less sensitive to external conditions (e.g. weather and geography) than conventional meat production (Treich, 2021). For example, mycoproteins and bacterial proteins are location agnostic, implying that their production is not restricted by soil quality, rainfall, land area etc. Factories for these proteins are geographically flexible provided there is transport connectivity (for distribution of goods and delivery of production inputs) and reliable energy supply (Newton and Blaustein-Rejto, 2021). For example, cultured seafood could be produced in inland locations that are more resilient to extreme weather events.

Additionally, the NPE reduces the risk of antimicrobial resistance (AMR) and emergence of foodborne illnesses and infectious diseases (such as COVID-19) associated with intensive livestock production systems (O'Neill et al., 2016; Santo et al., 2020; Espinosa et al., 2020). Cultured meat and plant-based alternative products could also minimise concerns about animal welfare in the meat production process as they are viewed as being a "moral improvement" (Treich, 2021).

2.2.3 Environmental Benefits of the NPE

At present, food production directly and indirectly accounts for over 26% of global GHG emissions, as shown in Figure 1 below (produced by Our World in Data using data from Poore and Nemecek, 2018). Of these, approximately 60% of emissions are due to animal-related products (i.e. meat and dairy).

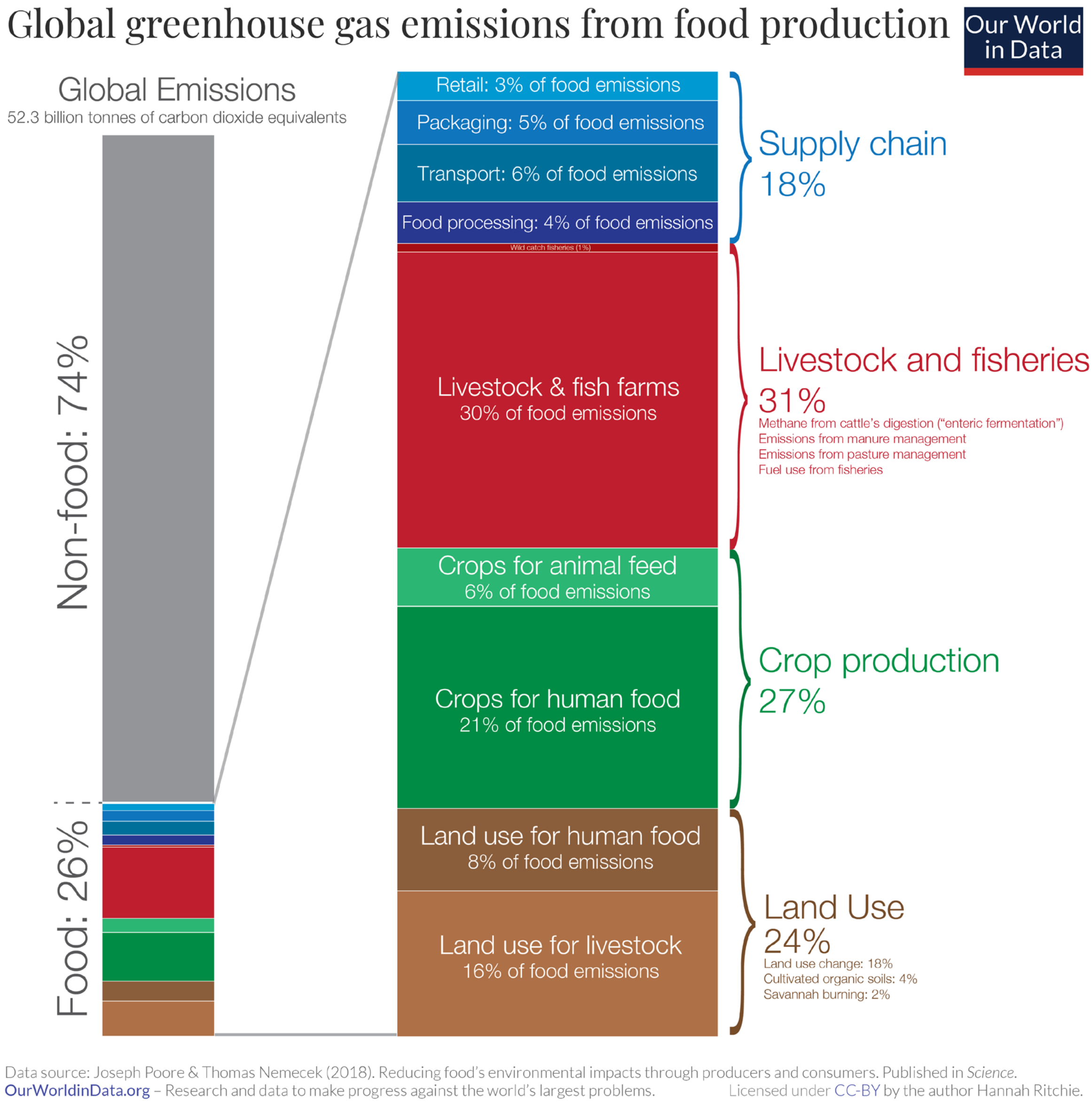

Figure 1 GHG Emissions from Food Production. Data from Poore and Nemecek (2018) and Figure produced by Our World in Data. Carbon dioxide equivalent values CO2eq are used to aggregate emissions of different gases (such as methane and CO2) using the 100-year Global Warming Potential (GWP100).

Emissions related to products from ruminant animals (e.g. cows, goats, and sheep) are responsible for some of the highest GHG emissions per 100g of protein (Collett et al., 2021; Poore and Nemecek, 2018). Ruminants have a very high carbon footprint due to methane production because of their enteric digestive process and significant CO_2 emissions associated with land conversion for grazing and animal feed crops, especially for beef herds (Poore and Nemecek, 2018). The GHG emissions across the supply chain from protein-rich foods can be seen in Figure 2. Additionally, animal products use approximately 83% of the world's farmland while providing only 37% of our protein and 18% of our calories (Gerber et al., 2013; Poore and Nemecek, 2018).

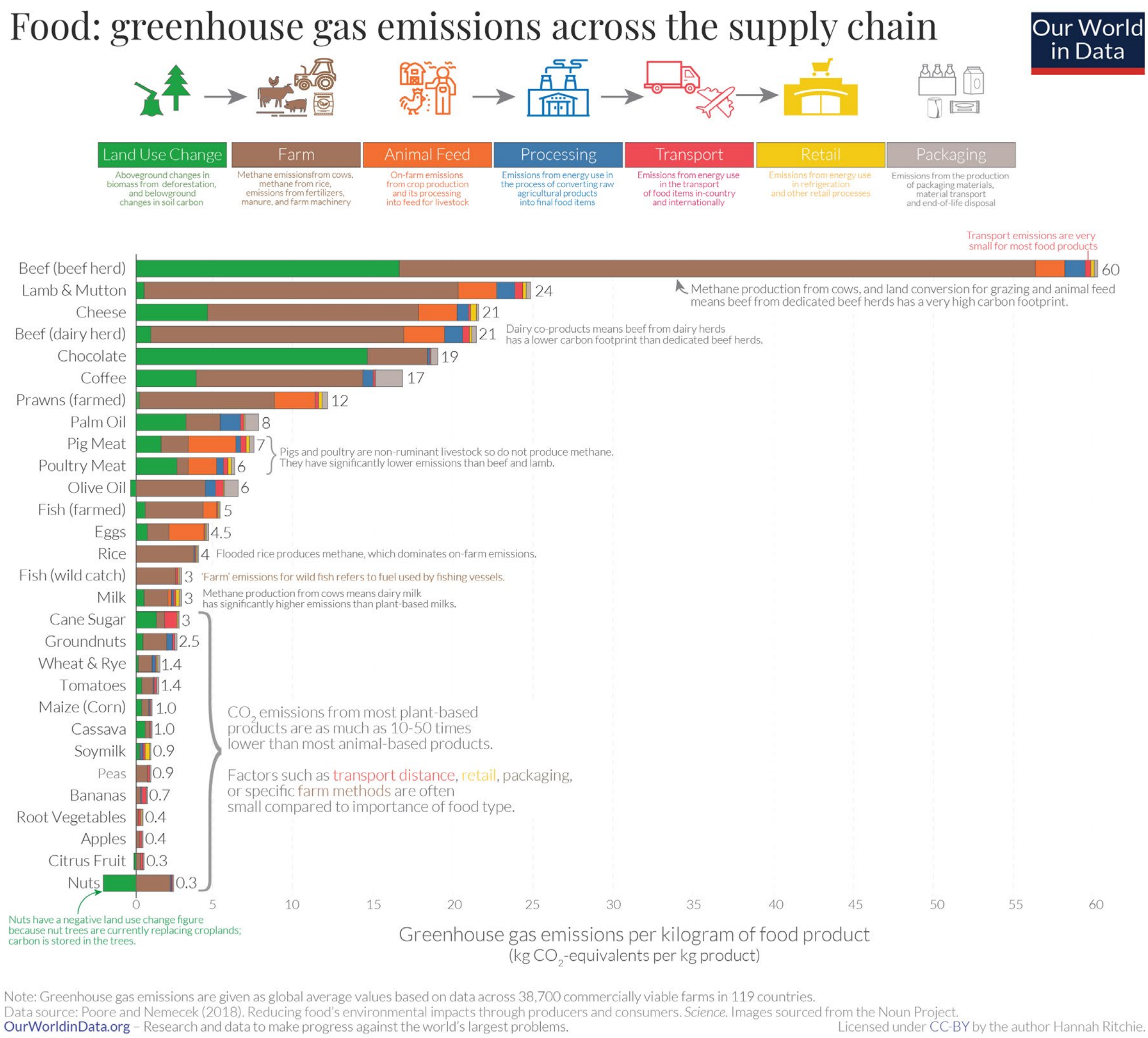

Figure 2 GHG Emissions (CO2eq) from Protein-Rich Foods, per kilogram of food product. Data from Poore and Nemecek (2018) and Figure produced by Our World in Data.

In comparison, alternative proteins have much lower environmental impact per kg of food. A 2015 life-cycle analysis showed that animal-free dairy products use 91% less land, 98% less water, and 65% less energy, while emitting 84% less GHGs compared to conventional dairy products (Steer, 2015). Presently alternative proteins such as plant-based proteins, insects and mycoproteins emit only 2% of the GHG emissions of beef and 10% of the emissions from poultry (Parodi et al., 2018). Other alternative proteins such as algae, cultured meat, and bacterial proteins offer a more moderate emissions reduction due to their high energy consumption. However, if they are produced with renewable energy in a net-zero world, they have the potential to offer reductions of up to 99% of the emissions associated with poultry (Collett et al., 2021).

