ELLEN MACARTHUR FOUNDATION

10 circular investment opportunities

for a low-carbon and prosperous recovery

Many voices from governments, businesses, and civil society have been calling for a response to the devastating impacts of the Covid-19 pandemic that does not turn attention away from other global challenges such as climate change, biodiversity loss, and plastic pollution. Yet, solutions from the past will not be up to the problems we face today, as the multifaceted nature of the crisis we are experiencing requires new thinking and the redesign of our current economic model.

In an unprecedented response to the Covid-19 crisis, trillions in economic stimulus are being unveiled all around the world. In the next stage of their recovery plans, governments will have to decide where these funds will be allocated. The circular economy, as an instrument to decouple economic growth from resource use and environmental impact, opens up the way for a resilient recovery and a next wave of economic prosperity. By fostering innovation and competitiveness, reducing resource dependency and environmental impact, and creating new jobs, the circular economy presents a promising way forward.

Building on the past ten years of research carried out on the circular economy, the Ellen MacArthur Foundation highlights in this paper how policymakers can pave the way towards a resilient recovery. As part of this, ten attractive circular investment opportunities that spread across five key sectors of the built environment, mobility, plastic packaging, fashion, and food, have been identified. Each sector is independently explored in a series of Insight papers, along with a piece offering perspectives on policy outlook. These individual papers, as well as the full combined paper, can be found at the Ellen MacArthur Foundation page: Covid-19: The economic recovery.

Food

Two circular investment opportunities for a low-carbon and prosperous recovery

While the pandemic has exposed the vulnerabilities of the current food system and strained food security in some areas, it has also reignited people's interest in their food. In the midst of the health crisis, the value placed on nutritious food that benefits, rather than degrades nature, has grown, strengthening the case for shifting towards regenerative food production. At the same time, to ensure high levels of value and access are retained, the need for improved food collection, redistribution, and valorisation infrastructure has become glaringly apparent. Investments in these areas will thus be key to building back a more resilient and healthy food system that enables greater food security while allowing both people and nature to thrive.

Taking into account the overall economic impact of the pandemic, a staggering **265 million** people around the world are expected to be at risk of facing acute food insecurity in **2020**

The pandemic has had mixed impacts on the food industry. On the one hand, initial global lockdowns decreased spending on eating out and takeaways, while increasing the popularity of from scratch cooking and, subsequently, the global food expenditure on groceries.[1] To avoid crowds and travelling far, people also switched to buying their food from smaller local retailers, or even ordering food directly from farmers themselves.[2]

In some places, these trends have been supported by the increased adoption of online ordering and home delivery services, resulting in a 11.5% increase of online food purchase compared to the previous year, in the UK alone.[3] A surge in demand for foods perceived to be safer and healthier has also been detectable in the midst of the pandemic.[4]

Meanwhile, the upstream players in the supply chain, such as farmers, have been challenged with oversupply issues due to a number of factors. Mobility restrictions created shortages of seasonal migrant agricultural workers in some regions. This resulted in exceptional admissions and visa extensions being urgently put in place for these 'essential workers' to ensure food security in host nations could be retained.[5] The lockdowns and border closures also constrained producers in their ability to transport their goods to where they were demanded.[6] Infrastructural shortages and the inflexibility caused by extreme efficiency and specialisation of supply chains, have only further exacerbated oversupply issues. Farmers typically delivering to out-of-home eateries have suffered cancelled orders from shut down schools, restaurants and other B2B customers, facing issues in finding alternative markets for their goods and struggling to adjust their production, packaging, and distribution systems to fit the needs of retail consumers.[7] As such, redistribution of these stocks has been difficult, leading to massive post-harvest losses of food.[8]

Many of the trends detected during the pandemic in the food sector are also projected to continue into the future. The health-consciousness of consumers is predicted to rise, increasing the demand for foods that are, for example, local,

healthy and certified organic, and that can be traced through the supply chain to their origins to ensure their safety.[9]

