PACE
Platform for Accelerating the Circular Economy

Circular Economy Action Agenda

FOOD

In partnership with
resonance

CONTENTS

WHO WE ARE

PACE is a global community of leaders working together to accelerate the transition to a circular economy. We bring leaders together from across business, government and civil society to develop a collective agenda and drive ambitious action.

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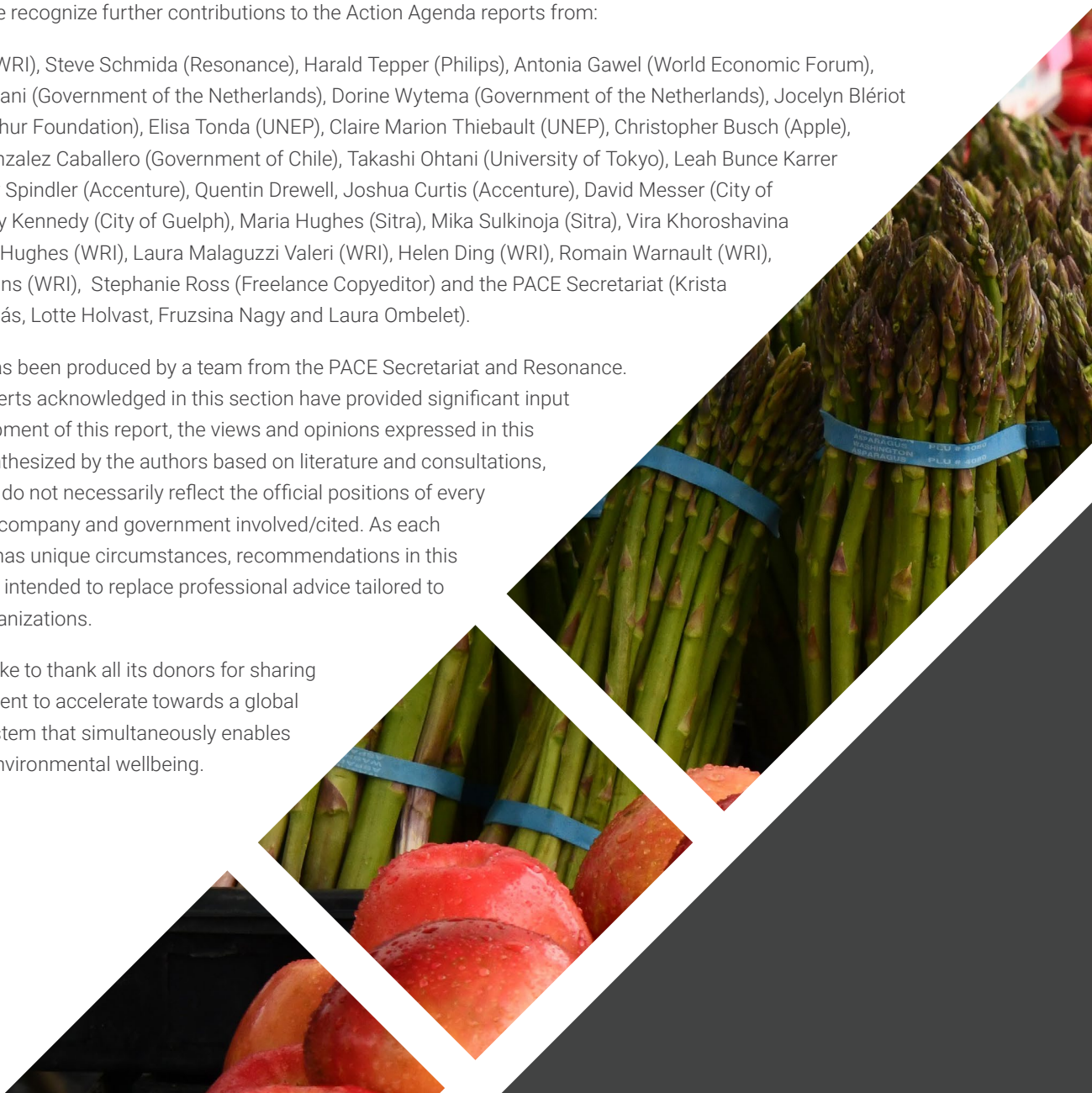
PACE would like to thank all its donors for sharing our commitment to accelerate towards a global economic system that simultaneously enables human and environmental wellbeing.



IN SUPPORT OF THE CIRCULAR ECONOMY ACTION AGENDA

INGER ANDERSEN | Executive Director, UN Environment Programme

"Scaling up circularity and sustainable consumption and production is essential to address the three planetary crises we are facing: the climate crisis, the biodiversity and nature crisis, and pollution and waste crisis. The calls-to-action should inspire and redirect the efforts of government, business and finance, and consumers, because at the end of the day, each and every one of us has the power and responsibility to contribute to the transition."

TIM BENTON | Research Director, Emerging Risks, and Director, Energy, Environment and Resources Programme, Chatham House

"An inclusive circular economy that promotes sustainability and decent work will help countries to build prosperous economies and just societies. The economic recovery from the COVID pandemic is an opportunity for governments to collaborate and accelerate this shift from linear to circular internationally."

MARTIJN LOPES CARDOZO | CEO, Circle Economy

"The Circular Economy Action Agenda delivers the necessary insights and a strong narrative for action within five areas where urgent change is needed. By enabling cross-sectoral partnerships to tackle these challenges, PACE is proving itself as a conductive change agent to help close the global circularity gap. We look forward to collaborating and delivering results within these key areas together".

FRANS VAN HOUTEN | CEO, Royal Philips

"Transitioning to a circular economy requires all of us to team up and commit to doing things fundamentally different. The PACE Action Agenda will help guide and drive circular ways of working across the board, changing how we create value without devastating environmental impact. I call on all leaders to join PACE and commit to adopt climate actions and prioritize circularity."

NAOKO ISHII | Executive Vice President and Director, Center for Global Commons, The University of Tokyo

"Tremendous stress on the environment from our food system has not been discussed until recent years and has not received the attention it deserves in many countries – including Japan. Food is deeply connected to our lives, personality, and culture, and its transformation requires all stakeholders' active involvement. This paper serves action plans that many stakeholders can take and will be a good guide for them."

PETER LACY | Chief Responsibility Officer and Global Sustainability Services Lead, Accenture

"The circular economy offers an opportunity to unlock value and decouple growth from the use of scarce and harmful resources. This Action Agenda lays a foundation for the collaboration and innovation that is necessary to make production and consumption more sustainable for people and our planet. Now is the time to embrace end-to-end transformations that can create value while ensuring a more sustainable future."

DAME ELLEN MACARTHUR | Founder, Ellen MacArthur Foundation

"The circular economy is a solution framework that offers better growth while addressing the most pressing global challenges. The calls-to-action help reinforce the need for transformation of our most iconically linear value chains, towards an economy that eliminates waste, preserves the value of resources, and helps regenerate natural systems."

LLORENÇ MILÀ I CANALS | Head of Secretariat, Life Cycle Initiative (UNEP)

"The key for a transition to sustainable consumption and production patterns is anchored in the value chains – where circularity strategies are supported by strong life cycle thinking and assessment. We are proud to work with PACE partners in ensuring the calls-to-action address the key hotspots along these value chains' life cycle, to ensure we shift the needle on the planetary crises we face."

JANEZ POTOČNIK | Co-chair, International Resource Panel (UNEP)

"It was a pleasure to contribute to the development of the Action Agenda with our expertise in resource management issues. We are pleased with the clarity to which the reports have contributed. Now is the moment for stakeholders across all sectors to come together and pick up the calls to action."

STEVE SCHMIDA | Co-founder and Chief Innovation Officer, Resonance

"If we are to achieve the SDGs, circularity must be embedded into the very fabric of how industries and economies operate. The Circular Economy Action Agenda lays out a clear vision for how leaders from across business, government and civil society can partner together to drive sustainable, equitable action."

CAROLINA SCHMIDT | Minister of Environment, Chile

"We already know how the circular economy can make a key contribution to mitigate climate emissions. Now it's time to act. PACE's Action Agenda condenses and highlights the most urgent and effective pathways to unleash the transformation to a circular economy at a global level. Policy makers, scientists, businesses and citizens everywhere should put this powerful agenda into practice—today."

ANDREW STEER | President and CEO, World Resources Institute

"Circularity is the shape of the future. Shifting from the destructive take, make, waste model of the past is crucial if we are to achieve the SDGs. The new Circular Economy Action Agenda, which brings together insights from scientists, government officials, and business executives, presents a bold and clear way forward to a more sustainable approach that will benefit people and the planet."

MARIE FOSSUM STRANNEGÅRD | CEO, IVL Swedish Environmental Research Institute

"The Action Agenda is crucial reading for anyone working to improve social and environmental wellbeing through circular economy. We were glad to be part of the process to develop the reports and to be able to contribute with our decades of experience in translating environmental science into improvements in the society."

ELS VAN SCHIE | Director of Environment and Safety Department, RIVM

"Our goals on safe healthy and sustainable food for all can only be reached by the means of a safe, healthy and sustainable agricultural system. Therefore, insights on environmental and human health impacts of both product and production processes are required as part of the transition to a sustainable agricultural production system."

STIENTJE VAN VELDHOVEN | Minister for the Environment, The Netherlands

"The circular economy is our secret weapon for achieving our climate and sustainable development goals. PACE's Action Agenda demonstrates the need for a fundamental shift in the way we produce and consume. It contains concrete examples of a new economic reality taking shape. Let's use the Agenda to upscale cross-regional collaboration, build cross-sectoral partnerships and continue to build a circular world."

DOMINIC WAUGHRAY | Managing Director, Centre for Global Public Goods, World Economic Forum

"The twin crises of the pandemic and climate have underscored the need for more sustainable consumption and production. We must build on this momentum to forge new collaborations with policy makers, business leaders and consumers to ensure that resources are maximized, value chains are transformed and the circular transition can become a reality. The time is now."

MARINKE WIJNGAARD | Managing Director Circular Economy & Environment, TNO

"TNO is happy to be part of the PACE scientific community. We believe that through an integrated assessment of possible scenarios and through technological innovation we can find the right answer to every environmental question and make an accelerated transition to a circular economy feasible."

FOREWORD

We call on businesses, governments, and civil society leaders around the world to join us in raising the level of ambition to create a circular economy. Investing in a circular economy will be crucial to helping us realize the social, environmental, and economic benefits of the 2030 Agenda and the Paris Agreement, as well as to build a sustainable economic recovery from COVID-19.

This year over 200 circular economy experts from 100 businesses, governments and civil society organizations joined hands through PACE to develop the Circular Economy Action Agenda. The calls-to-action in the Agenda provide clear priorities for leaders around the world to join us in solving critical issues and taking advantage of open innovation opportunities.

Circular Action Means Impact. Embedding circular principles and goals across industries and governments' priorities will be crucial to reaching our 2050 net zero commitments. Changing the way we make and use products can contribute to addressing 45% of global greenhouse gas emissions, making a critical contribution to mitigating the impending climate crisis. Along the way, the widescale adoption of circular business models presents a US$4.5 trillion economic opportunity.

Circular Action is Urgent. Our current economic system is based on linear principles of extracting natural resources, using them up, and creating huge volumes of waste. Our use of resources has tripled since 1970, and could double again by 2060 if we continue business as usual. Despite advances in technology, the growth rate in material consumption continues to increase faster than our population growth, with many social and environmental impacts resulting from inequities in consumption and production.

Not only is this linear model unsustainable, the economic impacts of COVID-19 have shown how vulnerable we are to economic shocks resulting from any disruption in the current flow of resources.

There is another way. By working towards a circular economy we can transition to a system that is designed to prevent waste and pollution, keep products and materials in use, and regenerate natural systems—leading to a more resilient economy.

Circular Action is Clear. While we have experienced an increase in interest in the circular economy, investments and scale are not happening fast enough. We believe that more alignment among leaders is required to show the way forward. These reports set out clear priorities for action in five critical focus areas—plastics, electronics, textiles, food, and capital equipment—providing important lessons that can be applied elsewhere.

There is much that can be done. Governments can set policy, companies can adapt their business models, the finance sector can invest, researchers can provide the scientific backing, and we can all do our part as individuals. But the biggest challenges mandate that we work together. That is why we join hands at PACE: creating the space for collaboration across sectors so that we can identify new solutions and scale up what works.

Join us as we take bold steps forward to create the better world we know is possible.

David B. McGinty
Global Director, PACE

EXECUTIVE SUMMARY

The Circular Economy Action Agenda has been designed to accelerate the transition to a circular economy—and to a better future for people and nature. It transforms existing knowledge into a collective agenda that will inform and mobilize action.

Our food system has seen some great achievements in feeding the world's growing population, but will be unable to sustainably support the global population of tomorrow. We need to build a sustainable food system where the growing, eating, and disposal of food creates net benefits for the economy, people, and the environment.

How can circular strategies contribute? By applying circular economy principles to food system value chains, three objectives are defined as circular components of an ideal future food system: food is produced in ways that regenerate nature; food is not lost or wasted; and commonly wasted resources are used productively.