There are additional environmental benefits associated with a transition to the NPE. Land that has traditionally been used for grazing animals can be repurposed to provide nature-based greenhouse gas removal services (GGR). Figure 3 shows the vast potential savings from a dietary shift to traditional alternative proteins, otherwise known as a vegan diet. For the next 100 years, this change could offer emissions reductions of near 15 Gt per annum.

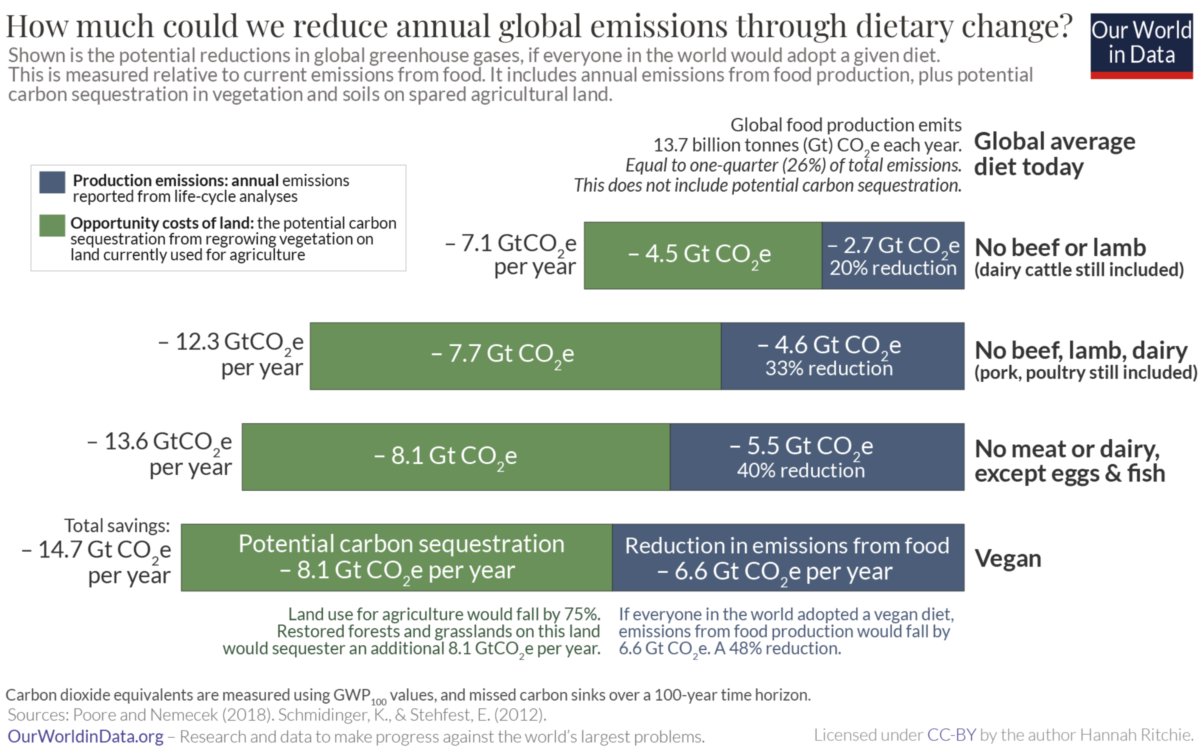

Figure 3 Emissions reductions and potential CO_2 sequestration with dietary changes over the next 100 years. Figure produced by Our World in Data.

Income from providing this carbon sequestration could serve as an additional revenue stream for livestock farmers who are impacted by disruptions in the conventional meat industry (Section 3).

In summary, the environmental benefits associated with transitioning towards the NPE include significant reductions in GHG emissions, water use, and land-use which could be ecologically restored to be a carbon dioxide sink as well as generate biodiversity and socioeconomic benefits for rural communities.

3. The Case for Activist Policy

We argue that the COVID-19 pandemic in 2020-1, along with the food and energy price shocks being experienced in 2022, provide a transformative opportunity for the NPE as policy makers endeavour to refocus on interventions that support socio-economic development, price stability and green growth. A low-carbon transition in the food sector is needed to meet the nutritional demands of a growing population in a sustainable manner while simultaneously addressing the SDGs related to tackling climate change, biodiversity loss, natural resource depletion, and hunger. The overarching aim of policy intervention should be to maximise the economic, environmental, and societal benefits of the NPE, while minimising the barriers and risks associated with deviating from the status quo. Achieving this requires multi-stakeholder collaboration between the private sector, public sector, and civic society. Policymakers play a pivotal role in facilitating this collaboration.

3.1 A Just Policy Framework: Aligning NPE Policy with Covid-19 Recovery Strategy

The cyclical, structural, and frictional challenges associated with the NPE transition underscore the need for a just policy framework. Rebasing agricultural activity towards the production of alternative proteins could have significant implications for domestic livestock industries that provides a livelihood for many people, including those who are among the most vulnerable to climate change (Tubbs and Seba, 2019; Treich, 2021). The livestock sector is valued at $1.4 trillion, comprising 40% of agricultural GDP worldwide and supporting 1.3 billion people - primarily small-scale farmers (FAO, 2020).

A just transition requires implementing adaptive policy measures that support workers, firms, and communities that would otherwise be negatively impacted by downsizing environmentally damaging industries (ILO and IDB, 2020). Without a just policy framework, transitions will be difficult due to insufficient human capital, inadequate skills, credit and capacity constraints, infrastructural barriers, and the possibility of exclusion from these sectors (Santo et al., 2020; Newton and Blaustein-Rejto, 2021). Much of the world's grazing land is not suitable for crop production and many of the skills and resources required in the NPE are not those that livestock farmers currently possess (Newton and Blaustein-Rejto, 2021; ILO and IDB, 2020; ILO, 2013, 2017). As a result, the biggest "losers" from a protein transition in the food sector are key players along the livestock industry supply chain whose jobs may be threatened, sources of livelihood disrupted, and ability to diversify into the NPE hindered (Changing Markets Foundation, 2018). This would include livestock farmers, processors of livestock products, and animal feed producers.

As such policymakers need to facilitate this protein transformation by designing policies that redress the distributional effects and systemic inequalities that may arise from disruptions within the contemporary protein and livestock industry (Sexton et al., 2018). This can be achieved through social protection schemes that mitigate risks and support farmers and rural communities during the period of transition (e.g. direct cash transfers and other safety net programmes), training initiatives and human capital development, agricultural subsidy reform, and the establishment of an agricultural land management regime (e.g. increased payments for providing ecosystem services). These adaptive measures will be discussed in greater detail in Section 6. Ultimately, public policy should offer a holistic interventionist approach that seeks to accelerate adoption of beneficial alternatives while minimising the disparities among putative winners and losers that arise in the transition towards a low-carbon food system (UNEP et al., 2008).

An effective and targeted policy response to facilitate the NPE could be streamlined within a broader green recovery strategy aimed at stimulating economic activity and driving a long-term downward trend in GHG emissions (Hepburn et al., 2020; O'Callaghan and Mudrock, 2021). This can be achieved by designing green stimulus packages that are able to achieve multiple "co-benefits"[3] at once to maximise gains and minimise opposition. The concept of co-benefits offers a useful lens for identifying policy pathways that can be incorporated into recovery packages to maximise support for a sustainable and just NPE transition.

There are several factors relevant to the design of green recovery packages including the long-run economic multiplier, impact on inequality, contributions to national wealth, speed of implementation, affordability, efficiency etc. (Hepburn et al., 2020). These can be realised by identifying policy levers that mutually reinforce the environmental, economic, and societal co-benefits of the NPE which overlap with some of the criteria listed above. Recovery packages that support the broader economic (long-run economic multiplier), social (positive health outcomes, animal welfare, AMR resistance), and environmental (reduced GHGs emissions, land, and water use) co-benefits would enable countries to build back better and more sustainably.

Ultimately, recovery packages that "seek synergies between climate and economic goals" have greater potential to strengthen national wealth, tackle inequality, and enhance productive human, physical and natural capital (Hepburn et al., 2020). As a result, countries should identify co-benefits (e.g. for health, environment, employment, and the economy) at the policy design stage so as to shape implementation criteria that maximizes impact. To summarise,

[3] Co-benefits are described as "additional benefits of tackling multiple issues simultaneously" (Parsons and Hawkes, 2018).

policymakers should use this transformative opportunity to facilitate a just transition towards the NPE by carefully allocating resources towards investments in high productivity assets, with greater economic multipliers to generate a capital stock and labour force well-equipped to deal with the challenges of the future (Hepburn et al., 2020).

4. Policy Measures

This section identifies important policy measures needed to facilitate a just transition to the NPE. The policy levers analysed for intervention include accounting for externalities, stimulating innovation, promoting behavioural change, and building public trust.

4.1 Accounting for Externalities

The negative externalities associated with livestock production are not currently reflected in retail prices and there is evidence to suggest that the livestock sector has remained largely under-regulated by policymakers (Bonnet et al., 2020; Krattenmacher et al., 2020; Funke et al., 2021). The lack of regulatory attention and targeted externality-correcting policy instruments in this sector, compared to energy and transportation, could be attributed to high monitoring and transaction costs alongside political considerations such as resistance by incumbents. As a result, current fiscal and regulatory measures tend to favour carbon-intensive and environmentally harmful activities that are largely misaligned with the low-carbon transition (OECD, 2015). Realigning agriculture-related fiscal policies with sustainability and climate objectives has the potential to support a just transition towards a more sustainable and low-carbon food system.

Policies that increase public disclosure (e.g. carbon accounting and labelling) and influence the relative price and affordability of different foods (e.g. taxes and subsidies) have the potential - when implemented with other policy measures - to generate a healthier and more sustainable food environment. Such policy measures can help shift producer and consumer behaviour through price signals that reflect external "costs," generate fiscal revenue for ecosystem services and sustainable land-use, reduce environmental degradation, promote healthy diets, and address other global challenges. These socio-economic and environmental impacts overlap for an effective COVID-19 green recovery strategy and should thus be prioritised by policymakers.