Additionally, the increased trend of at-home cooking and eating is likely to continue, as more people are likely to embrace remote working and as a result spend more time at home.[10] At the same time, online food shopping as well as deliveries from grocery stores and restaurants are predicted to remain at higher levels than before the pandemic, and even continue their growth.[11] Regulation around food safety will also become more stringent while consumer concern regarding this heightens.[12] Meanwhile, the expected global population rise to 9.7 billion by 2050 will require food system adaptations to ensure adequate nutrition is provided for everyone.[13] As 80% of the world's food is projected to be destined for cities by 2050, consumption patterns in urban areas will also have a greater influence upstream, thereby potentially redefining the urban-rural dynamic through, for example, increasing demand for local production.[14]

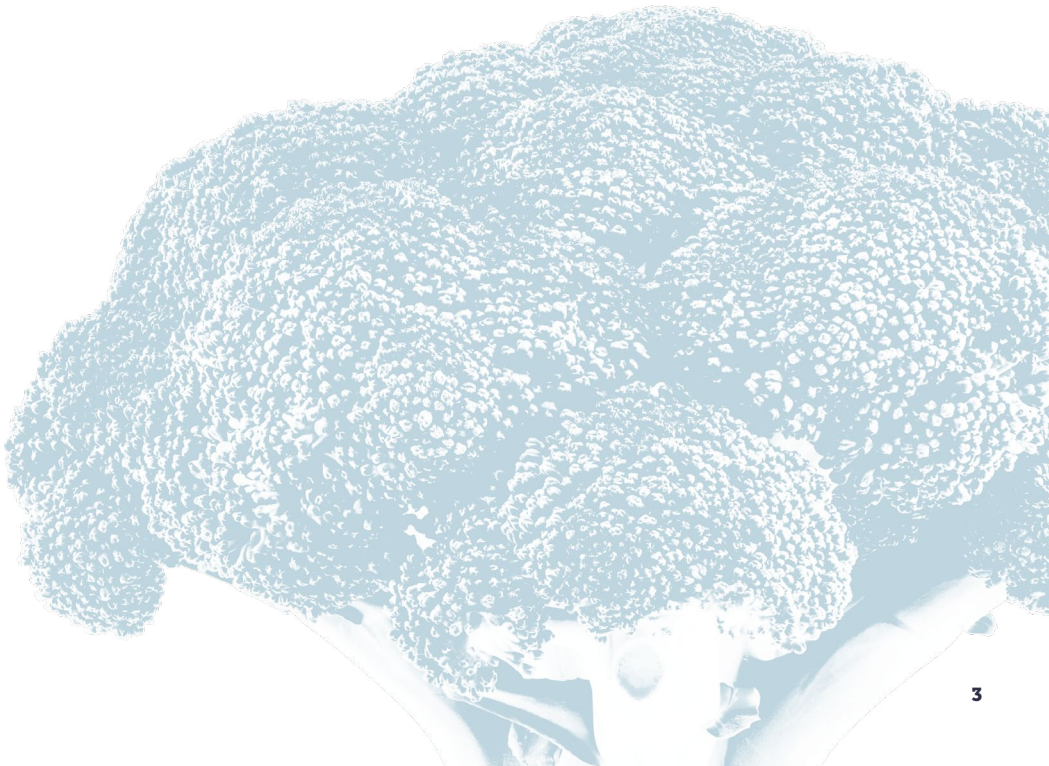
As funds around the world are being made available to aid the recovery of the agricultural sector, there is a growing need to ensure they get directed towards areas that can address all these future trends and challenges effectively. This will require clear direction setting, which is currently lacking. For example, in France, a total of EUR 1 billion has been allocated for the agricultural sector recovery, without specific conditions tying the use of all these funds to areas that also support the ecological transition and help the country reach their climate goals, among other priorities.[15] Without any such conditions, there is a risk that investments are directed towards short-term rescue areas, rather than long-term recovery efforts that could improve the overall resilience of the food system.