Circular economy emerged from using natural resources more efficiently and sustainably, yet its impact goes well beyond resource use. A circular economy for food can bring clear benefits to human health and biodiversity, by reducing pollution and increasing nutrition. Producing food in ways that regenerate nature can bring an increase in decent jobs and better farm economics. Reducing food loss and waste can play a significant role in combating climate change and improving food security. Using commonly wasted resources in productive ways can be an environmental and socioeconomic win-win.

There are also points of attention and knowledge gaps. The resource use and climate impact of farming depends on many factors, including geography, crop type and agricultural practices. A critical factor is land use change. Furthermore, due to the highly complex nature of the food system, the social and economic impacts of changes in food loss and waste is not yet fully understood.

Despite the dire need and significant opportunities, a circular transition of the food system faces many barriers beyond the control of any individual stakeholder. From literature study and interviews carried out for this report, 19 key barriers have been identified that work collectively to slow progress towards the vision of a circular economy for food.

Building on these impact and barrier assessments, we put forward 10 calls-to-action. Each call-to-action is a priority area where actions are most needed today, to overcome key barriers and to optimize impact:

1. Enable Transitions to Planetary Health Diets
2. Scale Productive and Regenerative Agriculture Practices
3. Increase Value of Nature-Regenerative Food Production to Farmers
4. Better Understand Hotspots of Food Loss and Waste
5. Integrate Food Loss and Waste More Broadly in the SDG Agenda
6. Increase Investment in Food Loss and Waste Reduction
7. Reframe Wasted Food and Byproducts as Valuable Resources
8. Facilitate Secondary Market Development and Access
9. Enable Sanitary Cycles for Human Waste
10. Increase Information Accessibility and Data Utilization

A variety of actions can be taken up by different stakeholders under each call-to-action. Some examples are given. We invite every changemaker to come up with ideas and initiatives to address these action points, adapting them to different contexts.

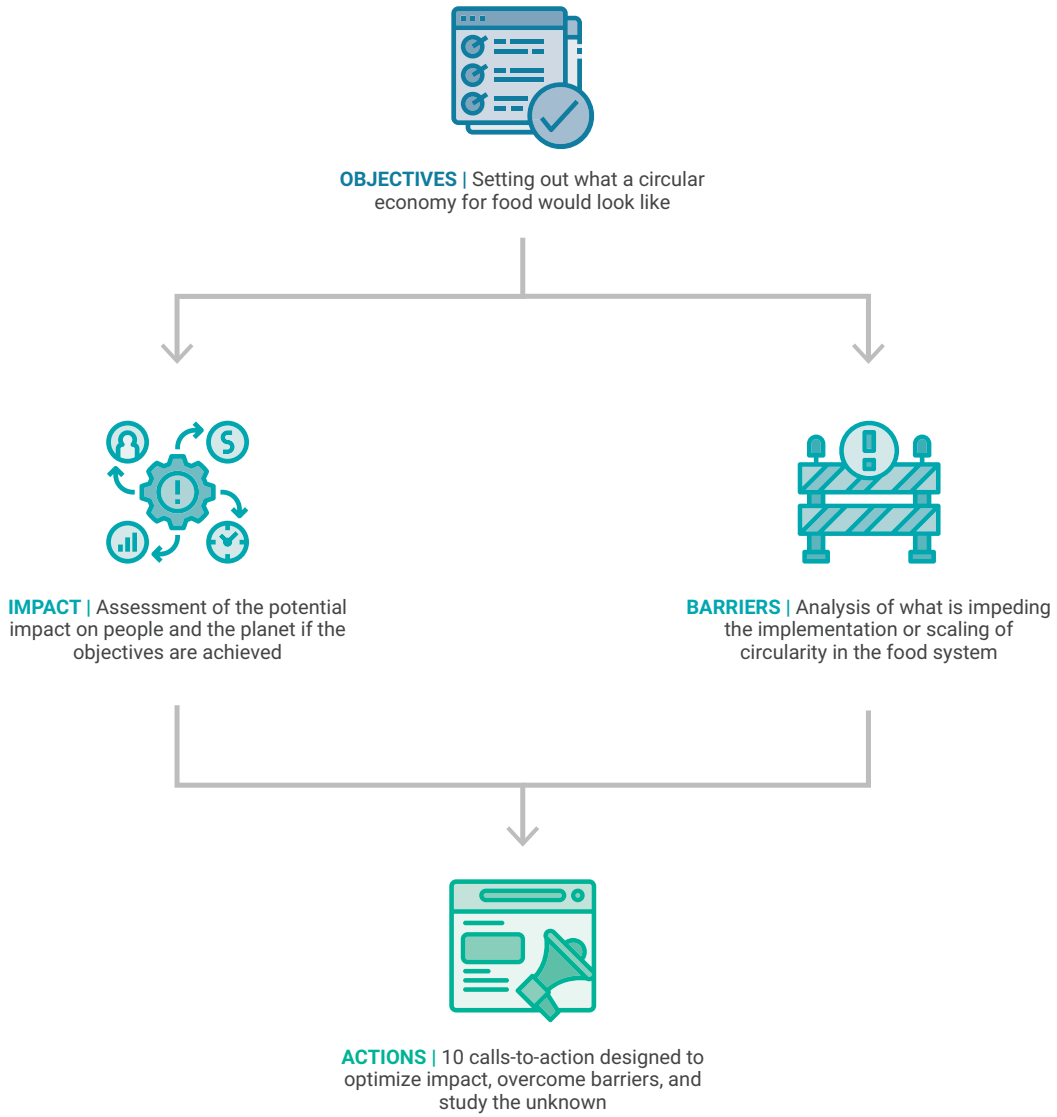
ABOUT THE ACTION AGENDA

The Circular Economy Action Agenda is designed as a rallying call for business, government, and civil society. It is currently made up of five publications: electronics, plastics, textiles, food, and capital equipment. The aim is to transform existing knowledge into a collective agenda that will inform and mobilize action within the PACE community and beyond.

Our economy has been highly successful in increasing productivity and elevating the living standards of parts of the population. In doing so, it has also created many challenges, both environmentally and socially. The need for solutions is more urgent than ever. A circular economy has been proposed as a way to address these challenges, with the ambition to harmonize economic and ecological goals.

Researchers have already documented the challenges our food system faces today, the need for a sustainable transition, and the role of circular economy in the systemic change.[1] This report builds on the existing literature to identify the actions needed for a better and faster transition to a circular economy for food. Each report has four main chapters: Objectives, Impact, Barriers, and Actions (see Figure 1).

FIGURE 1 • Structure of the Action Agenda Reports



How we Developed the Action Agenda

PACE brings leaders together from across sectors and industries to develop a collective agenda and drive ambitious action, creating a space for leaders to work in partnership and overcome challenges together. The Action Agenda is the result of collective efforts by working groups made up of representatives from business, government, civil society, finance, and research organizations, collaborating throughout 2020. In total, more than 200 experts from over 100 organizations have contributed via over 80 phone interviews, more than 20 group discussions and substantial written inputs. The reports try to integrate all insights, balance different viewpoints, and identify where further alignment is needed. We believe that this diversity of viewpoints is crucial for designing and realizing a better transition.

OBJECTIVES | What Do We Mean by a Circular Economy for Food?

We all desire and strive for a future of human and environmental wellbeing. The circular economy is a key path towards that future. This chapter explains how the community currently sees circular strategies being applied to the food system and sets out three objectives.

Our food system[2] tightly connects our environment, society, and economy. Recent decades have seen great achievements—due to increases in productivity there are 200 million fewer hungry people today than in 1990, despite a two billion increase in global population (Food Aid Foundation n.d.). But this system will not be able to sustainably support the global population of tomorrow. The shocks caused by COVID-19 have laid bare the vulnerability of the current food system to many people for the first time. How can a system where crops lie rotting in fields due to disrupted markets, while lines stretch for miles at emergency food handouts, simultaneously be good for business, people, and the environment?

Luckily, leaders across public, private, and civil society sectors are recognizing the risks of business as usual, increasingly working together to build a sustainable food system where the growing, eating, and disposal of food creates net benefits for the economy, people, and the environment (The Rockefeller Foundation 2020; Champions 12.3 2020; McGlade et al. 2020; Ellen MacArthur Foundation 2020). The tragedy and disruption of COVID has only accelerated awareness of the need for this transition (Severson 2020).

The transition to a sustainable food system is broad and complex. The system must, "deliver food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised" (Nguyen 2018). How can circular strategies contribute? A circular economy for food is still a relatively new concept, and there is no widely-adopted definition as yet. Therefore, to develop this Action Agenda, three circular economy principles[3] were applied to food system value chains to define overarching objectives of an ideal future food system. This process led to three objectives where circular strategies can be best leveraged to drive change:

1. Food is produced in ways that regenerate nature
2. Food is not lost or wasted
3. Commonly wasted resources are used productively

The food system we need will not materialize without concerted effort across all sectors; it will require stakeholders to work together to solve issues, and collaborative actions will need to be directional, getting closer to a circular economy over time, versus in one drastic moment of change.

1: FOOD IS PRODUCED IN WAYS THAT REGENERATE NATURE

Today, food production in many parts of the world is resource-intensive, wasteful, and polluting (FOLU 2019; Searchinger et al. 2019; Ellen MacArthur Foundation 2019). Yet agriculture has great potential to regenerate natural systems: to keep soil healthy, water clean, store carbon and provide homes for a range of biodiversity both above and below ground. This objective has two aspects: first, it is critical to shift *what we grow*—with a global move toward a 'planetary health' diet[4] that is richer in fruits, vegetables, and more diverse protein. Second, it is important to shift *how we grow*—changing production methods to include more resource efficient and regenerative methods such as agroforestry, permaculture and silvopasture.

CIRCULAR ECONOMY FOR FOOD PRODUCTION

A wide range of terminology exists for food production future states, though none has been commonly adopted yet to define the circularity aspect. This report uses "regenerate nature", as this is closest to the circular economy principles. There is not a singular definition of regenerative agriculture, for this report we use the Food and Land Use Coalition's broad definition: "(Regenerative Agriculture) includes a set of practices that regenerate soil, that reduce but do not necessarily eliminate synthetic fertilizers and pesticides, and that go beyond the reduction of negative impacts to ensure that agriculture has a positive environmental effect." This should be viewed as a component of a holistic sustainable transition, instead of a siloed pursuit.

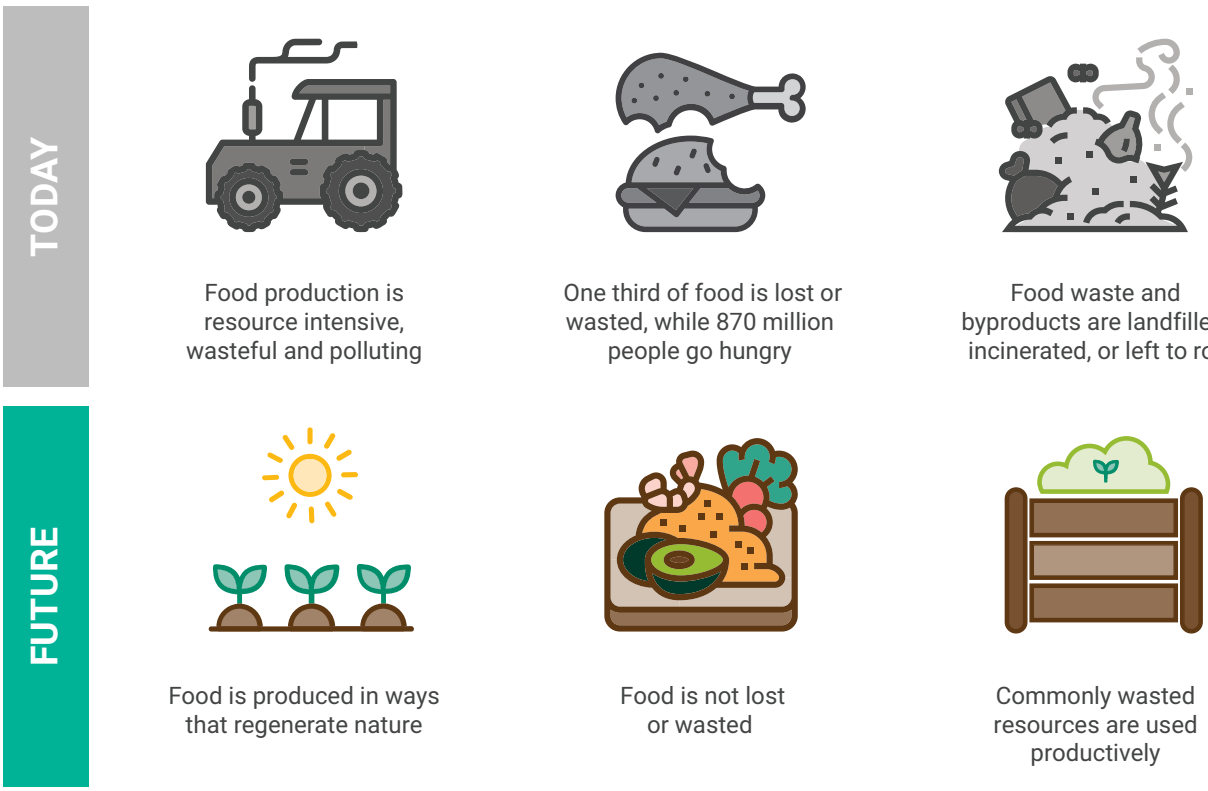
2: FOOD IS NOT LOST OR WASTED

This objective ties directly to Sustainable Development Goal (SDG) 12.3: at least a 50% reduction in global food loss and waste by 2030. The focus of this objective is on the edible component of food that could be consumed if it was not lost or wasted from field to fork. If food loss and waste were a country, its GDP would be approximately $950 billion (equivalent to that of the Netherlands), and it would be the third largest greenhouse gas emitter in the world (WRI and WRAP 2019). Reducing food loss and waste is a key objective shared among many leading food system transformation initiatives, including the Champions 12.3 coalition ('Champions 12.3' n.d.), WRI's Creating a Sustainable Food Future report (Searchinger et al. 2019), and the EAT-Lancet Commission on Food, Planet, Health (Willett et al. 2019). Food loss and waste needs to be reduced across the full value chain, including agricultural production, post-harvest handling and storage, processing and packaging, distribution and retail, as well as at consumer level.