4.1.1 Disclosure

There exist very few meat and dairy companies that measure or report their climate emissions so knowledge about individual carbon footprints remains limited (Changing Markets Foundation, 2018). Such gaps in reporting have enabled big meat and dairy companies to continue their climate damaging practices while avoiding public scrutiny. As such, governments could impose legislation mandating carbon accounting and public disclosure that enable investors, companies, organisations and consumers to effectively manage their environmental impact and drive a structural transition over time to lower-impact foods. This can be achieved by developing emission reporting tools that facilitate the monitoring, reporting, and verification of agricultural emissions. For example, Cool Farm Tool is a calculator used to make a GHG emissions and carbon footprint assessment of a farm based on harvested yield, fertilizer application, energy use, pesticide applications etc. Similarly, CarbonCloud uses modern technology and a biophysical model to calculate the climate footprints of companies with a high degree of accuracy and efficiency. The overarching aim is to encourage companies to understand, calculate, and share their climate footprint, as those such as Oatly, Estrella, and Naturli' have done.

Moreover, the CDP (formerly the Carbon Disclosure Project) is a not-for-profit charity that runs a leading global disclosure system that encourages companies worldwide to measure, manage, disclose, and ultimately minimise their GHG emissions. By collating corporate climate change data and providing it to the marketplace, the CDP is increasing environmental transparency and accountability. This information-based policy lever could transform markets by incentivising producers to compete on this newly visible attribute (de Serres et al., 2010). This could inform incentives as the "true costs" of animal proteins are measured and managed.

The use of carbon labels on products has been gaining popularity and is an effective tool to allow for greater transparency in food production methods and positively influence consumer "green" purchasing behaviour (Joshi & Rahman, 2015). For example, many vegan and dairy alternative companies such as Quorn and Oatly include the carbon footprint of their products on their packaging and some Scandinavian countries (e.g. Sweden and Denmark) have expressed interest in imposing carbon footprint labels on all grocery items (Toussaint, 2021). The content of these labels is not limited to GHG emissions but could also include organic produce or environmentally sustainable labels (i.e. ecolabels) that report land, water, and pesticide use and inform consumers about the quality, features or production methods that reduce environmental impact (Thøgersen et al., 2010).

Essentially, it is anticipated that as consumers gain knowledge about their 'ecological footprint', there would be an associated increase in the market demand for more eco-friendly products, which would also encourage manufacturers to adopt more sustainable practices (FAO, 2012). One of the most comprehensive eco-labelling programmes is Germany's "Blue Angel" which has been in existence for 25 years and covers over 3,600 products. Ecolabels are also being developed and adopted in many developing countries such as India, Indonesia, Thailand, and the Philippines (FAO, 2012). Although progress is being made, carbon labels are yet to be commonplace and there is still a general lack of targeted industry-wide product specifications and labelling, resulting in limited understanding of the product composition and costs of animal protein. Thus, the transition towards the NPE would be facilitated if more products included carbon labels and environmental impact information at point-of-choice.

4.1.2 Fiscal Intervention

Fiscal intervention that creates a healthy and sustainable food environment would reduce risks to the whole society and is part of the core policy mix needed to support low-carbon agriculture and the NPE transition. Although the economic, social, and environmental costs from livestock production are significant, they have remained largely unaddressed in fiscal policy (Funke et al., 2021). In fact, current subsidies on food commodities and market support measures are largely directed towards intensive meat and dairy farmers and the big corporations that profit from them (FAO, 2012; Changing Markets Foundation, 2020). This encourages meat and dairy companies to continue their climate damaging practices and has resulted in unhealthy processed food products becoming significantly cheaper than healthy alternatives. As such, the appropriate pricing of meat which reflects its social and environmental costs should be at the forefront of policy regulation.

Food purchasing patterns are highly sensitive to price signals, especially when there are “close untaxed substitutes" available (Thow et al., 2014). A number of studies (Springmann et al., 2018; Garnett and Finch, 2016; Chatham House, 2015) have found that increasing the cost of unhealthy foods while lowering the cost of healthy foods is an effective tool for shifting consumption habits. This can be achieved by taxing unhealthy foods (e.g. pricing meat externalities) and subsidising healthy foods. For example, the strongest evidence that taxes on unhealthy products evoke a positive dietary change can be seen in the UK’s 2018 “sugar tax” (i.e. taxes on sugar-sweetened beverages) which resulted in many soft-drinks being reformulated to reduce their sugar concentration and a shift in sales towards products with lower sugar levels. Thus, a tax on meat could support the NPE transition by encouraging the uptake of meat substitutes, decreasing their relative price, and making them more competitive with conventional meat products (Funke et al., 2021). This in turn could indirectly accelerate the development and commercialisation of alternative protein products which could enhance their nutritional and sensory attributes (e.g. taste and texture) and increase the degree of substitutability between meat and alternative protein sources. Some OECD countries have adopted environmental taxes on agricultural inputs to reduce the environmental impact of meat and dairy products (FAO, 2012).

Moreover, a portion of the fiscal revenue generated from the meat taxes could be allocated to correcting market failures in a manner which support livestock farmers (i.e. the primary losers of the NPE transition) and produce societal benefits, thereby easing potential opposition from incumbents (Funke et al., 2021). For example, in Sweden, the revenues generated from a climate tax on food products were allocated to farmers for selected ecosystem services (e.g. peatland restoration) which strengthened the environmental effectiveness of the tax policy and increased the net income of farmers (Gren et al., 2021). This is part of a larger policy measure focusing on the establishment of an environmental service market (e.g. Payment for Ecosystem Services) which is an important fiscal tool that can deliver strong environmental, economic, and societal co-benefits and will be discussed in greater detail in Section 6. Moreover, meat taxation in high-income countries (HICs) may have an overall positive effect on global food security as the reduction in meat consumption would lower global food prices and benefit poor people in developing countries (Funke et al., 2021).

4.2 Stimulating Innovation and Knowledge Creation

Innovation is a key driver of low-carbon transitions and is largely influenced through core public funding of green R&D. Policy measures that stimulate innovation are needed to create an enabling environment for the NPE transition and support alternative protein production, commercialisation, and scaling. This includes attracting private and public investment, promoting R&D incentives, and facilitating knowledge creation by investing in collaborative scientific research with universities and academic institutes. Currently, alternative protein technologies (especially for cultivated meat) are still in the very early stages of development and deployment and remain largely underfunded by the public sector (GFI, 2021c). It is critical to mobilise public sector funding and encourage capital and innovation investment across the entire value chain to support the protein transformation, generate green jobs, and promote the creation of knowledge - particularly around the economic, health and environmental impact of alternative proteins. This could facilitate the creation of a robust knowledge base and trustworthy data that can help the emerging NPE follow the appropriate development pathways to produce best outcomes.

4.2.1 R&D Investment

Creating an enabling environment which encourages public and private investment in alternative protein technologies, collaborative scientific research, and systemic innovation is critical to accelerating the transformation of our food system (Herrero et al., 2020). The success of the NPE requires public investment in alternative proteins development, commercialisation, and scaling to ensure that the finished product formulation aligns with consumer preferences (i.e. sensory attributes), nutrition, price, sustainability, and variety (Carmichael, 2019). Areas to support scientific R&D in alternative proteins include crop optimisation, ingredient processing, and end product formulation to ensure that plant-based meat can successfully compete with conventional meat (GFI, 2021c).

Alternative protein technologies (especially for cultivated meat) are still in the very early stages of development and deployment so greater intervention is needed to reduce barriers and scale diversified protein production and consumption. Nevertheless, progress is being made and innovation has allowed for the commercialisation of a larger variety of meat analogues such as the 'Beyond Meat' and 'Impossible Foods' burgers. Additionally, NotCo is a Chilean food-tech company that uses AI technology to replicate animal protein and develop plant-based products and Umiami is developing a unique and proprietary technology to texturize plant-based proteins. While private sector R&D is necessary, it risks being duplicative with benefits accruing primarily to individual companies.

In contrast, publicly funded research has a significantly broader impact, stimulates further research, and has a long-run economic multiplier by facilitating economic growth, job creation and knowledge spillovers (GFI, 2021c). The economic co-benefits associated with investment in alternative proteins should motivate governments to fund R&D on novel protein sources and open source technologies that are used across the alternative meat sector (Newton and Blaustein-Rejto, 2021). Governments around the world (e.g. UK, Singapore, Israel, Canada, Japan, Israel, and the Netherlands) are recognising these benefits and actively supporting the development of alternative protein sources. For example according to the UK National Food Strategy plan, DEFRA has budgeted £280 million to support innovation as part of its Agricultural Transition Plan, with a particular focus on "farmer-led" innovation.

Early-stage research on a particular innovation also gives rise to a transferable skills base which can then be applied to other innovations. These innovation 'spillovers' are particularly high for novel products (Dechezlepretre et al., 2017) and in R&D-intensive industries (Bloom et al., 2013). There is a steep learning curve for alternative protein technologies (Funke et al., 2021) and since the total social returns on developing new technologies exceed the benefit to an individual firm, this should further incentivise public funding to support R&D in the sector (ADB, 2015).

Investments in novel innovations are often risky, costly, and slower to develop under the private sector (Treich, 2021). The longer time frames and uncertainty over whether their investment will yield sufficient returns could thus disincentivise private firms from investing in green R&D. Governments are often better equipped to handle the technical bottlenecks facing the alternative proteins industry and address the informational asymmetries, financial shortfalls due to risk, and other frictions that may arise in innovation investments. The public sector also has a higher tolerance and the resources needed to support the long-time horizon associated with foundational technological and scientific R&D (GFI, 2021c). This could facilitate long-term research resulting in cutting-edge innovation and technological breakthrough as opposed to incremental advances made by the private sector where risk appetites may be lower. Additional forms of intervention to scale up production of alternative proteins could include concessional finance and grants.

4.2.2 Knowledge Creation

A successful protein transition will require building knowledge and evidence on diversified proteins, filling knowledge gaps, setting holistic science-based targets and pathways, and establishing a robust database to track progress and developments in the sector. Knowledge-based capital has become an essential component for long-term productivity growth and is particularly relevant in the context of low-carbon transitions, as it accelerates the adoption of new technologies (OECD, 2017; Andrews and Criscuolo, 2013). Thus, governments should spur innovation through R&D funding alongside engagement with universities and other partnerships to build a strong knowledge base and gather robust data on alternative proteins. This is particularly important as there is greater scope for industry-academic collaborative partnerships to support interdisciplinary research in the nascent sector (GFI, 2021c). The UN Food System Summit emphasised the key role of universities in building support and developing innovation ecosystems or knowledge hubs that are both regional and global to facilitate collaborative research and dialogue to transform our food systems. The alternative proteins sector has been gaining traction in academic curricula. For example, GFI Brazil partnered with Federal University of Paraná to create the first cultivated meat course titled "*Introduction to Cellular Animal Science"* which is offered to postgraduate students (GFI, 2020c). Similarly, the Nanyang Technological University recently approved an alternative proteins course designed to build the industry's talent pipeline.