The circular economy provides an effective blueprint for achieving a stronger food sector recovery. It offers many solutions that can leverage future trends and address the identified issues faced by the industry, including: shifting to regenerative food production methods; developing surplus edible food prevention and redistribution, and by-product collection and valorisation infrastructure; reconnecting with local food production; scaling the adoption of circular indoor urban farming; and diversifying ingredients including protein sources to offer alternatives to industrially produced animal products. Though all of these could contribute to the creation of a better and more resilient future food system, in the current situation, two especially attractive circular investment opportunities arise:

9 Tools enabling farmers to shift to regenerative agricultural production

10 Food surplus and by-product collection, redistribution, and valorisation infrastructure

These selected opportunities highlight especially attractive areas that can help address both the short- and long-term goals of the public and private sectors. Together they provide solutions to key challenges created by the pandemic; meet governmental priorities for economic recovery; offer circular economy growth potential; and help reduce the risk of future shocks.



Tools enabling farmers to shift to regenerative agricultural production

to create food systems that allow people and nature to thrive

The pandemic has heightened anxieties around food safety, while highlighting the unhealthy state of the current food system.[16] For the food sector to re-emerge from the pandemic stronger than before, increasing system resilience and reducing the sector's environmental impacts will be vital.[17] Investing in a faster and broader shift towards regenerative agriculture could offer attractive opportunities for achieving this vision of a healthier and more resilient food system of the future that benefits natural systems and people alike.

A **USD 78– 116 billion** spend on accelerating the adoption of regenerative production has been estimated to yield **USD 2.3–3.5 trillion** in lifetime operational cost savings

Investing in the acceleration of regenerative agriculture can reduce costs and increase profits in alignment with evolving consumer demand. A recent report by the World Economic Forum indicated that by 2030, 191 million jobs and USD 3.56 trillion in economic opportunities could be created by reforming food, land, and ocean use by, among other things, making greater use of regenerative agricultural practices.[18] In a regenerative system, input costs can also be reduced as enriched soil organic matter and mutually beneficial relationships between different crop and animal species are created, thus reducing agricultural reliance on pesticides and synthetic fertilisers. For example, a USD 78–116 billion spend on accelerating the adoption of regenerative production through promoting practices such as planting diverse cover crops, no tillage, and multiple crop rotations, has been estimated to yield USD 2.3–3.5 trillion in lifetime operational cost savings.[19]

Diversifying the types of food grown can also lead to greater farmer income diversification, subsequently improving both crop-resilience and the resilience of producers' livelihoods in the face of external shocks, such as those created by climate change.[20] Moreover, the profitability of regenerative agriculture has in some cases even been found to be higher than that of conventional food production systems. For example, a 2018 study on corn fields found that those managed regeneratively saw a 78% increase in profits compared with conventionally farmed fields.[21] In addition, the growing demand for healthy food, accelerated since the onset of the global pandemic, is only likely to increase the attractiveness of regenerative agricultural produce, with 72% of Europeans reporting to put more effort into healthier eating in the future.[22]

Regenerative food production systems can also create significant environmental benefits by improving the ecosystems in which they are embedded. The current linear industrial agricultural food production system is extremely extractive and degrading of natural systems. In the linear way of cultivating food, increased agricultural yields are linked to the heightened use of synthetic fertilisers and pesticides that leads to soil, erosion, and depletion of valuable mineral resources, jeopardising their long-term fertility. A 2015 study estimated that one-third of global soils were moderately to highly degraded, threatening food security of the future.[23] To circumvent these issues, a shift to a regenerative food production system is needed. Regenerative food production is aimed at building healthy, biologically active ecosystems: improving, rather than degrading the environment in which the food cultivation or livestock rearing is embedded.[24] These aims can be reached through a variety of practices, such as crop rotations and diversification to promote greater biodiversity, no-till farming, using cover crops, and managed grazing.[25]

With an emphasis on improving the ecosystems in which they are embedded, regenerative food production systems work with nature, rather than against it. A 2017 paper by Farmland LP found that USD 85 million of farmland—which under conventional farming would have generated USD 8.5 million in ecosystem harm—was able to generate USD 12.9 million value in ecosystem services after being regeneratively farmed.[i,26]

By encouraging the diversification of the production system and moving away from monocultures, regenerative agriculture can also increase biodiversity while strengthening soil health and the resilience of farmer livelihoods.[27] With biodiversity loss having been identified as a key global challenge of the future, and being included in the UN's Sustainable Development Goals,[28] the ability of regenerative agriculture to increase biodiversity can also make the adoption of this system effective in mitigating the risk of future crises.