3: COMMONLY WASTED RESOURCES ARE USED PRODUCTIVELY

The first priority should be to get edible food to the people who need it, although some waste of edible food is unavoidable, as a resilient food system will have some waste built into it to help buffer shocks. This objective focuses on edible food waste that cannot be redistributed, as well as inedible by-products from food processing, and human waste. These materials can also be kept in use in economically viable ways. Currently less than 2% of the valuable nutrients in food by-products and human waste generated in cities are recycled back to agriculture (Ellen MacArthur Foundation 2019). Reimagining these wasted materials as valuable resources with productive uses (such as insect feed, textile or plastic feedstock, fertilizer and energy sources) can spur innovation for new products and market development. This in turn helps to incentivize stakeholders along food value chains to adapt their business models and generate new revenue streams, while reducing the cost of waste disposal.

FIGURE 2 • Major Challenges in the Food System Today and the Circular Objectives



IMPACT | How Might a Circular Economy for Food Affect People and Planet?

This chapter presents a literature-based assessment of how the circular objectives may have an impact on the world, if achieved. Circularity alone cannot solve all today's problems. No solution alone can. It is therefore important to understand where circularity can deliver benefits, as well as areas that require attention or further research.

Circularity is not the end goal. It is, however, an important pathway contributing to the end goal, which is achieving greater human and planetary wellbeing—as described by the Sustainable Development Goals and the Paris Agreement. It is crucial to keep this north star in focus, and to steer the circular transition accordingly for a balanced, positive outcome.

The environmental and socioeconomic impacts of the food system today are already thoroughly documented (Metabolic 2017; Ellen MacArthur Foundation 2019; Searchinger et al. 2019). In this Action Agenda, we look to the future and ask the question: *if the circular objectives are achieved, how might people and planet be affected?* It is important to understand where the circular economy can deliver benefits, as well as where points of attention and knowledge gaps exist.

Science-based, forward-looking impact assessment of increased circularity is still a relatively new field. As an initial step towards this understanding, the three objectives defined in the previous chapter were assessed by a group of scientific experts (see Appendix), based on existing literature along five impact categories:[5]

- **Resource use**: use of minerals and fossil resources.
- **Climate change**: greenhouse gas emissions from the value chain.
- **Human health and biodiversity**: largely as a consequence of land, water and chemical use, as well as air, water and soil pollution. Soil health and nutrition are also considered.
- **Economic wellbeing**: a broad category covering income, wealth, value-added, and their distribution; trade, productivity, competitiveness, entrepreneurship, resilience and investment.
- **Decent work**[6]: a broad category that includes the promotion and realisation of standards and fundamental principles and rights at work, creating greater opportunities for women and men to decent employment and income, enhancing social protection, and strengthening social dialogue.

The figures below give an impression of how each circular objective may affect the five impact categories: could it bring benefits, trade-offs, or is it uncertain due to insufficient knowledge or evidence? A more detailed analysis can be found in the Appendix. It should be cautioned that impacts are almost always complex, with boundary conditions, caveats and exceptions, and always evolving, e.g. as new technologies emerge. Therefore, these qualitative labels should never be seen as absolute or static.

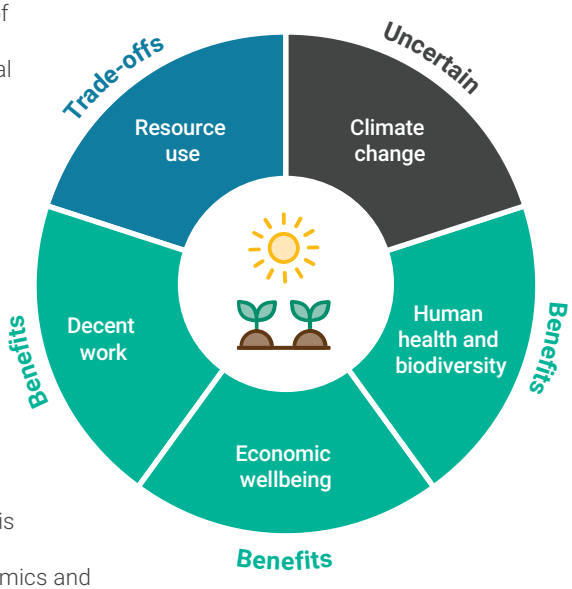
Any complex transition comes with pros and cons. We should not be locked into inaction for fear of the risks and uncertainties. Quite the opposite; we should take proactive action to optimize the impact of a circular transition, including leveraging win-wins for maximum benefits, mitigating trade-offs and risks, and investigating the yet unknown.

FIGURE 3 • Expected Impact of Producing Food in Ways That Regenerate Nature

RESOURCE USE | Regenerative farming reduces need for resources (e.g. synthetic fertilizers and pesticides) per hectare but may need more land due to lower yields (Kirchmann 2019). Net impact depends on crop type, practices, and changes in productivity.

CLIMATE CHANGE | Climate impact of farming depends on factors including geography, soil type, agriculture product type, practice, and timeframe. Regenerative farming practices' contribution to greenhouse gas reduction, e.g. by increased vegetation and soil carbon capture, is still a topic of debate, partly originating from different definitions of regenerative agriculture (Ranganathan et al. 2020; EIT Food 2020). Another critical factor is land use change—if forests are cleared to create new farmland to compensate for potentially lower yields, net emissions may increase.

HUMAN HEALTH AND BIODIVERSITY | Growing food regeneratively can reduce health issues related to pesticide exposure, air pollution and food contamination, with an estimated annual saving of $650 billion by 2050 (Ellen MacArthur Foundation 2019). Regenerative farming will improve soil health (LaCanne and Lundgren 2018), though the link between soil health and human health still needs to be better explored. Transition towards 'planetary health diets' is better for human health, with reduced risk of disease (Milani and Skaven Ruben 2020) and improved biodiversity due to reduced land use change and water use pressures.



ECONOMIC WELLBEING | Productive and regenerative agriculture is estimated to be a $1.4 trillion business opportunity globally (World Economic Forum and Alphabeta 2020), offering positive farm economics and benefits for regional GDP (LaCanne and Lundgren 2018).

DECENT WORK | Sustainable food production practices are expected to create more full time and decent jobs globally (Herren et al. 2011). However, labor conditions may not improve automatically compared to conventional farms. Targeted efforts are needed to ensure the quality of these jobs (Green for All 2011).

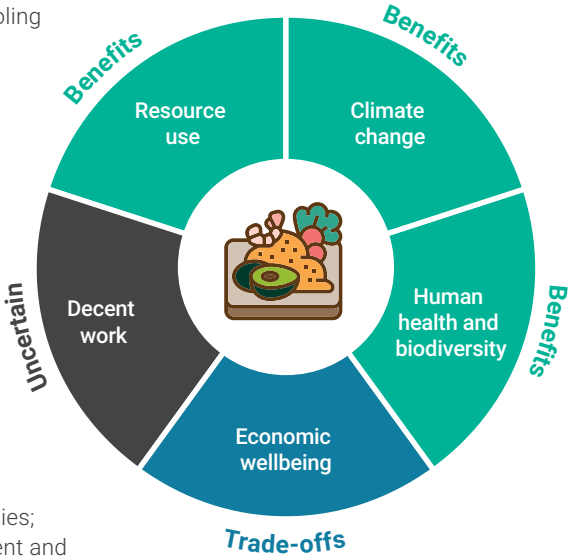
FIGURE 4 • Expected Impact of Reducing Food Loss and Waste

RESOURCE USE | Food loss and waste reduction can in most cases alleviate the need to further increase food production, therefore reducing material, water, land, and energy use throughout the supply chain.

CLIMATE CHANGE | Food loss and waste reduction may reduce energy use and greenhouse gas emissions from food production (World Bank 2020). More cold transport and storage is needed, but the benefits outweigh the drawbacks (James and James 2010), especially if low-carbon cooling solutions are used.

HUMAN HEALTH AND BIODIVERSITY | Reducing food loss and waste means more nutritious food available for human consumption, since nutrition-rich foods (e.g. vegetables, fruits and animal proteins) are disproportionately susceptible to both loss and waste.

ECONOMIC WELLBEING | The relationship between changes in food loss and waste and the behavior of food systems is still not well understood. Reducing food loss and waste can improve food security, by reducing food demand and therefore prices (World Bank 2020).It may also increase household savings, supply chain efficiency and competitiveness. On the other hand, economic simulations have projected reduced demand for food production leading to declining farm welfare from lower sales and prices (though improved farm welfare has been reported from specific case studies; Ambler, Brauw, and Godlonton 2018), as well as loss of employment and reduction in GDP (World Bank 2020; Herren et al. 2011).



DECENT WORK | New employment may be created in the storage and handling of food donations (ReFed 2016). Reduced production derived from reduced food loss and waste may lead to less on-farm jobs (Herren et al. 2011; Ambler, Brauw, and Godlonton 2018). Overall, more research is still needed on the social impact of food loss and waste reduction measures.

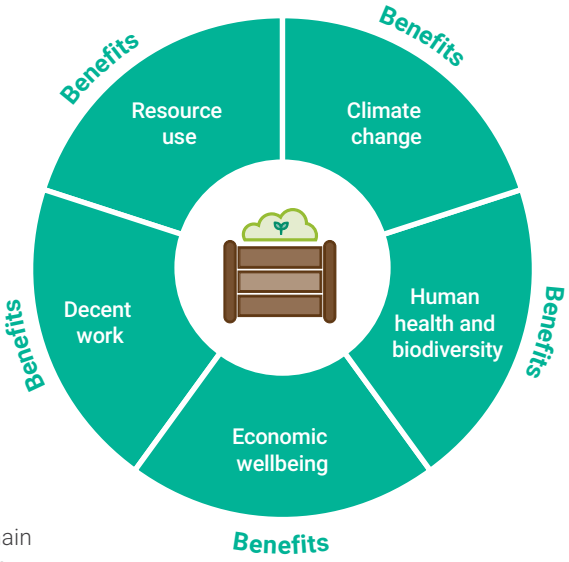
"The Action Agenda by PACE helps create the systemic change needed for transitioning to a circular economy in key sectors. The calls-to-action provide us an opportunity to reach multiple goals, from our climate goals to halting biodiversity loss, reducing our overconsumption of resources, and increasing societal wellbeing by transitioning to a circular economy."

Mari Pantsar, Director, Sustainability Solutions, The Finnish Innovation Fund Sitra

FIGURE 5 • Expected Impact of Using Commonly Wasted Resources Productively

RESOURCE USE | Using unavoidable or non-edible food waste, byproducts, and human waste can: reduce synthetic fertilizer use if used as fertilizer (UNEP 2019); reduce fossil resource use if used as plastic and textile feedstock (Esteban and Ladero 2018; de Santana Costa, Asfora Sarubbo, and Vasconcelos Rocha 2017); reduce biomass input if used as animal feed—whether directly or used to grow insects such as black solider flies as a replacement to fish meal. Recycling nutrients can both reduce the need for new inputs and minimize nutrient losses (UNEP 2016).

CLIMATE CHANGE | Using food waste, byproducts, and human waste as fertilizer may reduce greenhouse gas emissions through less synthetic fertilizer use and less uncaptured emission from landfills. If bioplastics made from non-avoidable food waste and byproducts displace the production of fossil-based polymers, greenhouse gas emissions can be reduced (Groot and Borén 2010).



HUMAN HEALTH AND BIODIVERSITY | Sanitary systems to recycle human waste can reduce soil, air and water pollution and related diseases, especially in low-income countries (Rodriguez et al. 2020). Organic fertilizers will improve soil health (Van Zanten, Van Ittersum, and De Boer 2019; Gomiero, Pimentel, and Paoletti 2011). When waste is used as fertilizer, attention should be given that micro-pollutants do not accumulate in soil (Harder et al. 2019).