4.3 Promoting Behavioural Change

The IPCC (2018) report identifies "low GHG-intensive food consumption" as a critical pathway towards achieving the SDGs and Paris climate goals. Reducing consumption and production of animal-based products remains the single most effective way to minimise personal environmental impact on the planet and steer towards net-zero emissions (Poore and Nemeck, 2018). There is a growing body of literature which suggests that consumers do not adequately account for the risks to the environment and their own health when consuming meat, resulting in long-term 'internalities' from diet-related disease (Funke et al., 2021; Hartmann and Siegrist, 2017; de Boer and Aiking, 2018). As such, a critical role of policy intervention to support and sustain the protein transition is to induce a dietary shift towards healthier and more sustainable foods. This can be achieved by using information-based policy levers such as dietary guidelines and public food procurement initiatives that are effective in driving behavioural change and influencing demand for lower-impact foods (Potter et al., 2021; FAO, 2012, 2013).

This is particularly relevant for High-income Countries (HICs) where there is currently excessive meat and dairy consumption.

The COVID-19 pandemic has led consumers worldwide to re-evaluate how and what they eat in light of supply chain disruptions and public concern over the link between meat production and zoonotic diseases (FAIRR, 2020). This has resulted in a surge in the demand for plant-based products and governments could further this trajectory by introducing more lower-impact foods to catering menus and providing signals that evoke a targeted shift in consumer attitudes around the world. Ultimately, shifting to a more sustainable and low-meat diet will not only have a positive environmental impact but will also deliver significant individual and public health co-benefits by minimising the incidence of diet-related disease and generating indirect cost savings for public health budgets (Carmichael, 2019). The long-term environmental and societal benefits associated with these signalling tools underpin the urgent need for these measures to be integrated within recovery spending.

4.3.1 Dietary Guidelines and Health Advice

Establishing comprehensive national dietary guidelines can facilitate informed decision-making and increase demand for healthier and more sustainable foods. These guidelines typically set recommended levels of meat consumption and offer health advice encouraging the need to incorporate a range of alternative foods within healthier diets (Changing Markets Foundation, 2018). The Swedish Food Agency (SFA) was the first governmental body to include the environmental impacts of food production in its 2014 national dietary guidelines and other European countries such as the UK, France, Finland and the Netherlands have also set recommended levels of meat consumption in their dietary guidelines. For example, the UK established a national dietary guideline called the Eatwell Guide (EWG) and a recent study by LEAP (2020) found evidence that adherence to the EWG resulted in broad benefits to public health and the environment. This study provides evidence to support strengthened national action to improve diets. The EAT-Lancet Commission study provides a comprehensive and detailed proposal on what a balanced diet that is both healthy for people and the planet could be based on (Willet et al. 2019). Additionally, FAO and WHO have jointly produced guiding principles for sustainable and healthy diets that can be used and adapted by countries when framing their dietary guidelines.

The socio-cultural dynamics of food choice imply that the composition of these dietary guidelines may vary significantly culturally and regionally but these diets typically feature greater plant-based foods and moderate content of animal-based products (de Boer and Aiking, 2018; Hartmann and Siegrist, 2017). The implications of these socio-cultural differences for policymakers will be discussed in greater detail in Section 5.2. Moreover, since dietary preferences are endogenous and dynamically shaping the food system, there is potential for consumer behaviour and preferences to evolve so that a new equilibrium is reached where individuals eat less but more expensive meat (Funke et al., 2021). Ultimately, mobilising collective shifts in eating patterns could contribute to multiple sustainability objectives and would be part of a larger shift towards a more sustainable food system which is proven to be the most cost-effective mitigation technique available to consumers.

4.3.2 Public Procurement

Public procurement of food is an effective 'carrot'-type policy instrument designed to use government purchasing power to promote health, environmental, animal welfare, and other food policy objectives (European Public Health Alliance, 2019). Public food procurement (PFP) initiatives include school meal programmes and food purchases for settings such as public canteens, universities, healthcare facilities, armed forces, prisons, and other government procured services. A key feature of PFP is that it bridges the gap between food production and settings where food is consumed (i.e. influences what food will be purchased, from whom it will be purchased, and from what type of production systems it will be purchased). As such, PFP has transformative potential to shape norms around food, influence sustainable food consumption and production patterns, and drive change at the societal level (Swensson et al., 2021). The UN Food Systems Summit dialogues also recognised PFP as a critical entry point to leverage a food systems transition, having a key role in improving the availability and affordability of sustainable foods.

The use of policy instruments such as dietary guidelines to educate and encourage consumers to make informed dietary choices should be accompanied with PFP induced structural changes to food environments[4] that enable healthy and sustainable eating. For example, PFP can address barriers to shifting diets and altering food habits that arise due to limited availability of plant-based foods in catering menus which restrict choice, reinforce traditional diets, and impede behavioural change (Carmichael, 2019). Studies have found that repeated exposure to sustainable and healthy foods (e.g. by incorporating more plant-based options on catering menus) increases their sales, generates healthy eating habits, and helps normalise low-impact diets by improving attitudes towards healthy eating, particularly among meat-eaters (Lachat et al., 2009; Caldeira et al., 2017; Carmichael, 2019;). For example, Spain has developed PFP criteria that focus on increasing the availability of vegan and vegetarian menus and Denmark

[4] Food environments are the physical, economic and socio-cultural surroundings that shape the availability, affordability, and attractiveness of foods, thereby influencing consumption decisions and eating habits. The food and meals offered in public canteens and government procured services (e.g. schools, hospitals, universities) are the core constituents of food environments and are easily influenced by PFP (European Public Health Alliance, 2019).

has focused on training kitchen staff to improve their cooking and menu composition skills (European Public Health Alliance, 2019). Additionally, dozens of colleges, including Harvard and Stanford, are shifting toward more “climate-friendly” meals (Bloomberg Green, 2021). Thus, to improve access to sustainable and lower-impact foods, policymakers could consider bringing more plant-based foods to public-sector catering menus (e.g. in schools, hospitals, and other public-sector catering outlets) or mandate the provision of plant-based options that are widely accessible.

4.4 Building Trust and Acceptance

To successfully transition towards the NPE, governments may need to enhance legislation and fiscal incentives that stimulates investment, builds public confidence in alternative protein products, and sets clear trajectories that offer certainty to companies and investors regarding market opportunities in the alternative proteins industry. At present, national frameworks and legislation offer governments limited scope in making low-carbon choices (OECD, 2015). As such, legislative agencies should work towards developing appropriate laws and regulations that support the new wave of alternative proteins and address barriers pertaining to consumer acceptance, cost and price, product quality and development etc. (Godfray, 2019). This can be achieved through legislation enforcing the licensing and certification of alternative protein (AP) products and public awareness campaigns to support consumer uptake of alternative protein sources. Ultimately, governments should ensure that there is a robust regulatory environment which keeps pace with new developments in the alternative proteins market so that products and new technologies can enter the market with appropriate safeguards and public confidence.

4.4.1 Regulation: Alternative Protein Licensing and Certification

The establishment of licencing and certification programmes (e.g. USDA certified organic products) could strengthen consumer acceptance of alternative protein products and facilitate adoption of new products and processes within the novel food space offering alternative proteins. For example, in 2020, Singapore became the first country to grant regulatory approval for the sale of lab-grown meat. Additionally, certification programmes could allow producers access to higher value markets by providing objectively verified evidence that their production methods adhere to specific environmental, social, and ethical standards (FAO, 2012). These assessments follow a number of requirements that need to be standardised by government regulations so that products are deemed safe and eligible for whatever premium prices may be assigned by the consumer market. Without such certification, producers could be subject to market barriers and the same competitive pressures that would lead to lower prices faced by conventional producers (UNEP, 2008).

Moreover, attention should be given to improving food safety and processing quality to expand consumer acceptance and smallholder farmers' opportunities to integrate into the alternative protein supply chain (FAO, 2012). Equally important is regulatory oversight to ensure that farm labour occupational health and safety conditions are being met. Such legislation protects the public from health risks and unsubstantiated claims and facilitates producer integration into the alternative protein supply chain. Appropriate licencing and certification is necessary to stimulate innovation, promote value creation, and encourage alternative protein uptake (Godfray, 2019). Additional forms of regulatory oversight in the production process include monitoring the packaging, labelling, and marketing of products, which could also accelerate adoption of sustainable foods (Rubio et al., 2020).

4.4.2 Public Awareness Campaigns

An important consideration for policymakers is the potential for alternative protein products (specifically cultivated meat) to be "psychologically disruptive" as they could challenge our notion of meat (Godfray, 2019; Funke et al., 2021). This could impede their adoption and transition into mainstream food systems. Such "frankenfood" concerns could be overcome through effective communication and robust regulation over production processes (Collett et al., 2021). For example, governments can shape clear narratives based on scientific evidence to strengthen consumer acceptance of alternative protein. This could include engaging in public awareness campaigns and two-way discussions about alternative proteins and emphasising the economic, environmental, and societal benefits of the NPE, including the positive health and animal welfare implications associated with switching from animal-proteins. Public awareness campaigns are often characterised by mass media and marketing campaigns which are effective tools to raise awareness, gather acceptance, and change behaviour among the general population (FAO, 2013). Impossible Foods plans to launch its first mainstream, mass-market advertising campaign, "We Are Meat" to generate awareness of their meat-free products. Additionally, companies such as Burger King, Dunkin', and Starbucks have successfully employed broad marketing campaigns to introduce consumers to plant-based alternatives in their products. These early successes indicate a promising opportunity for increased expansion of alternative products into fast food and other limited-service restaurants, indicating growing consumer acceptance of these products (The Breakthrough Institute, 2020).

4.5 National Policy Plans and Food Strategies

This is a time of significant change in agriculture and food policy, with a lot more prominence being given to the development of national policy plans and food strategies to transform our food systems. The 2021 UN Food Summit and Global Fork to Farm Dialogues at COP26 offered an inclusive global platform that brought together key stakeholders (farmers, local governments, consumers) to generate ideas, facilitate learning, and encourage joint cooperation to bring food systems closer to climate negotiations. These large-scale events indicate growing recognition of the key role the food sector plays in achieving the SDGs and Paris climate goals. This is particularly relevant for the design of post-pandemic recovery which presents a critical entry point to make transformative change to our food systems. At the country level, the UK recently published the National Food Strategy Plan to promote a sustainable food system and proposed the post-CAP[5] Agriculture Bill (specifically around paying farmers for public goods such as environmental services and animal welfare improvements) which are reflective of wider trends picking up around the world. These developments also play a key role in signposting to businesses and industries that change is approaching and as such could be effective in rallying private funds to support the NPE and mitigate risks of "losing out" from this emerging sector in the future. There has also been strong emphasis on developing national pathways that take into consideration the varying economic, social, and cultural attributes of countries.