In addition, as fewer synthetic herbicides and pesticides are used in regenerative production, lower environmental toxicity can be achieved by circumventing harmful leakage, while avoiding the costs associated with its clean-up.[29] The reduced reliance on synthetic fertilisers manufactured using fossil fuels, combined with the adoption of practices such as no-tillage, also means that switching to regenerative production could – at a conservative estimate – reduce total agricultural GHGs by a minimum of 17% annually.[30] As food production and agriculture are currently responsible for over one-fifth of all GHG emissions, improvements in this area can have significant global impacts.[31] To add to this, regenerative food production has also been found to positively contribute to soil carbon sequestration, thus further increasing its ability to contribute to climate change mitigation. In fact, it has been estimated that in a period of 25 years, soils alone could sequester over 10% of anthropogenic carbon emissions.[32]

Moreover, by applying regenerative methods to the production of animal products, overall food production emissions can be even further reduced. As the current linear intensive livestock rearing practices are switched out for regenerative ones such as integrated crop and livestock operations, the massive GHG contribution of industrial livestock rearing can be addressed and the farm's carbon sequestration ability improved.[33] These savings may be very impactful given that livestock rearing in the traditional linear model was found to account for approximately two-thirds of the agricultural sector's total production-related emissions in 2009.[34] In addition, to ensure maximum benefits with regards to emissions reductions may be achieved, rethinking our food products and menus to diversify protein sources will be critical.

Investments in technical tools facilitating farmers' adoption of regenerative food production methods will be vital in achieving these benefits. Increasing the availability of specific equipment and non-synthetic inputs—such as biofertilisers, vertical tillage tools that preserve soil structure, and 'finger weeders' that can remove unwanted flora without toxins—will support farmers in making the transition.[35] Additionally, emerging digital and technological capabilities are giving way to new tools that provide valuable insight into soil quality, and crop and animal welfare, for example.[36] Digital farming, i.e. combining data collection, storage, analytics and decision modelling, can also be leveraged by large-scale farms in combination with big data and Internet-of-Things (IoT) solutions, to enable optimal regenerative results.[37] Examples of these solutions are already being tested and used, with the AI mobile app 'Nuru' using machine learning to identify plant disease symptoms from photos,[38] and service-based businesses, such as FarmShots and Vine View measuring hydration, health, and disease of crops through aerial and drone footage.[39]

The successful uptake of these technical solutions and regenerative practices will also require investments in farmer training. To improve training success and accessibility, both online solutions and in-person agricultural teaching will require investments. Local adaptations to training will be critical in ensuring that effective results and greater farmer acceptance can be achieved.[40] Examples of existing organisations helping farmers transition to regenerative practice, can be found in the Horn Farm Center for Agricultural Education[41] in the United States, and Sustainable Harvest International[42] in Central America, which provide in-person training. Other institutions, such as the Savory Institute and Ecological Farming Association (EcoFarm) provide online courses and links to relevant resources.[43] To enable

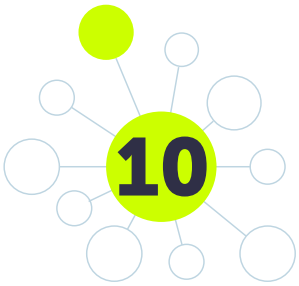
Regenerative food production can contribute to soil carbon sequestration, with a study estimating that in a period of **25 years**, soils alone could sequester over **10%** of anthropogenic carbon emissions.

i Ecosystem services encompass a variety of the benefits generated by natural ecosystems, such as water purification, and crop pollination and production.

a faster and wider farmer transition to regenerative production, more investments will, however, be needed to improve farmer access to these resources.