ECONOMIC WELLBEING | Productive use of commonly wasted resources will create new local businesses and increase supply chain resilience (Green for All 2011). Overall, more quantitative economic modelling research is needed.

DECENT WORK | Expected to create innovative employment in local enterprises that engage in the full waste-to-value chains, including resource collection (including container-based sanitation), aggregation, transformation, and utilization. Targeted efforts are needed to ensure the quality of these jobs. More research needed overall.

BARRIERS | What is Hindering the Transition to a Circular Economy for Food?

This chapter analyzes what is currently impeding the implementation or scaling up of circular strategies, considering all angles including policy, business models, finance, technology, information, culture, and behavior.

There has been much written about the significant economic opportunity that transitioning to a sustainable food system would bring. For example, the Food and Land Use Coalition (FOLU) found that $300-350 billion in annual investment would unlock more than 10 times that amount, $4.5 trillion, in annual business opportunities (FOLU 2019). The World Business Council for Sustainable Development (WBCSD 2019b) found that the circular bioeconomy is a $7.7 trillion opportunity. The Ellen MacArthur Foundation and Google have uncovered a $127 billion opportunity using artificial intelligence to design out waste in the food system alone (Ellen MacArthur Foundation and Google 2019).

There are a number of enabling trends that will help to capitalize on these opportunities, in particular the potential of digital innovation across the food value chain. Global online grocery shopping is estimated to be growing by 26% annually (WBCSD 2019a), and artificial intelligence in agriculture is expected to grow 65% per year (Weaver 2020). Consumers are also beginning

to flex their spending power, with sustainability-linked brands growing four times faster than their peers, and the alternative dairy and protein categories are both growing at 10% annually (WBCSD 2019a; Meticulous Market Research 2020). Though they remain niche market segments, alternative proteins have seen a dramatic spike in demand during the pandemic (Poinski 2020).

Yet, in the face of all the evidence of the dire need and significant opportunities, the food system is challenged in its transition, with many barriers beyond the control of any individual stakeholder. From literature study and interviews, we have identified 19 key barriers that may work collectively to slow progress towards the vision of a circular economy for food. Some of these stand in the way of a general transition toward a sustainable economic model, while others are more specific to a transition to a circular economy for food. Due to the complex nature of the food system, there are links, connections and overlaps between these, depending on the perspective of analysis. The goal is not to produce an exhaustive list of all barriers, but rather critical ones where collaborative action is needed to overcome them.

Cross-Cutting Barriers

Unsustainable diet habits – market demand drives "what to produce". Currently the global average intake of planetary health foods is substantially lower than EAT-Lancet's reference diet (EAT-Lancet Commission 2019). In particular, a preference for meat and dairy, among the most resource-intensive and environmentally damaging food products, has been increasing with rising affluence. Just 55% of crops grown globally are used to feed people, with the majority of the rest going to livestock (Cassidy et al. 2013).

Underutilization of technology – this barrier dually captures the relatively limited availability of technological solutions, as well as the limited uptake and use of solutions that are available, appropriate, and cost effective. While uptake of technology varies greatly across the world, the agriculture and food sectors are often steeped in traditional practices, due in part to the breadth of stakeholders involved (e.g. 570 million smallholder farms worldwide (Trendov et al. 2019)) and lack of supporting rural infrastructure and knowledge of solutions. There are significant potential gains currently being missed.

Information by itself does not change behavior – we have known for decades about the dangers of climate change and the risks of unhealthy diets, and yet we are slow to change our collective and individual ways (Attwood 2020). Unfortunately, humans are not wired to make rational decisions based purely on information presented to us. Many resources have been spent on positive food education campaigns that failed to influence human behavior, due in part to a lack of consideration about the choice environment or real engagement with those they wish to influence.

Lack of transparent and traceable supply chains – having visibility along the entire supply chain is a critical step toward transitioning to a more circular model. However, many supply chains remain opaque due to the number of hands food passes through from farm to fork, and the complexity of logistics for global supply chains (Veldhuizen et al. 2020). Put simply, how can you change a supply chain that you cannot see?

Externalities are not accounted for – the market dynamics of the food system currently encourage producers to push many environmental costs into externalities – such as biodiversity loss, land and water use, greenhouse gas emissions – as ways to reduce their costs in pursuit of small profit margins. Price signals along the value chain are a critical way of changing market dynamics, and currently food prices account for neither their environmental impact nor their nutritional benefit.

Lack of coordination and collaboration – the food system is currently governed by silos in government and industry that need to increase their coordination and collaboration to send consistent signals to markets and individuals (Kalibata 2020). For example, food is often considered to be the responsibility of the ministry of agriculture, but it also has critical crossover with health and nutrition, environment and natural resources, finance and trade, and sanitation and waste management. A lack of harmonization often leads to each silo focusing on metrics that pull against each other and further entrench the status quo, instead of moving toward holistic solutions together.

Barriers to Producing Food in Ways that Regenerate Nature

Systemic focus on quantity of calories instead of quality of nutrition – the industrialization and globalization of agriculture has led to over 75% of food coming from just 12 plant and five animal species. Today, calories are the unit of measurement used to judge the success of the food system, when it should be nutritional content. While this system has led to more total calories being produced than the global population needs since 1990 (Knorr and WWF 2019), it relies on linear practices that extract nutrients and reduce soil biodiversity. This means external nutrients such as phosphorus and nitrogen need to be mined and added to fields, reducing the resilience of agricultural lands.

Perverse incentives from regulation and markets – markets and policies such as subsidies have been providing incentives that are individually economically rational, but collectively harmful. Recent research has uncovered $451 billion spent annually on ecologically harmful agricultural subsidies across the globe (Deutz et al. 2020). In an attempt to ensure global market competitiveness, these incentives prop up harmful practices that would not be economical without government assistance. In addition, there is a lack of demand from food manufacturers, retailers, and public procurement for foods and ingredients that are produced in ways that regenerate nature.

Diverse production systems increase complexity – industrialization and the desire for scale lend themselves to monoculture production, due in part to the reduction in complexity and allowing system designers to focus on a limited set of variables. While diverse production systems may be healthier, more resilient and more productive when well executed, each additional variable increases complexity—making successful implementation more challenging and increasing the need for strong farmer capacity, training, and support systems.

Historical underinvestment in nature and nature-based solutions[7] – historic underinvestment in the protection and restoration of nature, which today has a shortfall of $600-820 billion annually (Deutz et al. 2020), has led to increasingly creative ways of continuing to extract value from nature without returning any value, instead of investing in and applying nature-based solutions. This has led to agriculture being a key driver of deforestation, desertification, disappearing fresh water supplies, and the need to transport commercial beehives to pollinate crops (Rossi 2020).

Lack of finance and assistance for a transition to regenerative production methods – finance has not accounted for linear risks such as soil degradation and biodiversity loss in pricing models, while lacking the tools to assess the value of novel production methods that can lead to positive financial returns. This reduces the flow of finance available to farmers to invest in a transition. In less developed contexts, technical assistance has often focused narrowly on improving yields of staple crops, instead of taking a systems perspective and promoting environmentally beneficial practices that grow nutritious crops.

Barriers to Reducing Food Loss and Waste

Blind to significant segment of food that is lost or wasted – most of the information we have on food loss and waste comes from Europe, and assumption-based models are used to extrapolate details to other regions. By not knowing exactly where food is being lost and wasted, from field to fridge and beyond, it is hard to develop impactful programs that utilize capital most effectively. Data availability and quality is increasing, but its effective use to drive decisions is frequently missing (Searchinger et al. 2019).

Lack of government policy on food loss and waste – government policies on reducing food loss and waste, such as those on increasing food recovery opportunities, can send a strong signal to the private sector and individuals. Many governments currently do not report their food loss and waste.[8] It is rarely recognized in government policies on topics such as climate food security, and nutrition. Only 11 countries currently include food loss in their Nationally Determined Contributions (NDCs) and none include food waste (Schulte et al. 2020).

Lack of cold chain, storage, and logistics in lower-income regions – lack of storage facilities and training on harvest and storage best practices account for an estimated 40% of food losses in developing countries (EAT-Lancet Commission 2019). The lack of infrastructure goes beyond storage, and includes for example equipment to capture post-harvest losses, and roads. Cold chain technologies and sustainable longevity-enhancing additives (Apeel 2019) are also not abundant, even though they could help overcome infrastructure deficit. Beyond infrastructure, a large amount of logistics for trade are paper-based, a system prone to errors and delays that can lead to food losses.

Economic impact of food loss and waste not captured and used in decision-making – American consumers could save $5.6 billion by cutting spending on food that is never eaten (ReFed 2016). Most food waste is considered an acceptable business expense instead of a potential cost saving strategy, since information is not captured in a way that helps decision-makers understand the total cost to their bottom line. In addition, there is a perceived high market risk due to a lack of historical data that prevents financial decision-makers from investing in food loss and waste mitigation.

Barriers to Utilizing Wasted Materials

Commonly wasted materials given zero market value – in the eyes of many, wasted materials are perceived as a burden they need to pay others to get rid of, usually at a low cost with poor environmental outcomes. This perception creates a status quo bias, limiting any incentive to think about the value of commonly wasted materials and creative ways to keep the materials in use and retain their value.

Comingled and contaminated waste streams – in order for composting and anaerobic digestion systems to work effectively and produce safe outputs, their waste stream inputs need to be pure and clear of plastics and potentially hazardous organic contaminants (Langdon et. al. 2019). In many parts of the world, there is no separate collection for organic waste— for example 57% of municipal waste in Africa is organic waste (UNEP 2018). Even where there is separate collection, unclear guidance, use of plastic bags to line food waste bins, and overpackaging of food products can lead to plastics contamination entering waste streams (Noyce and Nichols n.d.). Procedures to economically manage organic contaminants prior to land application need to be developed and scaled.

Lack of distributed waste processing infrastructure – in many parts of the world there is no collection, processing, or logistics infrastructure to help treat and turn organic waste into viable products such as fertilizers. Globally, only 2% of the organic waste cities produce is looped back to productive use (Ellen MacArthur Foundation and Material Economics 2019).

Lack of secondary markets and access to those that exist – due to industrial economic development's focus on linear value chains, and the circular economy for food being an evolving concept, there has not been much research and development on secondary markets designed to keep surplus, lower-quality food and byproducts in use, and a lack of awareness of those that do. Even when value chain actors are aware of other potential uses, there is a lack of data, secondary marketplaces, and platforms that easily connect sellers to buyers at scale.

ACTIONS | Where is Action Most Needed for a Better and Faster Transition?

Findings from the impact and barrier analysis are synthesized into 10 calls-to-action to overcome the barriers towards a circular economy for the food system, and to optimize impact by amplifying wins, mitigating trade-offs and researching the yet unknown.

Building on the impact and barrier assessment presented in previous chapters, we put forward 10 calls-to-action for a better and faster transition to a circular economy for food. This is not a complete list of everything that needs to be done. Nor should the list stay static, as the world evolves rapidly. Instead, each call-to-action is an area where actions are most needed today, to overcome key barriers to a transition and to optimize impact. Under each call-to-action, a variety of actions can be taken up by different stakeholders.

Some examples are given in this report, though they are neither exhaustive nor prescriptive. We invite every changemaker to come up with ideas and initiatives to address these calls-to-action, adapting them to different contexts. A summary of how each stakeholder group (governments, businesses, civil society, finance, research organizations) can drive the change can be found at the end of this chapter.

A circular economy can better contribute to the broader transition toward a sustainable food system of the future by joining forces with other components of the transition to coordinate, harmonize, and create synergies between efforts, and ensuring actions are based on principles of equity and social inclusion. Additional actions needed for the sustainable food transition, as well as some specific components, are already being laid out by the Food and Land Use Coalition, Champions 12.3, the Eat-Lancet Commission, UNEP, World Resources Institute and others.

CALL-TO-ACTION 1 |
Enable Transitions to Planetary Health Diets

To ensure that food is produced in ways that regenerate nature, it is critical to shift what we eat—and therefore what we produce. The supply of foods grown in regenerative ways is highly dependent on consumer demand, which is trending in the wrong direction as the burgeoning global middle class continues to acquire a taste for relatively resource-inefficient protein sources such as red meat.[9] This demand drives deforestation, as land is cleared for pasture and to grow soy and grain for animal feed, exacerbating environmental damage including greenhouse gas emissions, finite resource use (nitrogen and phosphorous), pollution, and biodiversity loss. Therefore, to increase the share of food produced in ways that regenerate nature, it is critical that we shift our diet choices.

Advances in behavioral and data science can be leveraged to nudge consumer demand toward diets that consist of a greater quantity and diversity of fruits, vegetables and plant-based proteins. Designing for such diets will be a critical enabler of increasing the share of food produced in a way that regenerates nature. Designers working across the food system, from product development to consumer choice architecture, to national dietary guidelines to public awareness campaigns, will play an important role in creating routes toward these new diets being the cultural norm and the path of least resistance. The direct-to-consumer models proliferating globally as a response to COVID lockdowns open the door for choice architecture through online platforms that can nudge consumers to include more sustainable and local crops and produce into their meals.