[5] Common Agricultural Policy (CAP)

5. Recognising Heterogeneity

National governments differ significantly in their social, environmental, economic, and political priorities and COVID-19 recovery packages will reflect these differences with varying climate implications (Hepburn et al., 2020). Cross-country heterogeneity - e.g. relative wealth, socioeconomic structure, diets, cultural norms, political climate, recovery capacity - implies that no one form and degree of intervention would be appropriate across all countries. As such, effective public intervention requires designing a policy framework that has been adapted to the local context and reflects the conditions, resources, and needs of the country (Global Alliance, 2020). This implies that various national governments may impose a different set of policies and strategies to support the transition towards a low-carbon food system based on their specific country requirements and priorities (FAO, 2012). Doing so enables countries to effectively manage the inherent complexity of policymaking by understanding the interaction and impact of different policy measures within national contexts and identifying the best form of implementation (OECD, 2017).

In the context of a low-carbon transition in the food sector, understanding the economic, socio-cultural, and environmental dynamics of meat consumption is important in shaping an appropriate policy framework to support the NPE. Cross-country heterogeneity will also influence the scale of impact from growing the NPE (i.e. the associated net benefits of the NPE are not normally distributed, nor are they guaranteed) as well as the ability to respond with a just policy framework. Important factors to consider for a successful protein transition include dietary trends (i.e. levels of meat consumption and willingness to shift to alternative proteins), level of socio-economic development (i.e. institutional arrangements, composition of labour markets, resources, and capacity), and green recovery capacity (reflecting country priorities and requirements). Ultimately, these factors will collectively influence the local policy mix required for attracting investment and support for the NPE - the policy implications of such heterogeneity will be discussed in Sections 6 and 7.

This section will focus on dietary trends and identify factors driving cross-country variation in meat and dairy consumption. Dietary habits are largely influenced by economic factors (GDP, economic dependence on agriculture, financial capacity to implement change), socio-cultural factors (religion, history, and culinary traditions), as well as environmental factors (geographical location) resulting in spatial variations in cuisine and diet (de Boer and Aiking, 2018; Sabate and Sorey, 2014).

5.1 Economic Factors

Economic factors such as GDP per capita have driven significant variations in global meat consumption. Studies have identified a positive correlation between income level and meat consumption such that wealthier countries are consuming more meat, on average, than poorer countries (Cole and McCoskey, 2013; FAO, 2017). In 2018, the average annual meat consumption per capita for OECD countries was 86kg, with people in the US consuming 123kg (OECD, 2018). In contrast, the average annual meat consumption per capita in Africa and some parts of Asia remain comparatively low, standing at 14kg and 32kg, respectively (OECD, 2018). This is below the world average level of 42kg. Additionally, meat intake in Western countries is estimated to be two to three times higher than recommended by official dietary guidelines and has been attributed to higher rates of diet-related disease including obesity (Popkin, 2002), heart disease (Westhoek, 2014), and even certain types of cancer (Amine et al., 2002; Pan et al., 2012; de Boer and Aiking, 2018; Sexton et al., 2019). This strong positive relationship between meat consumption and GDP per capita is illustrated in Figure 5.

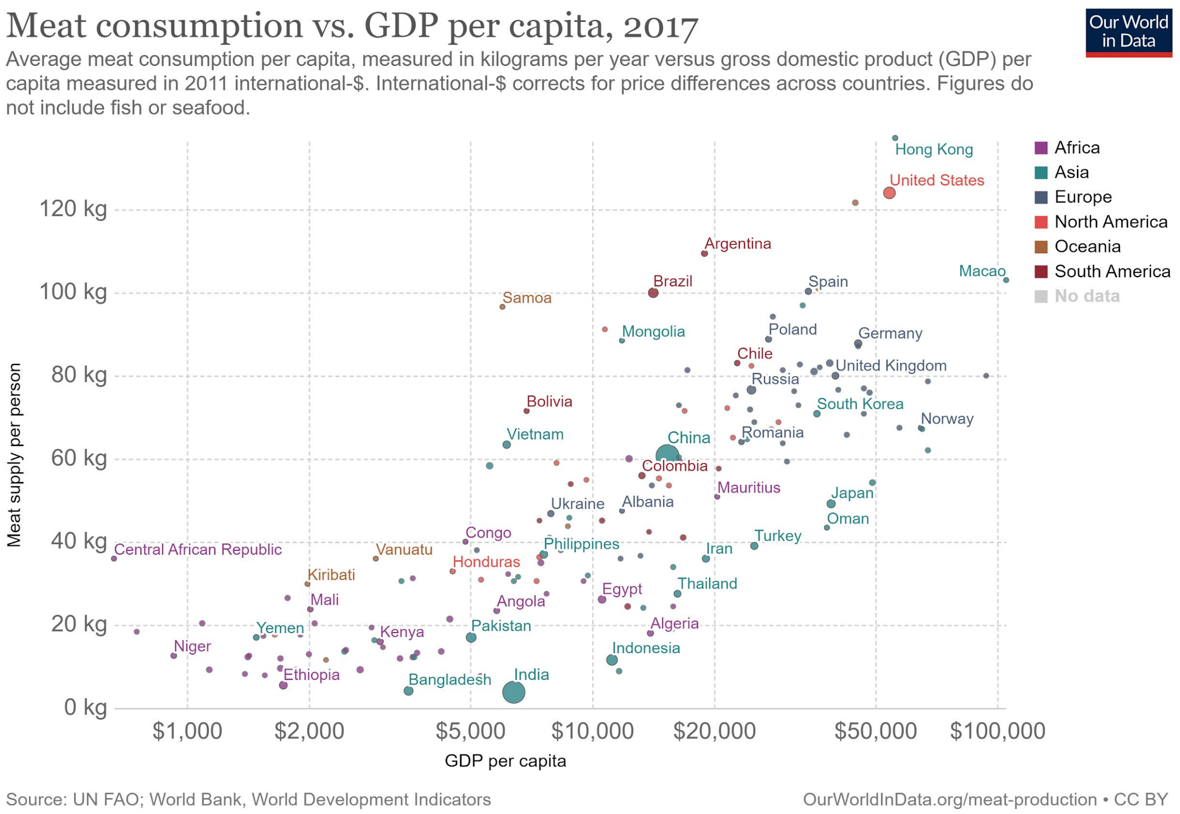

Figure 4 Scatter plot depicting the relationship between per capita meat supply (on the y-axis) and average GDP per capita (on the x-axis, with a log-scale). What we see is a strong positive relationship: the richer a country is, the more meat the average person typically eats ([Our World in Data](#)).

The emerging trends of global meat consumption seen in Figure 5 and other data highlight certain nuances and contours that are of relevance to policymakers. Most notably, the data indicates that although meat consumption increases with national income, the increase over time follows a S-shaped saturation curve which peaks at a certain level before reaching a saturation point where it stabilises and levels-off (Sans and Combris, 2015; Vranken et al., 2014; de Boer & Aiking, 2018). Since most affluent countries have reached this saturation point, per capita consumption of meat will not increase significantly with a continued rise in income in these countries (de Boer et al., 2006). For example, per capita meat consumption in most European countries - including the middle-income countries of Eastern Europe – has stabilized between 70 - 90kg (MGSSI, 2016). In the UK, daily meat consumption has declined by 17% over the last decade (BBC News, 2018) but this figure would need to double to meet the targets set out by the National Food Strategy plan.

However, this trend also implies that per capita meat consumption is likely to grow in low-income and emerging economies in conjunction with rising incomes in the future. This is already evident in major emerging economies (e.g. China) where levels of meat consumption are rapidly rising and converging towards levels seen in HICs (Wellesley et al., 2015). For example, the average Chinese person's consumption of meat is at 63kg per year compared to less than 10kg in 1960 (OECD, 2018), consistent with expectations that emerging economies will drive future global meat market growth (Changing Markets Foundation, 2018).

Additionally, a country's economic dependence on agriculture can also shape dietary habits and influence their need and capacity to make changes. As can be seen in Figure 6, a country's economic dependence on agriculture decreases with rising income, with low and middle-income counties (LMICs) being more heavily dependent on agriculture than HICs and upper-middle income countries (UMICs). This is an important consideration for policymakers as the type and scale of policy intervention will differ significantly for agrarian countries that typically consume less meat and use traditional farming methods to produce crops and maintain farmland.