Investments in tools to help establish a market for food grown using regenerative methods will also be needed. Digital and technological solutions that can provide timely, cost-effective, and accurate measurement data on the impacts of regenerative food production require investment to help producers and companies clearly communicate the benefits of regenerative food to consumers, creating greater demand-side pull for these products. One example of such a solution is the Soil Condition ANalysis System (SCANS) which reliably estimates soil carbon stocks by combining an automated soil-core sensing system with advanced statistical modelling and analytics.[44] Blockchain and other technologies enabling better traceability can also be harnessed to build consumer awareness of product origin, farming techniques used, nutritional content and environmental impact, thereby enabling the creation of greater demand for regeneratively produced goods.[45] Additionally, digital commerce platforms can provide enhanced channels for farmers to directly reach consumer markets. For example, SiembraViva provides training to farmers in Colombia to adopt more regenerative practices and then, through its e-commerce platform, delivers produce from the farmers directly to urban citizens' doorsteps.[46] The heightened demand created by the adoption of these solutions can, in turn, attract more farmers to adopting these practices, thus increasing the benefits that can be achieved through regenerative production.

The policy environment is increasingly supportive of investments in a regenerative agriculture system. A number of policies, though not directly related to regenerative agriculture, also benefit the movement towards this production method and strengthen its attractiveness in the future. For example, the Australian government formed an Emissions Reduction Fund, whereby farmers can receive credits for producing goods using lower emissions methods, and even sell them to others.[47] Meanwhile, the EU's Farm to Fork Strategy sets out targets to reduce the use of fertilisers by 20% by 2030, and the use of chemical pesticides by 50% by 2050.[48] Although these goals are not yet fixed in any legislation at EU level, the tone set by the strategy is clear and will guide future national implementation measures, notably under the Common Agricultural Policy (CAP), e.g. through supporting more environmentally sound ways of agricultural production.[49] Moreover, given the rising multi-stakeholder advocacy for a more restorative food production system, exemplified by, for example, the formation of the One Planet Business for Biodiversity cross-sectorial coalition in 2019,[50] policies in support of regenerative food production methods will likely only become more commonplace in the future.



Food surplus and by-product collection, redistribution, and valorisation infrastructure

to make the most of food and improve food security

Concern over the massive amount of food waste generated around the globe is ever-growing. In their SDGs, the UN has even set a target of halving global food loss and waste by 2030.[51] Creating a circular food system where surplus edible food gets redistributed and inedible by-products are collected and transformed into valuable products—rather than discarded as in the current linear model—will be necessary for the value of these streams to be retained in the economy. To attain this vision, critical investments in collection, redistribution, and valorisation infrastructure are needed.

Investments in food collection, redistribution, and valorisation infrastructure could enable the retention of substantial economic value and the creation of new revenue streams. Each year around the world the 1.6 billion tonnes of food wasted amounts to USD 1 trillion of economic costs.[52] This lost organic matter consists of edible surplus food and inedible by-products, both of which could be transformed from costly burdens to attractive economic opportunities through enhanced collection, redistribution, and valorisation efforts. In fact, food waste reduction has been found to present an annual economic opportunity between USD 155–405 billion by 2030.[53] The edible surplus food could either be redistributed through, for example, food banks, to help improve food security and fight hunger, or processed to create new food products and revenue streams.[54] The latter option could allow food manufacturers to save costs and attract substantial investments. For example, Renewal Mill, a flour-producing venture using the by-products of tofu and soy milk production as inputs, raised USD 2.5 million for a seed round in 2019.[55]

Inedible food by-products, in turn, could be valorised to create inputs for agriculture as well as new materials and bio-energy, depending on the mixture of by-products present in the stream and technologies available for processing. Innovative solutions for inedible food by-product valorisation can create new revenue streams for farmers and food businesses, while providing them with access to new growing markets. For example, with the global compost market projected to grow with a CAGR of 6.8% from 2019 to 2024, reaching USD 9.2 billion by 2024, investments into valorising inedible food by-products to compost could offer attractive economic returns for food producers and companies.[56] In some cases, food by-products are even well-suited to be transformed for material use in the bioeconomy. For example, Ananas Anam produces a leather-like material called Piñatex®, from the by-product of existing agriculture, i.e. pineapple leaves that would otherwise be discarded.[57]