WHERE CAN WE START:

- **Food retailers and service companies can design consumer choice environments to make the shift to plant-based, nature-regenerative diets easier**. This action can capitalize on recent advances in behavioral science that programs such as WRI's Better Buying Lab and Cool Food Pledge are leveraging, as well as the increase in share of consumers using online platforms where choice architecture can be especially effective in nudging shoppers toward more sustainable options.
- **Governments can update national dietary guidelines** and public procurement requirements to recommend planetary health diets, signaling the importance of dietary choice on both human and environmental health.
- **Food brands can design new products with underutilized crops** to boost demand for more sustainable, diverse, and nutritional local food supply, such as Unilever's Knorr Future 50 Foods for a Healthier Planet (Knorr and WWF 2019).
- **Civil society and research organizations can study the correlation between soil health and crop nutrients**, to better understand nutritional outcomes from eating regeneratively grown produce.

CALL-TO-ACTION 2 |
Scale Productive and Regenerative Agriculture Practices

To reach a future where food is produced in ways that regenerate nature, change is needed in how we grow as well as what we grow. It is important to grow the food we eat in ways that maximize resource productivity, while regenerating natural systems. This is critical for meeting the need of feeding a planet of 10 billion by 2050 while avoiding further land use change—which is driving deforestation, a leading cause of the vast negative impacts on climate, biodiversity, soil, and water today. While regenerative methods have the potential to deliver environmental benefits—such as by using fewer synthetic inputs per hectare—they may produce lower yields in practice due to their increased complexity. Therefore, more land may be needed to produce the same amount of calories if these practices are not implemented in farm systems that increase land productivity, such as agroforestry and silvopasture. The myopic pursuit of regenerative agriculture without consideration of knock-on effects could offset the potential benefits, as the potential for soil carbon sequestration is lower than that of above soil sequestration through trees and other vegetation (Searchinger and Ranganathan 2020).

Regenerative intensification on current agricultural lands, including methods that integrate managed livestock grazing, can restore degraded soil so it can ultimately support more diverse and higher yields per acre, while also delivering positive water and biodiversity impacts. The World Economic Forum estimates a $1.4 trillion business opportunity globally for productive and regenerative agriculture, that will result in 62 million jobs by 2030 (World Economic Forum and AlphaBeta 2020). In order to capture this opportunity, there is an urgent need to design and demonstrate integrated, holistic production systems linked to markets that grow regionally appropriate foods at scale, and create pathways for farms of all sizes to transition to regenerative agriculture.

WHERE CAN WE START:

- **Donors and food brands can partner to build capacity** of farmers, especially smallholders, to adopt locally appropriate regenerative methods and technologies that increase land productivity sustainably.
- **Governments and international donors can link financing for the transition to productive and regenerative agriculture with improved land and forest governance**, to reduce the risk of deforestation and negative land use change.
- **Research organizations can map ecological regions' regenerative agriculture potential** to prioritize transitions to regenerative production practices in landscapes with the highest potential. This action can be led by academic and research institutes to inform strategic policy and business decisions.
- **Governments and the private sector can partner to support farmers to shift production of crops** so they are grown in optimal locations based on local conditions and nutritional value, including through pilots to demonstrate models.

"At SYSTEMIQ, we believe that productive and circular farming practices are central to building a food system capable of feeding future generations while regenerating our planet. Supporting farmers to invest in the transition without having to bear the full risk is key to achieving this goal. That's why we aim to rally support from key stakeholders by demonstrating that investing in agricultural innovation, and the people willing to implement it, promises a brighter future for people and the planet. Acknowledging that our vision is closely aligned with the PACE Action Agenda we look forward to driving the much-needed change together."

Karl Fletcher, Associate, SYSTEMIQ

CALL-TO-ACTION 3 |
Increase Value of Nature-Regenerative Food Production to Farmers

Farmers are the critical stakeholders who will enable the transition most rapidly to a circular economy for food, and yet they are frequently left on the margins. There is an urgent need to elevate farmers—from smallholders to large scale—to listen to them and most of all to enable, incentivize, and reward them for not only producing healthy and nutritious food, but also for being stewards of the land and environment. Farmers currently have little financial incentive to improve their production methods, but may bear an unequitable share of the risk. Some farmers successfully navigate a transition to more sustainable methods, and do see improved economic conditions from increased quality and quantity of crops. However, most farmers lack the ability to invest in a transition while operating on thin margins. There is increasing evidence of the potential benefits (Systemiq and Soil Capital 2019; Indigo 2020), but systemic issues such as subsidy and policy choices and transactional purchase contracts reduce the incentive to change methods.

Governments can reorient their policies to reduce incentives for linear production practices, such as the $451 billion annually spent on perverse agricultural subsidies (Deutz et al. 2020), and reward practices with environmental benefits. Food brands, retailers, food service and public procurement can transition from transactions to relationships with the farmers that supply them, in recognition that the potential short-term profit benefits are outweighed by long-term supply chain sustainability and resilience. Additionally, in response to global food supply chain disruptions caused by COVID, there has been a drastic increase in calls for greater localization of food supply, demand for community-supported agriculture, and direct-to-consumer food marketing models, which are another route to increasing value to farmers by reducing intermediaries and transportation costs.

WHERE CAN WE START:

- **Food brands can strengthen and lengthen purchase agreements**, in recognition of the fact that more relational and long-term contracts can more equitably share risk, and help unlock financing for producers to invest in new infrastructure needed to transition to more sustainable methods.
- **Food brands can partner to develop a 'bundle of buyers' approach**, where buyers of different commodities that grow together well in a multi-crop farm system come together to ease market access and create incentives to increase the productivity and diversity of farmland.
- **Civil society and development organizations can help bring together smallholder farmers**, to increase the flow of financing and recognize them through preferential sourcing based on increased sustainability of production methods.
- **Civil society and research organizations can partner to develop methods for calculating the true price of food products**, in order to incentivize transitions to more sustainable production practices.
- **Innovators can develop low-cost carbon, water, and biodiversity impact verification technology**, in order to enable more effective payment for ecosystem services markets for production practices. This action can be enabled by governments and multilaterals through innovation competitions and incentives aimed at engineers and technologists.
- **Farmers and farmer organizations can demonstrate profit-enhancing regenerative transitions** in which farmers are able to increase their returns by improving soil health, such as was demonstrated by Regenacterra in Belgium (Systemiq and Soil Capital 2019).

PARTNERS IN ACTION | AGRI3 Fund

Enabling Access to Capital for Farmers Scaling Regenerative Agriculture

Farmers are key actors in the transition to a more sustainable food system. Yet, they often struggle to access the (patient) capital required for investing in smart technologies and implementing new agricultural practices. The AGRI3 fund aims to close this gap by facilitating transactions between farmers and the financial sector. This entails catalyzing private financial resources through de-risking mechanisms to increase transactions that foster sustainable forest management, alongside the implementation of innovative and regenerative agricultural solutions.

"We aim to unlock at least $1 billion in finance towards deforestation-free, sustainable agriculture and land use," says Hans Loth, Head of UN Environment Partnership at Rabobank. Together with UN Environment Program and IDH The Sustainable Trade Initiative, the Dutch bank has developed a holistic, blended financing strategy to increase the flow of capital to farmers, as well as that capital's effectiveness. This way, the AGRI3 fund enables farmers to access fit-for-purpose finance and tailor-made technical assistance to scale agriculture production that regenerates nature.

PARTNERS IN ACTION | Cool Food Pledge

Empowering Consumers to Make More Sustainable Dietary Choices

To support consumers to eat in a more sustainable way, they need to be offered more sustainable food in their everyday life. The Cool Food Pledge is a global initiative that helps dining facilities—restaurants, campuses, governments, hospitals—commit to a science-based target to reduce their food-related greenhouse gas emissions by 25% by 2030 relative to a 2015 baseline—a reduction in line with the goals of the Paris Agreement.

"Eating more sustainably is at the heart of a more sustainable food future," says Edwina Hughes, Head of Engagement at WRI's Cool Food Pledge. Using cutting-edge behavioral science from the Better Buying Lab and "nudging" diners to eat more climate friendly food, Cool Food Pledge members are taking practical action to shift diets.

CALL-TO-ACTION 4 |
Better Understand Hotspots of Food Loss and Waste

Much of the literature on food loss and waste globally is derived from what is happening in Europe, and heavily based on modelling and assumptions. To better develop prevention and recovery strategies (which are the most economical and impactful strategies for combating food loss and waste (ReFed 2016)), more details are needed about where food is lost from field to fridge. There is an urgent need to collect and analyze more global data (Flanagan, Robertson, and Hanson 2019), to help develop and execute strategies to achieve SDG 12.3.

The Food Loss Index (FAO 2020) and the Food Waste Index (UNEP n.d.), as the indicators for SDG target 12.3 to halve food waste at retail and consumer level and reduce food loss across the supply chain by 2030, provide a globally recognized and applied standardized quantification method for measuring and tracking changes in food loss and waste at country level. The European Union is leading the way by requiring all member states to report on food loss and waste using a standardized approach in 2021. UNEP will publish new globally modeled food waste estimates in early 2021, while urging governments to use the Food Waste Index methodology to measure baselines and track progress to 2030, especially in developing countries where the data gap is particularly acute. Using a Target-Measure-Act approach to food loss and waste reduction will have significant economic, environmental, and societal benefits. Countries and companies are already demonstrating success - some are more than halfway there - but much more needs to be done globally to reach the target (Champions 12.3 2020).

WHERE CAN WE START:

- **Governments and civil society can increase donor funding for food loss and waste measurement** programming in ODA-recipient countries, in order to develop targeted interventions and projects to reduce food losses and waste that are contextually appropriate.
- **Governments with robust food loss and waste quantification can share best practices and methodologies** with other countries or regions.
- **Civil society and researchers can partner to develop an auditable international standard** for data quantification that builds on the Food Loss and Waste Protocol in coordination with the private sector.
- **Governments can develop national commitments** to developing a Target, Measure, Act strategy as recommended by Champions 12.3, in order to collect the data needed to create new programs and strategies to reduce waste.

CALL-TO-ACTION 5 |
Integrate Food Loss and Waste More Broadly in the SDG Agenda

Reducing food loss and waste is a critical component of any comprehensive food system transformation, such as that recommended by the EAT-Lancet Commission. While reducing food loss and waste is explicitly included in the SDGs via SDG 12.3, its importance in many other aspects of sustainable development is often overlooked. For example, if it were a country, food loss and waste would be the third highest greenhouse gas emitter after the US and China. Yet there is limited inclusion of strategies to reduce food loss and waste in climate strategies; only 11 countries include reference to food loss and waste in their Nationally Determined Contributions (Schulte et al. 2020). Beyond SDG 12 (responsible consumption and production) and SDG 13 (climate action), it also has clear potential to drive positive impacts on SDG 2 (zero hunger by improving food security) and SDG 15 (promote sustainable ecosystems and halt biodiversity loss).

WHERE CAN WE START:

- **Civil society can drive public awareness campaigns** of the impact of food loss and waste on climate emissions and biodiversity, alongside the personal economic losses of household waste such as the Wasting Food: It's Out of Date and Love Food Hate Waste campaigns.
- **Businesses and government can integrate food loss and waste into their climate change and biodiversity loss mitigation strategies**, including Nationally Determined Contributions and corporate sustainability commitments.
- **Civil society can fund research institutions to study the potential socioeconomic, health, and biodiversity impacts** of achieving SDG 12.3, and map other SDGs in order to further understand the current negative impact of wasted food and potential positive outcomes from waste reduction to spur further action.

CALL-TO-ACTION 6 |
Increase Investment in Food Loss and Waste Reduction

The costs of food loss and waste frequently remain hidden across the value chain, and so rarely factor in economic decision-making. In a study using data from across the globe, when businesses reduced their food waste there was an average 14x return on investment, meaning that for every dollar an organization invested to reduce their food loss and waste they gained $14, with hospitality and workplace canteens averaging over a 20x return on investment (WRI and WRAP 2019). That is the type of return on investment that venture capitalists and chief financial officers dream of, yet many of the organizations that could most benefit from these investments, such as restaurants, do not have awareness of the true cost of their food waste, the ability to afford the upfront costs on their own, or the capacity to implement the strategies and new technologies.

Meanwhile, in less developed regions, there is a huge opportunity to invest in cold storage, logistics, preservation technologies and capacity training to secure nutritious food supplies—it is frequently the more nutritious fruits and vegetables that spoil the most easily. New financing mechanisms can be applied to help reduce barriers to capital across the globe, and an increase in donor funding for food waste reduction strategies can have benefits across environmental and health factors.

WHERE CAN WE START:

- **Private foundations and investors can develop a blended finance structure with retailers and fresh food brands,** to prove the investment case for waste reduction infrastructure and spur increased flows of private finance toward food waste reduction.
- **Civil society can develop a multi-stakeholder partnership** to take a value chain approach to increase availability, affordability, and use of climate smart storage, preservation, and cold chain technologies in farmer and distribution networks in low- and middle-income countries.
- **Investors and civil society can develop and demonstrate new financial mechanisms**, to lower the barriers to waste reduction technology.
- **Donor organizations and governments can increase technical assistance,** to increase value chain capacity of key processes to reduce food loss.