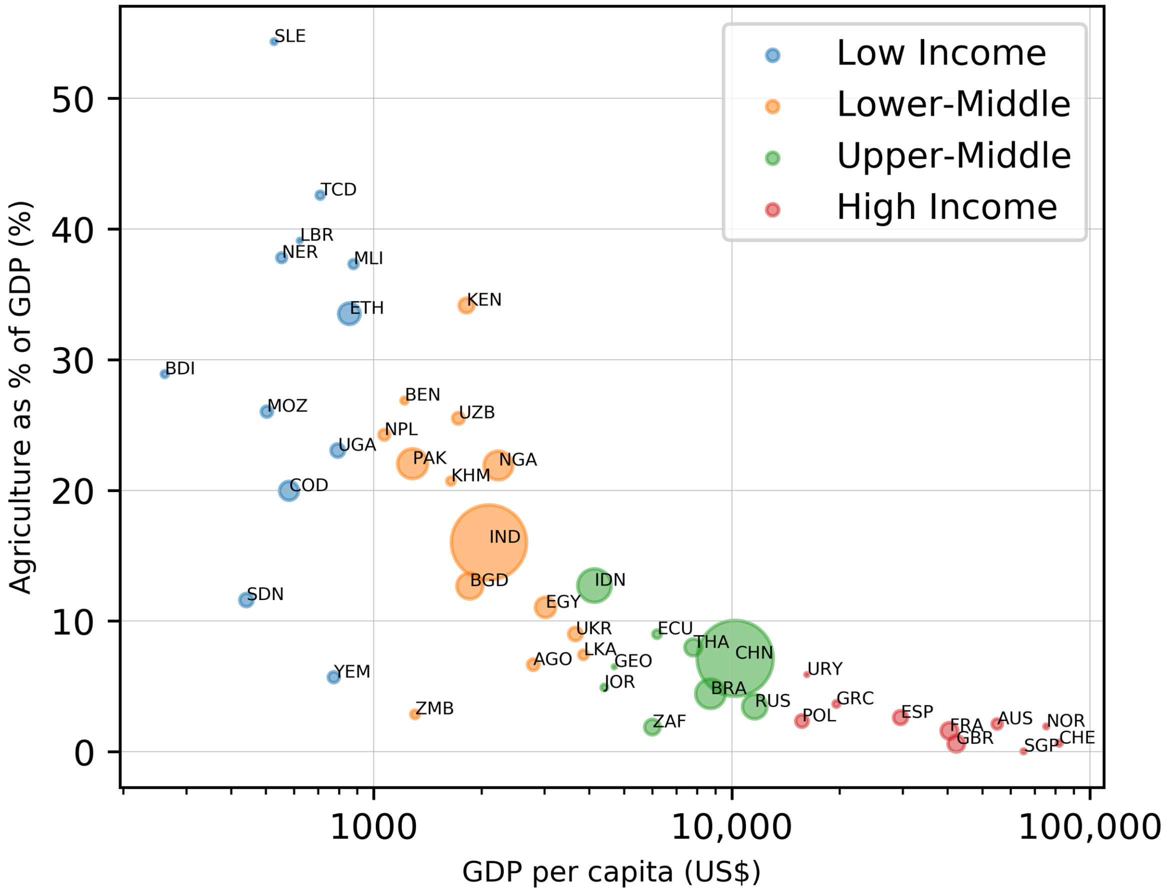

Figure 5 Economic dependence of countries on agriculture against GDP per capita. The income category of each country is shown by the colour of the marker, and the size of the marker is reflection of population. Note the logarithmic x-axis. Data from World Bank Open Data (2019)

5.2 Socio-cultural Factors

Culture, history, and culinary traditions can play a significant role in shaping different countries' dietary patterns by influencing what a country perceives as superior or inferior foods and their willingness to switch to alternative protein sources (de Boer et al., 2006; Leroy and Praet, 2015; Hartmann and Siegrist, 2017). Religion can also have a strong impact on food habits by establishing dietary norms and restrictions on what, how, and when to eat certain foods (Sabate, 2004). Additionally, some studies have found considerable gender differences in relation to meat consumption with women being more willing to reduce their levels of meat consumption compared to men (de Boer and Aiking, 2011; Schosler et al., 2015; Siegrist et al., 2015; Tobler et al., 2011).

6. Adaptive Intervention

Cross-country heterogeneity is an important consideration for policymakers in deciding the degree and type of intervention required to facilitate the NPE transition in different country contexts. Variations in dietary habits, level of socio-economic development (which influences the composition of labour markets, institutional arrangements, capacity and resources etc.) and green recovery capacity are some important factors that will have implications for policymakers. A just policy framework requires implementing adaptive policy measures that take into consideration this heterogeneity and support and mitigate risks for workers, firms, and communities that will be negatively impacted by the NPE. This section will explore the implications of heterogeneity on the local policy-mix required for attracting investment and support for the NPE and adaptive measures needed to enforce a just NPE transition. Ultimately, an effective and just policy framework for the NPE will need to adapt to meet the heterogeneous conditions and needs of countries.

Firstly, the general popularity of meat in HICs and the variety of factors that influence eating habits and shape food patterns suggests that significant change at the societal level is needed to achieve a "reversed" diet transition towards more sustainable foods (de Boer and Aiking, 2018). More active forms of demand-side policy intervention (e.g. dietary guidelines, campaigns to generate awareness, increased transparency, labelling etc.) should be implemented to drive long-term behavioural and societal change which mitigates the excessive levels of meat, dairy, and eggs consumption. In the EU, meat, dairy, and eggs collectively account for 83% of GHG emissions from all food products, as can be seen in Figure 7. Although predicting the levels of behavioural change that will be achieved through these interventions is inherently difficult, there is robust evidence which suggests that in HICs, a strategy focused on dietary change towards more plant-based diets can have a positive impact on both the environment and nutrition (Springmann et al., 2018). To quantify this, studies have found that halving the consumption of meat, dairy products, and eggs in the EU would result in a 25 - 40% reduction in GHG emissions from agriculture (Carmichael, 2019). Such high-impact shifts in consumer behaviours and choices are critical in ensuring that change is timely and consistent with the scale of the impending climate crisis. Regulatory efforts to tax meat in HICs could also be an effective policy tool to drive a structural transition over time towards lower-impact foods (Funke et al., 2021).

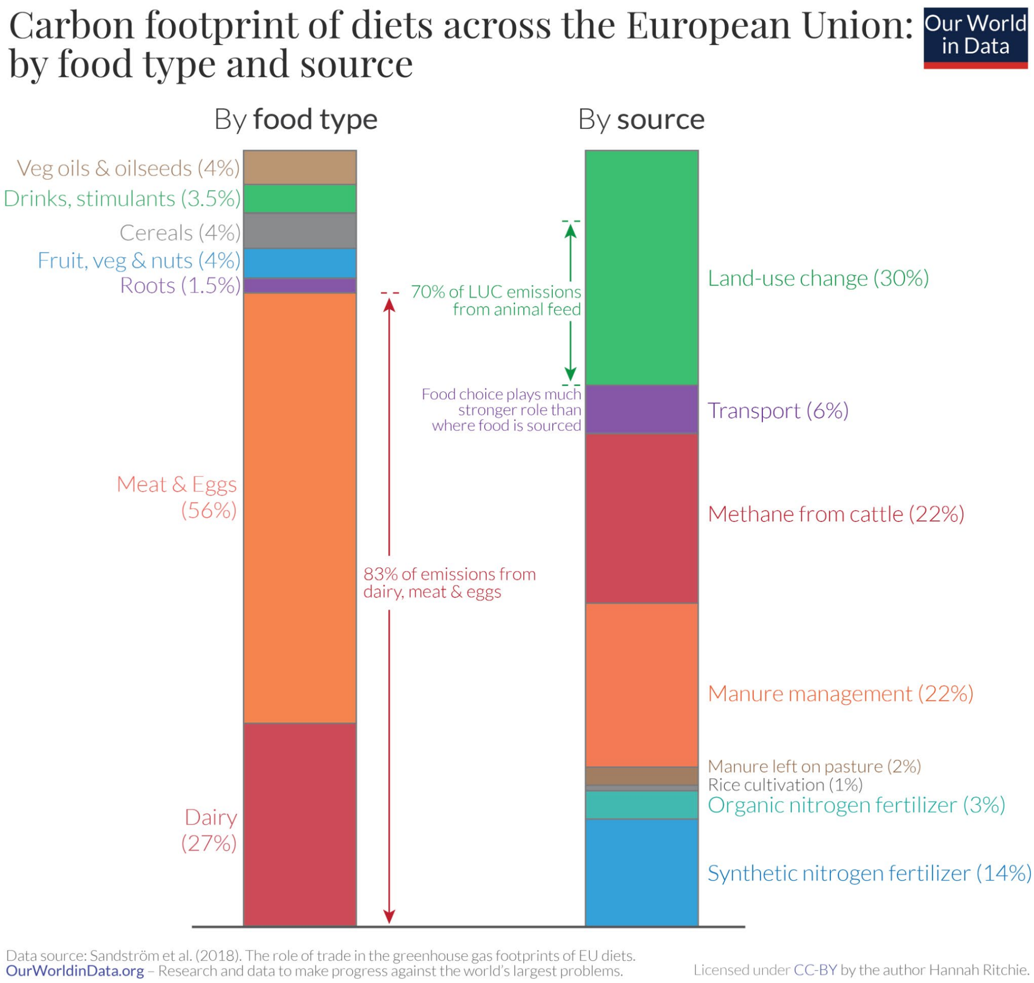

Figure 6 Carbon footprint of diets across the EU by food type and source. Data from Sandström et al., (2018) and visualisation produced by Our World in Data.

In contrast, in LMICs, where levels of meat consumption are low but have the potential to increase with rising incomes, there is a stronger argument for policymakers to focus on pre-emptive measures such as rural support spending via the establishment of an environmental services market (e.g. payment for ecosystem services) which could be more valuable than investment in green R&D, for example (Hepburn et al., 2020). If the NPE transition reaches a global scale, then key areas that require support in LMICs might include farmer training and extension services, along with temporary compensation assistance to farmers during early transition years (e.g. direct cash transfer programmes). National outcomes are likely to occur at varying stages and time frames depending on a country's level of development and policymakers must take this into consideration when deciding between active or passive forms of intervention to support the NPE transition (i.e. degree of deviation from the status quo).

Secondly, any large-scale systemic change will result in structural changes with certain places and communities being disproportionately impacted, as has been evident in low-carbon transitions in the energy and transport sectors (OECD, 2017; ADB, 2015). Lack of financial and human capital makes poor people particularly vulnerable to such transitions. As such, a country's level of socio-economic development will influence their institutional arrangements, composition of labour markets, resources, and capacity. This will directly impact the policy mix and degree of intervention employed by countries in supporting the NPE transition. For example, LMICs could face transitional challenges because of their relatively weaker institutions, inadequate skillsets, and rising youth population seeking employment (UNFCCC, 2020). There is a need for policymakers to smooth the edges of the protein transformation by designing adaptive policy measures that prioritise training and human capital development, agricultural subsidy reform accompanied with a robust social protection scheme (e.g. direct cash transfer programmes), and an agricultural and land management system that supports farmers through increased payments for providing ecosystem services. Collectively, these adaptive measures mitigate risks and safeguard the livelihoods of affected workers, enterprises, and communities during the period of transition.

6.1 Training and Human Capital Development

Studies have identified skill shortages and inadequacies as posing a major challenge for the transition towards a low-carbon, climate-compatible global economy (ILO, 2016). It is inevitable that a low-carbon transition in the food system will result in structural shifts in employment as the creation of new jobs will be accompanied with a demand for new skills. Adaptive policy measures should seek to minimise worker displacement and labour market adjustment costs while maximising the job-creation potential of the protein transition. This can be achieved by investing in human capital to shift the structure and capabilities of the labour force and ensure that no one is left behind (ILO, 2017). For example, the Philippines Green Jobs Act of 2016 provides a policy framework for supporting the transition towards a greener economy by incentivising enterprises to strengthen human capital and promote skill development for green jobs (ILO, 2019). The degree of skills change in the sector varies depending on the alternative protein source but on average, existing jobs are altered because of the adoption of new technologies or workplace methods.