This infrastructure will also play a critical role in unlocking a variety of environmental benefits for the food system. Currently, every year, one-third of all food produced globally is wasted.[58] Moreover, barely any of this waste is retained and valorised; in Europe only 16% of food waste is captured,[59] while globally less than 2% of all valuable nutrients present in urban food waste and by-products get valorised.[60] As a result, the energy and resources used to grow, harvest, transport, and package these wasted goods is also lost, which, when combined with the methane produced from landfilling some of

In Europe, only **16%** of food waste is captured, while globally less than **2%** of all valuable nutrients present in urban food waste and by-products get valorised

this waste, creates substantial GHG emissions.[61] In fact, food waste has been found to account for approximately 8% of the annual anthropogenic GHG emissions.[62] If, instead, circular solutions were employed to prevent food waste, increase the redistribution of edible food surplus, and increase the valorisation of unavoidable by-products and green waste through composting, 1.7 billion tonnes of CO_2 could be saved annually.[63] Furthermore, some of the USD 700 billion in environmental costs caused by the current linear food production system could be avoided by increasing the collection, redistribution, and valorisation of food surplus and inedible by-products.[64] With food waste volumes surging during the pandemic as a result of farmers' inability to get their produce to the market, the need for circular solutions that capture, redistribute and valorise surplus food and inedible food by-products will become increasingly important for easing the environmental strain of food systems.

USD 700 billion in environmental costs caused by the current system could be avoided by increasing the collection, redistribution, and valorisation of food surplus and inedible by-products

Reaping these benefits will require investment in physical infrastructure in low-income countries, such as cold chains that enable the storage, processing, and distribution of edible food. In low-income countries, most of the food loss occurs immediately after the harvesting stage, due to insufficient infrastructure to store or process excess food.[65] In India, for example, deficiencies in cold chain, distribution, and transport infrastructure are hindering industry growth.[66]

The vast lockdowns and significant disruptions to food flows caused by the pandemic, have only compounded these issues. For example, in Africa, the border closures preventing produce transport resulted in mountains of rotting crops in depots.[67] Increasing the availability of cold chain or specific food processing infrastructure could then extend the shelf life of food while addressing the main cause of food waste in these areas. Using freeze-drying infrastructure to process food, for example, allows it to be kept from spoiling before reaching consumers, while also retaining up to 98% of the food's nutritional value.[68] These solutions are already being trialled on the market as exemplified by, for instance, the Ugandan fruit and vegetable dehydrator Sparky Dryer that runs on garden waste and extends food shelf life from days to months.[69] However, much more investment is still needed for storage and processing infrastructure to effectively tackle the challenges of edible food surplus.

In high-income countries, infrastructure facilitating the redistribution of edible food surplus will be needed. In contrast to the situation in low-income countries, high-income countries generate the majority of their food waste at the post-consumer stage.[70] A 2011 FAO study found that 95–111 kg of food waste per capita was generated annually by European and North American consumers, while the corresponding number for sub-Saharan African and South/Southeast Asian consumers was a mere 6–11 kg.[71] A lot of this wasted food is still edible, but due to factors, such as confusing labelling or aesthetic issues, these items get unduly discarded.[72] In order to prevent this edible food from going to waste, investments in redistribution systems that allow retailers, restaurants, and consumers to redirect their surplus food, will have to be made. Many examples of such systems that could be widely adopted and further developed already exist, such as the FareShare FoodCloud platform connecting large retailers with surplus food to local charities, the Danish WeFood supermarket selling produce past its sell-by date at strong discounts, and the mobile app Karma showcasing the unsold restaurant meals that consumers can buy at half-price nearby.[73]

Processing infrastructure to collect and valorise discarded inedible food by-products will also be critical. Door-to-door collection systems, for example, may offer attractive opportunities for municipal organic waste valorisation. Though initially more costly, these systems have been found to generate purer and higher quality by-product streams at greater volumes, thereby lowering treatment costs and rejection rates further down the value chain.[74] Greater purity, in turn, can allow for these inedible streams to be utilised for higher value applications, thereby increasing the returns on valorised content. Organic fertilisers that can return valuable nutrients back to soils to help grow new food are one example of a product that can be made from purer inedible by-product streams. For example, Safi Organics helps farmers convert agricultural residues such as rice husks into a fertiliser blend that can improve farmer yield by up to 30%.[75] Alternatively, in some instances these valuable by-product streams can be turned into various bio-based materials, as evidenced by Orange Fiber, a fabric creating company, that uses pure streams of citrus juice by-products (i.e. peels) for the production of their material.[76]