"Transforming leftover food and production waste into nutrient rich fertilizers and animal feed, as well as turning livestock waste into fuel are just some of the ways in which resources that were once considered waste, can create value. At DLL, we work together with our partners and customers to identify potential synergies, connect the supply and demand side and scale viable solutions. We share PACE's conviction that building an accessible secondary market for food surplus and waste is key to building a future-proof food system."

Bill Stephenson, CEO and Chairman of the Executive Board, DLL

PARTNERS IN ACTION | FoodFlow

Showcasing a Zero Loss Fruit and Vegetable Chain

Africa's fresh food system suffers from poor logistics and an inefficient value chain, while its smallholder farmers lack access to technology, financial products, and training on modern farming practices. Consequently, more than 40% of fruit and vegetables are lost before reaching the consumer. FoodFlow set out to professionalize the system, starting with two targeted interventions: mobile cold storage as a service at the farmgate, and a mobile-based platform scaling the farm to fork concept.

"We believe reducing post-harvest food loss is a flywheel to driving sustainable change in the Kenyan food system," says Paul van der Linden, FoodFlow Program Lead at Enviu. By showcasing a 0% loss chain in Kenya, Enviu aims to pave the way for third-party businesses to scale proven concepts throughout East Africa, creating an inclusive commercial value chain to increase farmers' resilience. FoodFlow illustrates how simultaneously targeting key intervention points can catalyze systemic market development.

PARTNERS IN ACTION | Global FLAWLESS Partnership

Leveraging Economic Systems to Reduce Food Loss and Waste

FLAWLESS is a global coalition of partners aiming to accelerate action on food loss and waste by working with the financial sector to lower investment barriers for food and drink businesses. To this end, the partnership is scoping models for innovative financial products, such as efficiency-as-a-service, and pilots will be hosted via existing partnerships in Indonesia, Mexico, and South Africa.

Says Marcus Gover, CEO, WRAP: "WRAP has had great success reaping the environmental and economic benefits of reducing food waste in the UK through the Courtauld Commitment. FLAWLESS will help us take that collaborative model to the world and scale up our impact." The partnership aims to build a holistic market-driven model for food loss and waste reduction. By driving investments into such models, this pioneering approach could supercharge global efforts to meet SDG 12.3 to halve food waste by 2030.

CALL-TO-ACTION 7 |
Reframe Wasted Food and Byproducts as Valuable Resources

This call-to-action recognizes that, in order to design out waste and pollution from the food system, wasted materials have to be stripped of their stigma so we have the creative freedom to imagine using them in new ways—or by remembering old ways that have been largely forgotten. We also need to understand the full cost of the waste we currently produce, and the negative impacts of the systems we have created to handle it. There is a wealth of opportunity available for those able to reframe currently wasted materials and develop new business models and markets to facilitate their use. Reframing waste as a valuable resource is critical to unlocking the next two calls-to-action, and creating a future where currently wasted resources are used in productive ways.

While the linear culture has imposed a view of waste resources as 'disgusting', advances in behavioral science and social marketing show potential paths to shifting public opinion. These tools can be used in tandem with facts and figures on the value of currently wasted food and processing byproducts to help shift mindsets, spur innovations, and create demand for products made from previously wasted materials.

WHERE CAN WE START:

- **Civil society and research institutes can calculate the cost of wasted materials,** and prove the economic and environmental value of repurposing them.
- **Civil society can sponsor public awareness campaigns,** using behavioral science to highlight the full cost of waste and issues with waste treatment systems, in order to shift public perception of commonly wasted materials and spur entrepreneurs to capture currently unseen value.
- **Governments can ban food waste in landfill,** to increase composting rates and alternative uses.
- **Governments can invest in processing infrastructure**, such as composting and anerobic digestion systems, to transform commonly wasted foods into productive forms.
- **Civil society and research institutes can sponsor innovation programs,** to bring new models and technologies to market that can make use of currently wasted materials.

CALL-TO-ACTION 8 |
Facilitate Secondary Market Development and Access

Reimagining wasted materials as valuable resources spurs innovation and new product and market development. There is a burgeoning body of research on alternative uses of many types of byproducts, inspiring new business opportunities. One rapidly growing example is in the brewing industry, where spent grains are frequently repurposed for everything from fish feed to dog treats to baked goods. However, even when there are known uses for commonly wasted materials, markets that connect supply and demand are limited and challenging to access. Increasing ease of access to secondary materials markets for surplus, lower (cosmetic) quality or byproduct food material streams, will increase value chain resilience, keep materials in use longer, and even help direct food toward those who need it most. Digital technology and supporting policy initiatives can play an important role in ensuring any surplus edible food is redistributed for human consumption (Ellen MacArthur Foundation and Material Economics 2019), and processing byproducts can be used as feedstock in other food products, textiles, and energy generation, among other possible uses. For edible food that does not meet its primary market's specifications, there are an increasing number of examples from across the globe of stratification approaches that send different quality of produce to different buyers depending on the end use, such as in processed juices and frozen fruit. These efforts can be scaled up, and their lessons applied to different materials.

WHERE CAN WE START:

- **Civil society and research institutes can catalog alternative uses and markets for commonly wasted materials.** These can be valuable resources within and outside the food system, yet there is limited information on alternative uses and markets, which prevents new business models and supply chains being developed (Upcycled Food Association 2020).
- **Civil society and innovators can showcase byproduct business models**—from banana husks to household compost to human waste—that can inspire others to consider wasted materials differently. Showcasing these models can help to normalize byproducts for productive use, and help reduce stigma attached to waste.
- **Local governments can increase fees for dumping in landfills,** to shift the economics of wasting food and spur innovation and development of alternative business models that keep materials in use and connect to new markets.
- **Cross-sector and industry stakeholders can pilot and demonstrate industrial symbiosis** processes and partnerships for making use of commonly wasted materials.
- **Product developers at food brands can identify key materials** that are wasted in product development, and partner with researchers to assess the economic viability of alternative uses.

"Shifting to a regenerative and circular system for food and agriculture is not only key to securing decent livelihoods for small farmers and to mitigating climate change – it's also a global economic opportunity. We know what we need to do but we now need to accelerate the transition through action at scale and more investment. That's why the IKEA Foundation supports initiatives within the PACE network of organisations that grow the circular economy movement. Together, we can build a food system that serves humanity and the planet at the same time."

Per Heggenes, CEO, IKEA Foundation

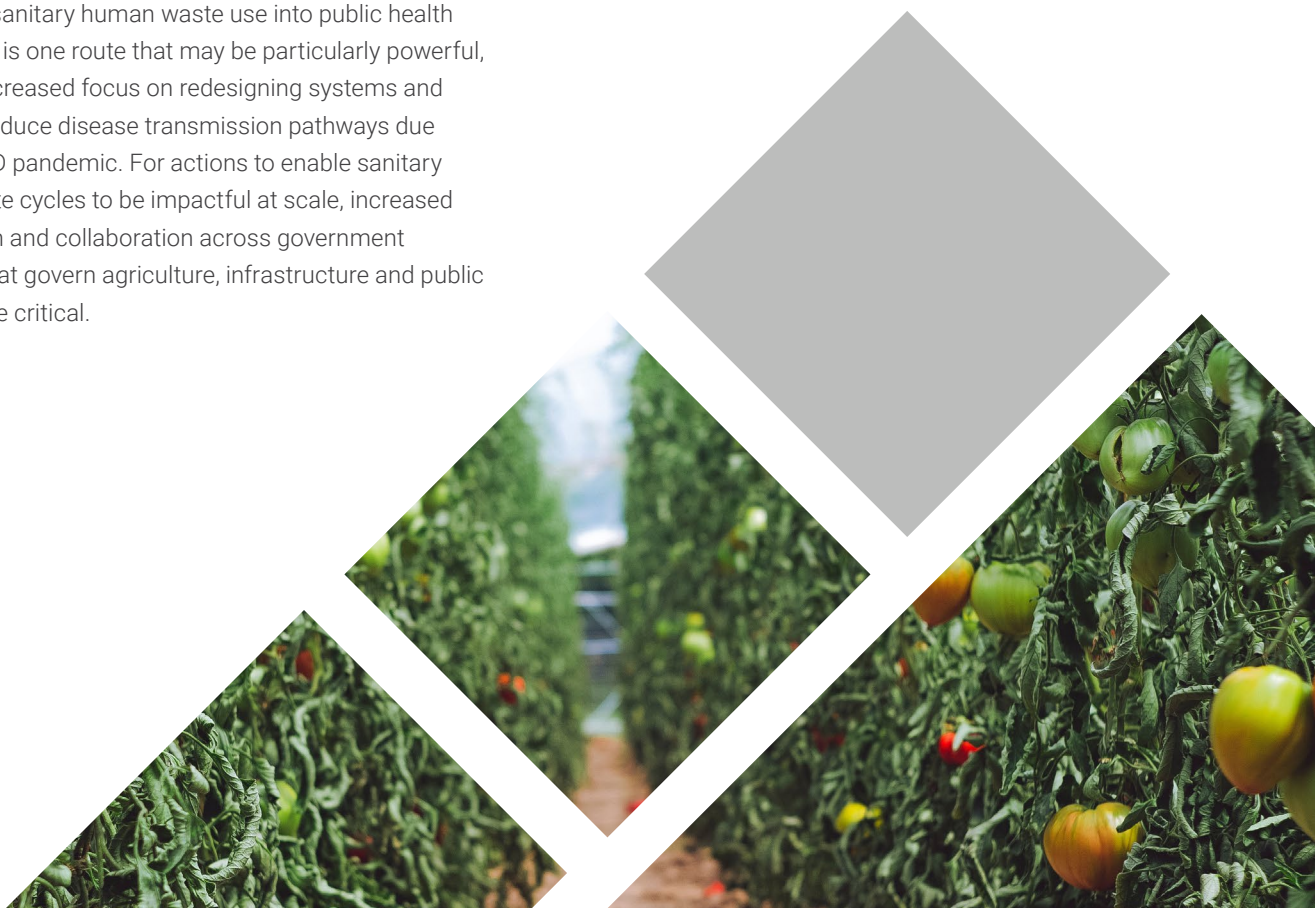
CALL-TO-ACTION 9 |
Enable Sanitary Cycles for Human Waste

Today, only two percent of nutrients in organic waste streams from cities are recycled, so there is a large opportunity to increase the circularity of the food system by moving from a "farm to fork" mindset to a "farm to farm" one. Recycling nutrients from human and animal waste locally helps to increase soil health, reduce environmental damage and increase system health and resilience. In many parts of the world, there are no systems in place to process human and household waste into safe and clean fertilizer that can be reapplied to soil to help grow more crops. Recently though, there has been an increase in the development of lower-cost distributed waste processing technologies that can create fertilizer for land, insect-based food, and energy for cooking/household use, which provides the potential to leapfrog sanitation development so circularity is more efficiently achieved by design. While in more developed contexts there are systems in place to loop livestock manure to fertilize crops, human and household waste is channeled through infrastructure that pollutes waterways instead, for many reasons including a lack of recognition of the value of the materials in these waste streams.

To achieve this objective, strategies need to overcome the negative perception of human waste and work out how to remove contaminants in sewage. Integrating the concept of sanitary human waste use into public health discussions is one route that may be particularly powerful, given the increased focus on redesigning systems and spaces to reduce disease transmission pathways due to the COVID pandemic. For actions to enable sanitary human waste cycles to be impactful at scale, increased coordination and collaboration across government functions that govern agriculture, infrastructure and public health will be critical.

WHERE CAN WE START:

- **International donors and innovators can partner to develop and demonstrate waste-to-value systems** for areas lacking sanitation services with immediate waste treatment for local food production in peri-urban areas. This can simultaneously meet sanitation, food production, employment, and health surveillance needs (such as the opportunity to screen for COVID and other health-related biomarkers).
- **Civil society and research institutions can articulate the cost of wastewater's environmental and public health damage**, to encourage alternative strategies.
- **Donors and governments can invest in distributed waste processing infrastructure** to increase the share of waste that is able to be recycled/composted into sustainable agricultural inputs.
- **Governments can use cities as innovation incubators** to test concepts that enable sanitary cycles for human waste within the food system.



CALL-TO-ACTION 10 |
Increase Information Accessibility and Data Utilization

Limited availability and accessibility of information hinders the speed of progress toward all three objectives. To transition food value chains from overly complex, inefficient and unequitable into resilient, regenerative ones, a first step is to understand the status quo. This means fully traceable and transparent supply chains, so that everyone across the value chain, from farmers to consumers, can see where and how their food is grown and where it is consumed.