The benefits associated with investing in human capital are multi-fold and necessary to not only support the low-carbon transition but to also stimulate economic activity and promote long-term growth (Romer, 1989; Lucas, 1988). Policymakers should prioritise skill building and worker retraining programmes in response to (i) continuing high levels of unemployment, (ii) the need to invest in human capital to support the low-carbon transition and economic growth and (iii) new injections to green projects in the form of recovery spending (O'Callaghan and

Mudrock, 2021). The prioritisation of training and skills development has the potential to expand the domestic absorptive capacity, or short-term ceiling, of green spending and generate long-term economic co-benefits by creating a labour-force well-equipped to deal with the challenges of the future (Hepburn et al., 2020; O'Callaghan and Mudrock, 2021).

Livestock farmers can potentially be retrained to bridge the skill gap, unlock jobs and diversify into the emerging alternative proteins market. This can be achieved by prioritising "green" skills development which match future growth priorities through the provision of extension services and retraining initiatives (O'Callaghan and Mudrock, 2021). However, livestock farmers may not realistically be able to transition into high tech jobs (e.g. involving cultivated meat) which require technical qualifications and specialisation in the field. Rather, the focus may instead be on developing and repurposing skills towards ecological restoration and nature-based solutions (e.g. GGR services).

6.2 Fiscal and Regulatory Support

The post-pandemic recovery could potentially unlock significant investment as an adaptive response to reinvigorate global economies. According to the FAO Investment Centre's Annual Review (2020), as the pandemic evolved so did public and private investment strategies, including conducting analytical studies, and shaping policy guidance. Particular attention was given to innovation, digital technology, blended finance instruments, and increased support for green investments.

The pandemic created an urgent need to restructure ongoing investments and design new ones to effectively tackle the challenges and limit disruptions faced in agri-food systems (FAO, 2020). It also led to the development of the FAO's online policy tools which employ big data for real-time information on the impact of COVID-19 on agri-food value chains, prices, and global food security. There was reliance on local capacity to facilitate policy design, capacity development, and knowledge-sharing which resulted in the development of national food system assessments and dialogues aimed to encourage targeted policy and investment decisions around food systems that were tailored to specific country needs.

To facilitate the NPE transition, more investment-related policy support is necessary to fill knowledge gaps, raise the visibility of investment opportunities, improve stakeholder dialogue, and strengthen and diversify public-private partnerships. It is also important to enhance the capacity of people and institutions to make better investment decisions by adapting skills and expertise to keep pace with a rapidly developing alternative proteins sector and constantly evolving investment landscape. Ultimately, there is an urgent need to link policy work with investment support to scale up impact as "the quality and quantity of investments made today shape the impact and outcomes of tomorrow" (FAO, 2020).

The NPE presents a huge opportunity for agricultural subsidy reform, i.e. to repurpose and redirect current agricultural policies in order to mobilise and target support towards better outcomes that facilitate the protein transition and more broadly, align with sustainability and climate objectives. Most existing agricultural policies support incumbent production systems, providing subsidies and market support measures to intensive meat and dairy farmers and the big corporations that profit from them (FAO, 2012; Changing Markets Foundation, 2020). These subsidies can play a significant role in driving unsustainable animal agriculture and hindering the transition towards a more sustainable food system. As such, the NPE transition cannot be achieved without fiscal and regulatory support that focuses on reforming existing supply-side policies and reallocating the funds from these subsidies towards the remuneration of environmental services, production of alternative protein sources, and investment in R&D. The amount of fiscal and regulatory support needed to implement reform and support the NPE transition will also vary depending on a country's financial capacity and economic dependence on agriculture. Ultimately, by removing, reducing, or reallocating agricultural subsidies, governments can reduce support for animal agriculture and create a more level playing field for the alternative proteins market (Newton and Blaustein-Rejto, 2020).

Agricultural reform of this nature could incite short-term resistance and even social unrest from incumbents. To facilitate change, governments may need to adopt or develop robust safety net programmes that offer temporary direct financial assistance to support livestock farmers during the period of transition (Climate Institute, 2009). This could include direct cash transfer programmes, interest free loans, compensatory in-kind transfers, and low-cost insurance against loss of income to safeguard livestock farmers and vulnerable communities from hikes in prices once the subsidies are removed (Climate Institute, 2009; ABD, 2015; ILO and IDB, 2020). Thus, anticipating the impact of price hikes on consumers and producers and compensating those who are negatively impacted "improves the political economy of policies and makes it possible to align environmentally motivated price reforms with broader development goals" (Schaffitzel et al., 2019; ILO and IDB , 2020). Moreover, past efforts to reform agricultural subsidies have shown that in order to sustain momentum for reform, there is a need for a strong institutional framework that imposes effective monitoring and evaluation tools through regular, up-to-date, publicly accessible, and comparable data on the progress and impact of agricultural policy (OECD, 2017).

The UN Food Systems Summit (2021) highlighted that governments around the world have started to devise and implement agricultural policy reforms to redirect public support towards enhanced soil and water quality, climate mitigation, and biodiversity preservation. Among recent reforms, the European Union's Common Agricultural Policy (CAP) aims to, among others, completely decouple agricultural subsidies from production, and reward farmers according to their contribution to environment conservation and farm employment (Ventura-Lucas et al., 2002; FAO, 2012). The CAP reform also enables farmers to receive income support on the condition that they sustainably manage their farmland and satisfy food safety, environmental, animal health, and welfare standards. Additionally, in 2020, the UK government proposed the post-CAP Agriculture Bill which sets out a legislative framework for the replacement of agricultural support schemes. Under the bill, farmers will be paid for the provision of public goods such as animal welfare and environmental improvements (e.g. through ecological restoration and NbS).

6.3 Agriculture and Land Management

Many policymakers are beginning to recognise the long-term economic and environmental benefits of establishing an agricultural land management regime that financially rewards farmer efforts to restore and sustainably maintain local rural ecosystems (UNEP, 2021). Ecosystem services play a critical role in sustaining the economy and protecting the environment by offering regulatory services (e.g. regulating air quality, climate, and food risk), preserving biodiversity, and providing services such as food, water, timber, and fibre (Global Assessment Report, 2005). Natural ecosystems have declined in size and condition by 47% globally which has been accompanied by accelerating rates of species extinction and biodiversity loss (UNEP et al., 2020). The IPBES Global Assessment report (2019)[6] estimates that approximately one million animals and plant species are at risk of extinction. Natural capital investment for ecosystem resilience and regeneration (e.g. restoration of carbon-rich habitats and climate-friendly agriculture) has the potential to deliver strong economic and job impacts while securing environmental progress (i.e. through further GHG emission reductions, biodiversity preservation, and co-benefits) and should be prioritised within COVID-19 recovery spending. According to a recent report by UNEP (2021), every US$1 invested in ecosystem restoration has the potential to create up to US$30 in economic benefits.

The NPE creates opportunities to diversify land use (EY, 2021). Public sector intervention could help create environmental services markets (e.g. GGR services) that ecologically restore land previously used for grazing or feed crop production (Collett et al., 2021). This could result in further reductions in GHG emissions and generate an alternative source of income for livestock farmers, provided they have been adequately trained and have developed the green skills needed to successfully engage in such services. Payments for Ecosystem Services

[6] The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

(PES) can monetize the value of reduced GHG emissions, increased carbon sequestration in soils, conserved freshwater resources, and other positive externalities that are generated through sustainable agricultural practices (FAO, 2012). Sustainable practices could include peatland restoration, grassland management, crop rotations, compost management, among others. For example, the World Bank launched the Kenya Agricultural Carbon Project (KACP) from 2011-2017 that focused on carbon sequestration through the adoption of sustainable land management practices (e.g. compost management, crop rotations and agroforestry) in Western Kenya.

The primary objective of PES schemes is to support livestock farmers by generating a stable revenue flow that helps reward farmers for reducing emissions and other externality costs associated with unsustainable agricultural practices. To encourage a just transition towards the NPE, such PES arrangements should be designed so that small-scale farmers and rural communities, not just large landowners, are able to benefit. By providing productive employment for poor and marginalized rural communities, the PES can protect those who might otherwise lose out from the agricultural transition (FAO 2012). For example, the KAPC projected that farmers would earn approximately US$2 million in PES payments over the 6-year duration of the project and that this would complement the economic returns that are expected from gains in crop yields and other agricultural products (FAO, 2012). Additionally, these schemes could also be an effective and equitable way to ease potential opposition to the NPE and reduce the rate of rural-to-urban migration (FAO, 2012). There is significant global potential to offer PES as a financial reward for farmer efforts to strengthen farmlands, restore soil quality, and engage in GGR services. In a study of global GHG abatement costs, McKinsey & Co. (2009) found that a number of green agriculture practices (e.g. organic soil restoration and grassland management) deliver significant abatement opportunities that will pay back themselves in a few years even with payments below €10 Euros per CO_2 equivalent ton. However, for this market to function well and be sustainable in the long-run, policymakers should consider developing mechanisms to monitor and evaluate the effectiveness of the service.

7. Framework for Facilitating the New Protein Economy

Sections 5 and 6 have demonstrated that an effective policy framework to facilitate the NPE transition will need to adapt to meet the heterogeneous conditions and needs of different country contexts. Cross-country heterogeneity will not only impact the degree and type of intervention required to support the NPE but will also influence the scale of impact from growing the NPE (i.e. the associated environmental, economic, and societal co-benefits) as well as the ability to respond with a just policy framework. This section attempts to develop a framework for accelerating to the NPE by clustering countries into archetypes where the contexts are comparable and specific policy intervention is more likely to yield a similar impact.

The archetypes are identified using three factors that have been shown throughout this report to impact the agricultural and consumption norms of a country: (i) meat consumption per capita, (ii) agricultural dependence of GDP, and (iii) income category of a country (high income, upper-middle, lower-middle, low income). These factors are mapped for a range of countries in Figure 8. From this, three distinct archetype categories emerge:

- **Archetype 1:** countries with high meat consumption, low economic dependence on agriculture, and higher income category (e.g. Australia, Spain, UK, France).

- **Archetype 2:** countries with lower meat consumption per capita, lower dependence on agriculture for GDP, and middle income. (e.g. India, Zambia, Indonesia, Thailand).