However, to enable the valorisation of these collected streams, investments into processing infrastructure and reverse logistics will be needed at the same time as well. Large structures such as anaerobic digesters that produce biogas and biofertiliser; bio-refineries that create protein feed, biofertilisers and biochemicals; composting facilities that generate valuable compost or biogas; and other innovative processing solutions that use, for example, insects to convert organic waste streams to valuable products, such as AgriProtein,[77] will need to be developed and distributed, ensuring their accessibility so that their benefits may be achieved.[78] At the same time, smaller scale distributed systems that can be used on-site, such as the anaerobic digester Waste Transformer, can also offer attractive solutions for valorisation of smaller localised inedible food by-product and waste streams.[79]

Digital infrastructure, particularly food flow mapping technologies, will play a key role in the emergence of thriving food networks. Currently, very little information is available for consumers about where food comes from, and for producers about where their food ends up. Some initial attempts of food flow mapping have been made, such as the regional efforts under the FAO's City Regions Food System (CRFS), which tested rapid food flow mapping in seven cities across the world.[80] Similarly, in the US, the first map of the country's food supply chain was just created in 2019, revealing 9.5 million links between value chain players across the country's counties.[81] However, with the global nature of the food supply chain, more investments are needed to develop global food flow maps that can help create clarity around the highly complex system.

Access to this data will enable much more effective use of resources and can improve system resilience, while the increased transparency around where food comes from (taking into account all the steps of the value chain), will enable consumers to make even more informed decisions about their purchases, as they increasingly wish to.[82] Meanwhile, regenerative food producers can benefit from being more easily recognised as such, thus enabling the streamlining of supply chains to better connect these farmers directly to buyers interested in their produce. Food waste streams can also be more easily identified and potentially even circumvented through mapping,[83] while the ease of redirecting unavoidable waste for redistribution or valorisation can be increased.

Digital technologies will play a major role in enabling this greater traceability, and as such require investments. Blockchain technologies allow for real-time traceability, thereby improving consumer confidence in food safety, a factor of great importance following the pandemic.[84] Internet-of-things solutions, combined with food sensing technologies that automatically capture and report data on the status of food in transport, for example, can also be used to help determine whether unsold food items can be redistributed or ought to be valorised in other ways.[85]

While existing examples of these technologies being applied for the food sector are not yet commonplace, innovation in the space is taking place. For example, in September 2020 Farmers Business Network launched GRO Network™, a platform that combines data provided by grain farmers with artificial intelligence to produce a low-carbon grain score, which can then be used by buyers to better inform them about the impact of their sourced goods.[86]

The policy environment is increasingly supportive of investments in food circulation and valorisation. Policymakers everywhere are becoming more aware of the detrimental economic and environmental impacts of food waste, while also starting to see opportunities in its valorisation. As such, numerous initiatives and regulations are, and have been, sprouting up around the world. Japan introduced the Food Waste Recycling Law in 2001 that improved the recycling rates of food-related businesses.[87] In 2017, the Australian government released its National Food Waste Strategy aimed at halving the country's food waste produced by 2030.[88] Meanwhile, the EU's Farm to Fork Strategy of 2020 set out to create legally binding targets on food waste reduction for each member state, in order for all member states to achieve their goal of halving per capita food waste by 2030.[89] With more innovations for food waste revalorisation popping up, and a growing concern over the issues surrounding food waste, it is likely policies around this matter will also become more commonplace and potentially more welcomed by citizens in the future.

The EU's Farm to Fork Strategy of 2020 set out to create legally binding targets on food waste reduction for each member state, in order for them to achieve their goal of **halving per capita** food waste by **2030**

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