On the consumer side, while surveys consistently show increasing interest and willingness to pay premiums for sustainable food, many consumers do not yet truly understand the toll that their food choices and waste have on both the environment and society, and are failing to turn awareness into buying decisions. Information must be paired with incentives and shared through stories to move the dial on consumer behavior (UNEP 2017). Additionally, because of the COVID-19 pandemic, there is an opportunity to help increase information on and awareness of the relationship between environmental and human health, and the vital role of food systems in that equation. Increasing consumer awareness of locally grown foods and recipes that use them will also help shift demand.

On the production side, there is a need to democratize farmer and buyer ability to access and use data that can help them reap the benefits from transitioning to regenerative practices. Even when data is available, it is not often packaged in user-friendly ways that enables farmers to use the information productively. Creating more open source, diverse data sets with agronomic, climate, and market information that can be accessed by innovators can also enable a proliferation of contextually appropriate digital tools, helping farmers create integrated production systems and maximize resource efficiency.

Finally, connecting consumers back to producers—enabled by supply chain traceability—can both help consumers understand their role in driving positive change, and give farmers a platform for sharing their perspectives and voice in the food system transformation conversation.

WHERE CAN WE START:

- **Food brands and retailers can commit to sharing full traceability** and impacts of food products, such as via digital means, in order to help consumers better understand where their food comes from and what it takes to deliver it.
- **Food brands and retailers can share their food waste data** on WRAP's Food Waste Atlas.
- **Civil society and food brands/retailers can create channels for consumers to connect with farmers** within the supply chains of popular items, to help humanize food production and give farmers a platform to share their stories and advocate for sustainability.
- **Civil society and governments can create public awareness campaigns,** to increase consumer awareness of the personal and environmental costs of food waste to shift behaviors.
- **Governments can partner with civil society and research institutes to create open source data sets**, to help develop new farmer-friendly tools to enable farmers to apply regenerative practices.

PARTNERS IN ACTION | Our Food Future

A Vision for a Waste-Free Guelph-Wellington

The Canadian municipalities of Guelph and Wellington County aim to create the country's first circular food economy by 2025 with three ambitious goals known as 50x50x50: increase access to affordable, nutritious food by 50%, create 50 new circular food businesses or collaborations, and increase economic benefit by unlocking the value of waste by 50%. The Our Food Future vision was catalyzed by a $10 million prize through Infrastructure Canada's (INFC) Smart Cities Challenge, which empowers communities to improve the lives of residents through innovation, data, and connected technology.

"The first fully circular gourmet meal is a great example for the kind of innovation we're seeing across Guelph-Wellington," says Cher Mereweather, President & CEO of Provision Coalition. Spent grain from local breweries is sent to an insect company growing fly larvae as animal feed. The larvae are then sent up the road to a fish farm where they make up part of the diet of sustainably farmed trout. Foliar fertilizer from the fish company is then sent to a local potato farm, and additional brewery grain and spent yeast goes to a local baker. The fish, bread and potato outputs come together at three different restaurants across Guelph-Wellington.

"This unique collaboration not only brings together local organizations with a common goal of preventing food waste, but also aims to demonstrate to others a powerful market creating mechanism to keep materials in use in the food system," says Barbara Swartzentruber, Executive Director, Smart Cities Office, City of Guelph.

PARTNERS IN ACTION | Colombia's 2030 Commitment

Promote Reduction of Organic Waste and Reuse of Residual Biomass

As part of its National Strategy for a Circular Economy, the government of Colombia set a new goal by increasing the use of residual biomass by 20% by 2030 and implementing actions to reduce food waste. A significant proportion of residual biomass comes from food waste along the value chain. For this reason, this aspect has been considered in their strategy and different actions have been identified to improve processes in agri-food systems.

"When developing strategies for reducing food loss and waste, it is important to consider regional differences between the gastronomy and food marketing sector in urban areas and the agri-food sector in rural areas," says Alex Saer, Director of Environmental, Sectorial and Urban Affairs of the Ministry of Environment and Sustainable Development of Colombia. The National Working Table for Residual Biomass will formulate specific actions to engage efforts in the reduction and recycling of food waste in urban and rural areas of the country by promoting waste valuation in agronomic, industrial and energetic sectors.

How Can I Drive the Change?

GOVERNMENTS

The most important step governments can take to drive food system change is to increase coordination and collaboration across those ministries and departments that touch on agriculture, environment, health, trade, and business aspects of the food system (Kalibata 2020), setting shared strategies in place and empowering stakeholders to deliver on them. Through a coordinated effort, governments can holistically evaluate and amend or create regulations, processes, and incentives critical to achieving the objectives. A few examples of key government actions to enable private sector innovation and action include:

- Create and strengthen land governance mechanisms.
- Realign agricultural subsidies toward production in ways that regenerate nature.
- Create binding food waste reduction targets and invest in their delivery.
- Include circularity in public procurement criteria.
- Implement food waste in landfill bans.
- Implement nutrient management regulations in partnership with private sector stakeholders.

BUSINESS

The critical actions of businesses will depend on their position in the value chain. Here are a few starting points for important segments:

- As the link to consumers, **retailers** can leverage their unique position in the value chain to incentivize brands to act on reducing food waste and increasing the sustainability of their products. They can also deploy dynamic pricing strategies to reduce in-store food waste. Additionally, they can commit to designing food buying environments that nudge consumers toward planetary health diets and the reduction of household food waste.
- **Food brands** can move to develop stronger contractual relationships with their suppliers, which incentivize and enable financing for transitions to sustainable production practices. Food product designers within brands can create recipes that use diverse ingredients grown regeneratively. They can also design new products that use more byproducts from their own and others' processes.
- **Pioneering farmers and food producers** can demonstrate the value of new systems to their communities and use their collective voice to support circular agricultural policy from governments. Farmers broadly can share their needs candidly with their buyers and suppliers who have public sustainability commitments to develop new, more productive and regenerative crop systems.
- **Input suppliers** can develop new technology and infrastructure to ease farm transitions to productive and regenerative methods, such as equipment better suited for multi-crop systems and agroforestry, and biological-based additives to replace inefficient pesticides and inorganic fertilizers. These can be supported by performance-based business models, to reduce the perverse incentives of current sales models.

CIVIL SOCIETY

Civil society can embrace and articulate the value of the circular economy as a key component of food system transformation, and therefore a key component of achieving the SDGs and Paris Accord. Organizations across the spectrum of civil society can spur action in a multitude of ways. Key actions include:

- Convening diverse stakeholders to develop coordinated and collective circular transition strategies.
- Using their platforms to educate individuals and advocate for individual change.
- Fund research and innovation in critical areas such as sustainable production, reducing food loss and waste and alternative market development.
- **Global development organizations** can also develop projects to help spur circular transitions to avoid lock-in to linear strategies and infrastructure.

FINANCE

The flow of capital toward circular strategies is increasing (Ellen MacArthur Foundation 2020), however a vastly greater sum will be needed to finance the transition to a circular economy for food. Different types of financial organizations will play different enabling roles, such as:

- Coalitions of **banks, private investors, and NGOs** can develop innovative financing mechanisms to unlock capital for investment in the action agenda across value chains, from agriculture transitions to food waste reduction technologies, and cold chain infrastructure to distributed waste processing.
- **Asset managers** and impact investors can commit capital to circular strategies, and develop circular food-oriented impact funds.
- **Institutional investors** can engage their investees to promote circular transitions.
- **Risk managers** can rethink risk models to price-in linear risks, and value the risk mitigation of circular strategies such as increased supply chain resilience and increased health and productivity of agricultural lands.

RESEARCH

While many of the strategies needed to transition to a circular economy for food are technically possible today, there is still significant need to increase our scientific understanding of critical factors that can accelerate adoption of and transitions to circular strategies. There is also the need to better understand the socioeconomic and environmental impacts these strategies and actions will achieve. Examples of research-led actions include:

- Innovate and design new food products, production, processing and disposal systems, and behavior change strategies.
- Develop scalable productive and regenerative farming practices to de-risk transitions.
- Map hotspots of food loss and waste across value chains and geographies with a standardized, cost-effective quantification methodology.
- Analyze effectiveness of interventions to reduce food loss so they can be showcased and scaled.
- Map organic waste flows and agricultural systems to enable optimal nutrient recycling.
- Uncover alternative uses for commonly wasted organic materials to help keep them in use.
- Understand the socioeconomic and environmental effects of circular actions, as well as links to other societal trends/transformations.

CONCLUSION

A circular economy is a key component of the critical transformation towards a sustainable, equitable, and healthy food system of the future, by producing our food in ways that regenerate nature, reducing food loss and waste, and putting commonly wasted resources into productive use.

In the transition into a circular economy for food, **let's keep aligned to the north stars** of greater human and planetary wellbeing. Circularity is not the end goal in itself, but an important means towards the end goal, a global economic system that enables human and environmental well-being. A circular economy for food can have profound effects across climate change, human health, biodiversity, economic wellbeing and decent work outcomes. Actions are needed to amplify the benefits—such as integrating food loss and waste reduction in climate change strategies, as well as to mitigate potential trade-offs—such as scaling agriculture practices that are both regenerating and productive, to avoid negative land use change. **Let's be guided by science**, to develop holistic indicators and set balanced targets, which are crucial to design the transition, monitor the progress and evaluate the impact, in alignment with the north stars.

The transition path to circular economy is challenged by barriers, many beyond the control of any individual stakeholder. Governments, businesses, civil society, finance institutions, research organizations—**let's team up** to take actions to move the needle. Each of us has a role to play in the calls-to-action, and there are specific actions that we can already take up today. Many leaders across the PACE community and beyond are already taking action. **Let's take ownership** and do what we can to drive the change. The PACE Secretariat looks forward to hearing from and working with you, to map progress, co-create actions, build new partnerships, demonstrate best practices, share learnings, and drive new commitments throughout the year and beyond to drive food system change at scale.

Let's get to work!

APPENDIX | Impact Assessment

This Appendix provides more details of the Impact Assessment, synthesized based on inputs from Karl Fletcher (SYSTEMIQ), Rebecca Nelson (Cornell University), Joyce Zwartkruis (RIVM), François Saunier (CIRAIG/Life Cycle Initiative), Jean-François Ménard (CIRAIG/Life Cycle Initiative), Sophie Fallaha (CIRAIG/Life Cycle Initiative), Hettie Boonman (TNO), Elmer Rietveld (TNO), Patrick Schröder (Chatham House) and several other working group members.

Food is Produced in Ways that Regenerate Nature

There are many different definitions of regenerative farming in the literature. In this report we use Food and Land Use Coalition's broad definition (see the Objectives chapter). With this definition, some organic farming practices can also be considered as regenerative, although it is commonly recognized that there are differences between these two terms.

RESOURCE USE

Regenerative farming reduces resource inputs such as water, synthetic fertilizers and pesticides per hectare, but may need more land due to lower yields (Kirchmann 2019; Pretty et al. 2006). The regenerative farming yield gap has been widely discussed in the literature (Bai et al. 2018; Gomiero, Pimentel, and Paoletti 2011). An analysis of various organic and conventional crop yields in Sweden reported an average 35% less yield for organically fertilized farming versus farming using synthetic fertilizers. Thus, the former would necessitate around 50% more arable land to achieve the same level of production as conventional farming (Kirchmann 2019). Other studies point to equal or even higher yields for regenerative agricultural approaches, depending on a variety of factors such as the crop type, access to irrigation, or the practice used (Rodale Institute 2014; Pretty et al. 2006).

CLIMATE CHANGE

The climate impact of farming depends on many factors, including geography, soil type, agriculture product type, practice, and timeframe. Some literature reports that regenerative farming practices can increase the energy efficiency and reduce the global warming potential of agricultural operations (Lynch, MacRae, and Martin 2011). A regenerative growing operation may achieve the same yield as a conventional one, while reducing greenhouse gas emissions per hectare by around 40% (Rodale Institute 2014). Using cover crops and cycling plant residue through livestock sequesters carbon (Lehman et al. 2015). Agroforestry can sequester carbon, increasing soil carbon stock by up to 40% depending on previous land use (de Stefano and Jacobson 2018). Transitioning to regenerative farming reduces on- and off-farm emissions from the use of synthetic fertilizers. For reference, FAOSTAT (2019) estimates the emissions from the application of synthetic fertilizers to be roughly 700Mt CO_2eq globally (on-farm emissions only).

Some regenerative practices have unclear or even negative benefits for greenhouse gas mitigation. No-tillage practices and their long-term greenhouse gas mitigation effects through soil carbon sequestration are currently under debate. One recent meta-analysis argues that with certain climate conditions and soil types no-till results in higher carbon sequestration, but with other conditions, that is not the case (Ogle et al. 2019). Manure application as the only nitrogen source can increase greenhouse gas emissions, particularly nitrous oxide (Zhou et al. 2017). Bringing cattle indoors reduces nitrous oxide emissions, but may lead to increased amounts of ammonia (UNEP 2019). Regenerative farming out-performs conventional farming in terms of CO_2eq emissions per hectare, but only sometimes out-performs in terms of CO_2eq emissions per unit of product (Lynch, MacRae, and Martin 2011). Clearing new land to bridge the yield gap of regenerative production could lead to increased net emissions where high carbon-stock ecosystems are cleared (Kirchmann 2019).