- **Archetype 3:** countries with low meat consumption per capita, higher dependence on agriculture for GDP, and lower income (e.g. Nigeria, Pakistan, Ethiopia)

These country archetypes can be used as a tool to identify and better define the effect of policy levers within a certain context. They serve as a starting point to understand the extent of the economic, social, and environmental co-benefits possible by certain interventions in different country contexts. As such, the analysis offered in this section is non-exhaustive and exploratory rather than conclusive.

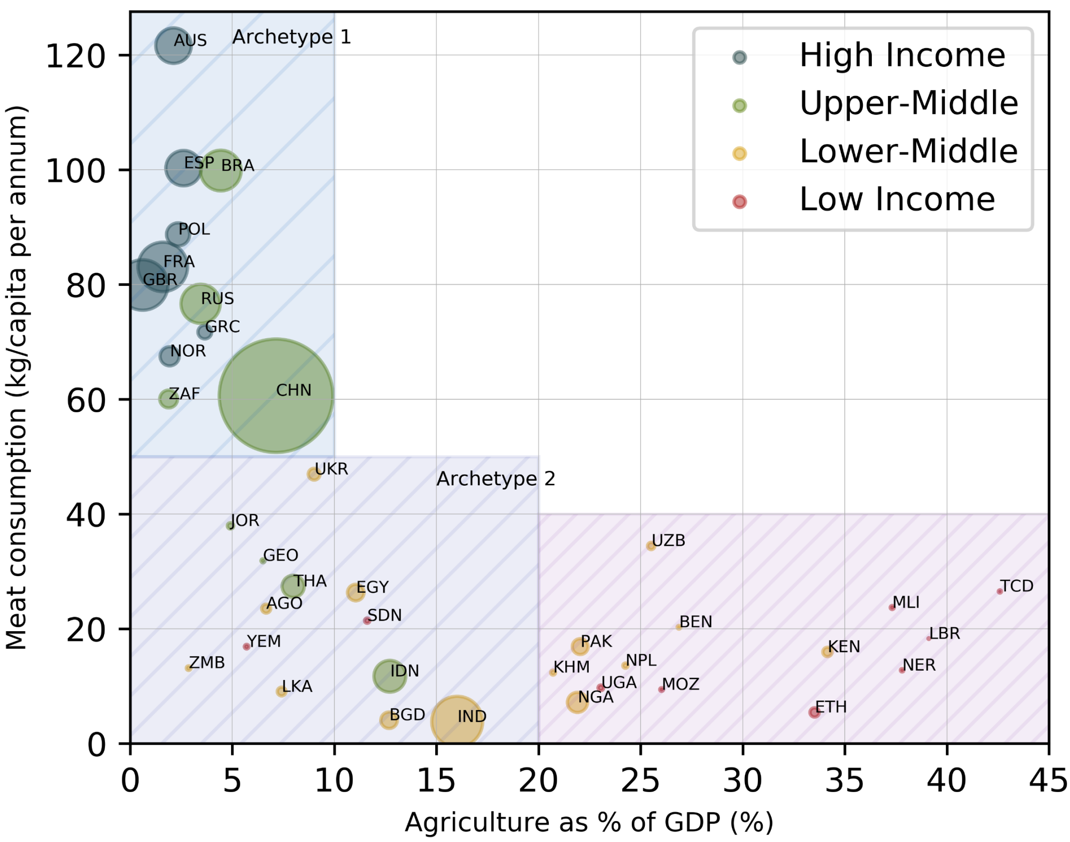

Figure 7 Countries are clustered into three archetypes based on levels of meat consumption (2013), agricultural dependence on GDP (2019), and income level (2019). Size of the marker represents total GDP (2019). Data from World Bank Open Data (2019) and Our World in Data (2021)

Building on the evidence in the previous sections, Figure 9 presents an illustrative summary of the impact of the policy interventions on each of the dimensions (economy, society, and environment), taking into consideration the different country archetypes. For example, policies that account for externalities and seek to drive behavioural change (e.g. disclosure, fiscal intervention, dietary guidelines, procurement, and public awareness campaigns) are likely to have a strong environmental and societal impact on countries in Archetype 1. These are HICs and UMICs that are characterised by excessive levels of meat consumption which is detrimental to both the environment and societal health. These are also countries that typically have the funds and resources needed to invest in alternative protein R&D which will generate a long-run economic multiplier and have positive knowledge and technological spill overs. This contrasts with countries in Archetype 3, where there are currently lower levels of meat consumption and hence, the same set of policies may have a limited impact and be inappropriate in the given context. In such contexts, there is a stronger argument for policymakers to focus on pre-emptive/adaptive policy measures as meat consumption is projected to grow in these emerging economies in conjunction with rising incomes in the future.

These policy measures might include rural support spending via the establishment of a land management regime, or training initiatives that deliver socio-economic and environmental co-benefits by further decreasing GHG emissions and generating an alternative stream of income for rural communities.

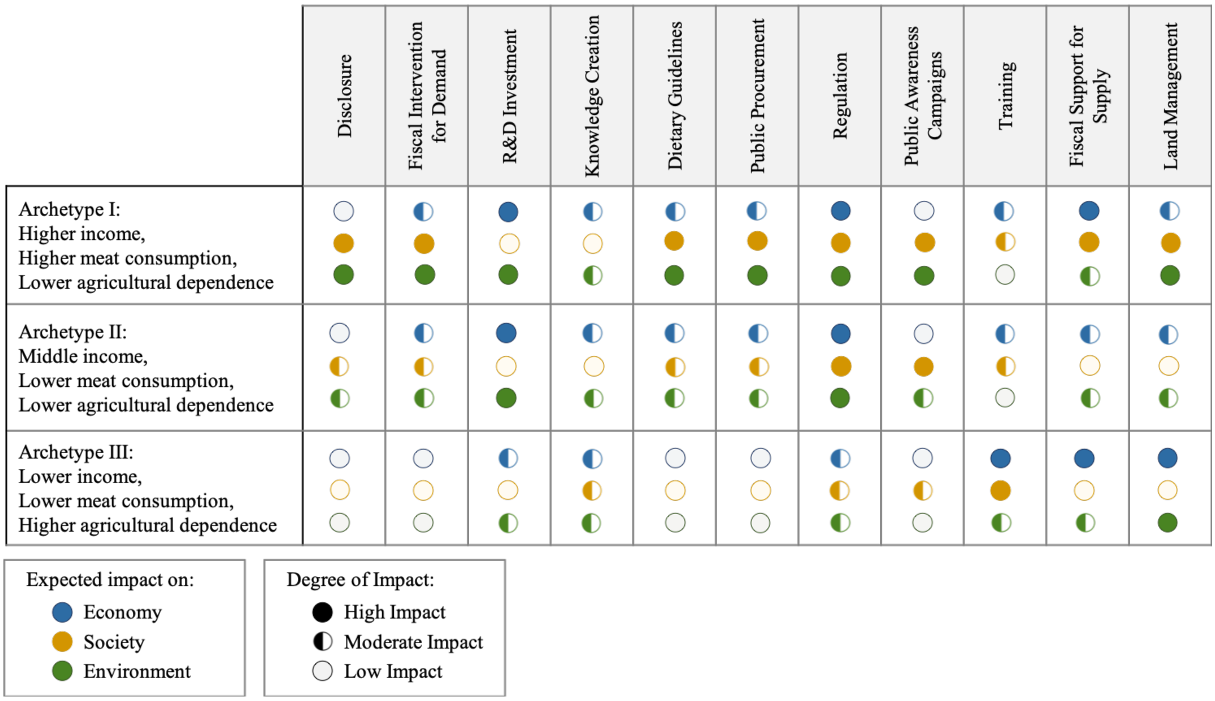

Figure 8 Illustrative scorecard that summarises the degree of economic, social, and environmental co-benefits that policy measures are likely to have, taking into consideration the different country archetypes.

8. Conclusions and Recommendations

The market for alternative proteins is developing rapidly and a combination of post-pandemic recovery and price shocks due to geopolitics offers a transformational opportunity to support and further realise the economic social, and environmental co-benefits of the NPE. These benefits include a potential alternative protein market of $290 billion by 2035, improved health which could decrease diet-related mortality by up to 7%, and emissions reductions of up to 60%. However, to realise these benefits, proactive policy measures that take into consideration cross-country heterogeneity are needed. The overarching aim of policy intervention should be to maximise these economic, social, and environmental benefits while minimising the barriers and risks associated with deviating from the status quo. Achieving this requires a just policy framework that is adapted to different country contexts and is well-aligned with COVID-19 recovery, alongside multi-stakeholder collaboration between the private sector, public sector, and civic society.

Many policy measures will need to be adapted to the local context, to realise the full potential of the NPE. For example, stronger demand-side intervention is needed in HICs to induce a dietary shift towards lower-impact and more sustainable foods (e.g. dietary guidelines and procurement) while more pre-emptive measures are needed in LMICs where levels of meat consumption are low but have the potential to increase with rising incomes (e.g. training initiatives and payment for ecosystem services).

However, there are certain policy measures that will be applicable in all contexts, including robust regulation to support alternative protein uptake and policy to support the installation of renewable energy resources. For the former, regulations will facilitate consumer acceptance by upholding food standards and ensuring that consumers are well-informed and feel confident in their decision-making. For the later, by transitioning from animal-based to alternative proteins, policy must ensure that emissions are not simply shifted from those related to animal production to those required to produce alternative proteins (e.g. bacterial protein and cultured meat are both highly energy-intensive). Thus, to mitigate this and achieve a net reduction in emissions, alternative proteins must utilise clean renewable energy.

Moreover, it is important to recognise that policy to accelerate societal change and technology adoption for the NPE is uncharted territory and inherently subject to uncertainty (Carmichael, 2019). Since no fully functioning market exists for some alternative proteins (e.g. cultured meat), there isn't a strong evidence base currently available to guide policymakers. As a result, the optimal form of intervention and most effective policy mix is largely dependent on the country context (as discussed above). Thus, the policy levers identified in this report are non-exhaustive and more explanatory rather than conclusive. Governments will need to take a pragmatic approach, adopt a "learn by doing" attitude (Chatham House, 2015), and draw on lessons learned from low-carbon transitions in other sectors such as energy and transport.

Policy implementation and design should also ideally include systems to monitor, evaluate and collect evidence on public engagement, behavioural change, progress towards emission goals, and co-benefits accrued for health, well-being, employment, and the economy (Carmichael, 2019). This evidence should then be made visible and easily accessible to all stakeholders including to advance green recovery, normalise low-carbon behaviour and technologies, accelerate change, and strengthen collective commitment and leadership for the NPE.

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