The climate impact also depends on what is being grown and what was being grown before. Some agricultural products are an order-of-magnitude more carbon intensive than others, so no matter how sustainable the practices employed, transition could nonetheless produce more greenhouse gas emissions. As an example, switching from a pure conventional wheat-soy rotation to a regenerative wheat-soy-grass operation will certainly produce more emissions per hectare from the addition of cattle to the mix, despite using more sustainable practices and potentially leading to lower emissions per unit of product (Ritchie 2020).

Furthermore, some sustainable practices may lead to greenhouse gas mitigation over shorter timescales, but not forever. Soil carbon sequestration cannot go on indefinitely, as soils will eventually reach a new soil organic carbon equilibrium and net carbon sequestration will halt. One example study shows that cattle raised using regenerative grazing techniques can achieve net emissions of -3.5kg CO_2eq/kg beef compared to 33kg CO_2eq/kg beef in conventional systems (Thorbecke and Dettling 2019). This however would only continue for 20-40 years, or until a new equilibrium is reached in soils.

HUMAN HEALTH AND BIODIVERSITY

Regenerative production systems are expected to benefit human health and biodiversity. Less nutrient leakage into the aquatic system and the air will result in less water and air pollution. According to the Ellen MacArthur Foundation (2019), growing food regeneratively could reduce health-related costs by $0.66 trillion per year by 2050 (assuming a 47% penetration rate). These costs are derived from reduced pesticide exposure, air pollution, and food contamination.

Regenerative agricultural practices can prevent and revert the loss of healthy soil. Several experiments of organic manured plots report a consistent increase of soil organic matter under regenerative management. For instance, in a trial lasting nearly 40 years,

researchers found that organically fertilized fields had a surface horizon three centimeters thicker and topsoil 16 centimeters deeper than conventionally managed fields (Gomiero, Pimentel, and Paoletti 2011). Another experiment found that the transition from conventional to regenerative farming improved soil fertility by increasing soil organic carbon and the pools of stored nutrients (Gomiero, Pimentel, and Paoletti 2011). Increased carbon plays an important role in soil health, water holding capacity, and nutrient cycling. While high soil organic matter can also be found in conventional food production systems, a holistic approach to analyzing soil health that includes pest abundance, presence of earthworms, biodiversity and water holding capacity, among other indicators, tends to favor regenerative systems (LaCanne and Lundgren 2018).

Regenerative farming systems generally harbor a larger floral and faunal biodiversity than conventional systems (Gomiero, Pimentel, and Paoletti 2011). Carbon-rich soils contain more abundant, diverse, and active bacteria and fungi that help plants fight diseases and pests (Lehman et al. 2015; Lori et al. 2017). A study comparing soil health in regenerative and conventional corn farms found that pest abundance per square meter was tenfold higher in insecticide-treated farms (LaCanne and Lundgren 2018). Organic manured farming, crop rotation and no-tillage can almost double the number of earthworms in the soil, a good indicator of the soil system's health (Bai et al. 2018).

While there has been some research on the link between soil health and human health, this interaction still needs to be better explored (Steffan et al. 2018).

ECONOMIC WELLBEING

Productive and regenerative agriculture is estimated to be a $1.4 trillion business opportunity globally (World Economic Forum and Alphabeta 2020). Sustainable food production is expected to have positive economic impacts at the farmer and regional scale (Herren et al. 2011). For instance, regenerative corn fields produce 29% less corn grain but generate nearly twice the profit ($ per hectare) compared to conventionally managed corn fields (LaCanne and Lundgren 2018). An important aspect of this margin is the reduced costs in input acquisition (e.g. fertilizers, insecticides, and seeds), which account for 32% of gross income on conventional farms versus only 12% in regenerative ones (LaCanne and Lundgren 2018). Regenerative agriculture activities and associated higher-skilled job opportunities generally have the additional economic benefit of local multiplier effects, seen with the extended circulation of income within rural local communities (Herren et al. 2011).

Another aspect of economic wellbeing is resilience to shocks, either physical (i.e. adverse weather) or financial (i.e. price fluctuations). Regenerative farming systems are typically more resilient to both. With better soil management leading to a better ability to deal with both droughts and floods, in some cases regenerative farms can out-yield conventional ones by up to 90% under severe drought conditions (Gomiero, Pimentel, and Paoletti 2011). Greater diversity of rotations entails that a price drop in any one crop is more likely to be buffered by others (Gaudin et al. 2015). Additionally, maintaining and increasing soil health will ensure future food production.

DECENT WORK

Productive and regenerative agricultural and food production practices are expected to create over 60 million jobs by 2030, and 200 million jobs globally by 2050 (World Economic Forum and Alphabeta 2020; Herren et al. 2011). Jobs would mainly be created in the localized production of inputs, manufacture of mechanized farm systems, and construction and maintenance of local and rural infrastructures, "as they must necessarily accompany the transition," (Herren et al. 2011). Regenerative farming creates more jobs per hectare than conventional farming. Regenerative farming techniques (e.g. intercropping, crop rotation, natural pest management, and composting) are difficult to mechanize, and therefore require more labor (Green for All 2011). In Europe, regenerative farms provide 10-20% more jobs per hectare than conventional ones (Offermann and Nieberg 2000). In the UK, this figure rises to 32% more jobs per farm than equivalent non-regenerative farms (Maynard and Green 2006). If all UK farmland transitioned to regenerative farming, this would create 93,000 on-farm jobs (Maynard and Green 2006). Additionally, the jobs created would involve younger farmers. In the UK, the median age of regenerative farm workers is 49, seven years lower than for commercial non-regenerative farms. Organic farming attracts a younger, more educated workforce with a higher propensity for entrepreneurship (Maynard and Green 2006). Skills development programmes will be needed for a just, inter-generational transition.

Greening agricultural practices does not necessarily result in quality jobs (Green for All 2011). A survey conducted in the US concluded that, aside from reduced pesticide exposure, poor pay and working conditions, large-scale organically fertilized farms are not much different from their conventional counterparts (Green for All 2011). To ensure that green jobs become decent jobs and workers' labour standards are lifted, some sustainable agriculture certifications, such as the Regenerative Organic Certificate (2020), include a section on Farmer and Worker Fairness.

Food is Not Lost or Wasted

Current literature on food loss and waste reductions are mostly based on the assumption that population and dietary habits remain the same. Under this premise, a reduction in food loss and waste would lead to a reduced need for food production.

RESOURCE USE

Lost and wasted food consumes 21% of all fresh water, 19% of all fertilizer, 18% of cropland and 21% of landfill volume (FAO 2016). Nearly 30% of the world's agricultural land is currently occupied to produce food that is ultimately never consumed (FAO 2016). Therefore, the potential resource use impact from eliminating or reducing food loss and waste is large.

CLIMATE CHANGE

Growing, processing, packaging, and transporting food that is ultimately lost or wasted is responsible for about eight percent of global greenhouse gas emissions. Additionally, as food waste rots and decomposes in landfills it releases methane gases into the atmosphere. This adds 0.355 kg CO_2eq/lb across all food types (ReFED 2016). The Intergovernmental Panel on Climate Change (IPCC) identified the mitigation potential of a 25% food loss and waste reduction across the supply chain, from harvest to consumption, to be 0.6-6.0 Gt CO_2 eq/yr of greenhouse gas emission savings in 2050 (Smith et al. 2014). This would translate to a 15% reduction in the greenhouse gas mitigation gap (Searchinger et al. 2019).

Some essential measures for food loss and waste reduction, such as more cold transport and storage, will require more energy and generate greenhouse gas emissions. The benefits still outweigh this, especially if renewable energy sources are used (James and James 2010).

HUMAN HEALTH AND BIODIVERSITY

Reducing food loss and waste could mean that more nutritious food (e.g. vegetables, fruits, and animal proteins) is available for human consumption. Generally, it is assumed that this translates into improvements in food security and nutrition (FAO 2019). Still, these positive effects will depend on where in the food supply chain the reductions take place. A case study from northern Africa and the near east describes how food loss reduction measures taken by primary producers lowered unit production costs and increased food supply. Increased efficiency in production led to a fall in domestic prices, which allowed households to buy more food for the same amount of money—resulting in higher food consumption levels (Ambler, Brauw, and Godlonton 2018).

According to the Ellen MacArthur Foundation (2019), designing out food waste could reduce health-related costs by $0.18 trillion per year by 2050 (assuming a 47% penetration rate). These costs are derived from reduced pesticide exposure, antimicrobial resistance, and air pollution.

Reducing food loss and waste could reduce the water, land and fertilizer use of agricultural systems (see Resource Use, above). A reduction in natural resource use will result in less pressure on ecosystems and biodiversity.

ECONOMIC WELLBEING

The relationship between changes in food loss and waste and the behavior of food systems is still not well understood. While farmers will be able to increase sales if less food is lost on their farms, demand for their products may fall if less food is lost or wasted throughout the supply chain (FAO 2019). Reducing food loss and waste can reduce food demand and therefore prices (World Bank 2020). It may also increase supply chain efficiency and competitiveness. On the other hand, reduced demand for food production may lead to declining farm welfare from lower sales and prices (though improved farm welfare has been reported from specific case studies, see Ambler, Brauw, and Godlonton 2018); as well as loss of employment and a reduction in GDP (World Bank 2020; Herren et al. 2011).

An analysis by WRI and WRAP (2019) on behalf of Champions 12.3, a coalition aimed at reducing global food loss and waste, studied the business case for pursuing such a goal. They found that a national strategy to reduce household food waste, launched in the UK in 2007, achieved a 21% reduction in waste in 2012 relative to 2007. The analysis concluded that the ratio of benefits to costs equalled 250:1 GBP, mainly through savings to consumers and the government, through waste disposal reductions. The same analysis explored a local initiative taken in London in 2012-2013. In this case, food waste was reduced by 15% with a ratio of benefits to costs of 8:1 GBP to the borough councils. These benefits increased to 92:1 GBP when including savings for households. Lastly, the study looked at 1,200 business sites across 17 countries for 700 companies (e.g. restaurants, hotels). Ninety-nine percent of times, the return on investment was positive.

DECENT WORK

Overall, more research is still needed on the social impact of food loss and waste reduction measures. New jobs maybe be created to deliver more efficient resource use. For instance, new employment may be created in the storage and handling of food donations (ReFed 2016). Job losses may occur across the supply chain. For instance, reduced production derived from reduced food loss and waste may lead to fewer on-farm jobs, especially in the short term, if current levels of post-harvest food losses are considerably reduced and resource use efficiencies are consistently increased (Herren et al. 2011). A case study from northern Africa and the near east describes how food loss reduction measures increased efficiency in primary production. This resulted in a reduced need for labour to produce the same output, which caused a fall in employment (Ambler, Brauw, and Godlonton 2018).

Commonly Wasted Resources are Used Productively

RESOURCE USE

Using non-avoidable food waste and byproducts as fertilizer can reduce synthetic fertilizer use and manufacturing (UNEP 2019). The recovery of nutrients from biowaste is expected to reduce or substitute the need for synthetic or inorganic fertilizers, the production of which has high energy footprints. Additionally, many nutrients present in food and agricultural waste are considered critical resources. Phosphorus is obtained from the mining of finite phosphate rock deposits, with current world supplies coming from just a few countries. This poses potential risks for future supply, given that there is no alternative to phosphorus as an essential plant nutrient. Parallel risks apply for other mined nutrients including potassium and micronutrients, especially zinc (Sutton et al. 2013).

Using non-avoidable food waste and byproducts (e.g. oilseed and hemp residues, pineapple leaves, or banana trunks) as a source of textile or bioplastic fibers has the potential to reduce the resource use impacts associated with the value chain of cotton and oil-based fibers (Esteban and Ladero 2018; de Santana Costa, Asfora Sarubbo, and Vasconcelos Rocha 2017).

CLIMATE CHANGE

Using food waste, byproducts and human waste as fertilizer may reduce greenhouse gas emissions by reducing the carbon-intensive manufacturing of synthetic fertilizer use (Sutton et al. 2013; UNEP 2019). Additionally, using resources that would otherwise be dumped will lead to less uncaptured emissions from landfills. Recovering nitrogen, phosphorus, and other key elements from waste has great potential to reduce the greenhouse gas footprint of farming. For example, around two percent of global energy use is specifically dedicated to the industrial synthesis of nitrogen, mainly through the Haber-Bosch process (Sutton et al. 2013). Nitrogen recovery from biowaste will reduce greenhouse gas emissions from this process.

If non-avoidable food waste and byproducts are used as bioplastics, they hold the potential to replace the greenhouse emissions associated with the production of fossil-based polymers. The global warming potential of bioplastics can be much lower than for fossil-based polymers (Groot and Borén 2010).

HUMAN HEALTH AND BIODIVERSITY

Using human waste as a resource has the potential to benefit human health and biodiversity, as the first requisite for such activities is the construction of better sanitary infrastructure (Rodriguez et al. 2020). Where there is inadequate or absent human waste management infrastructure (i.e. in low-income countries), the creation of efficient sanitary infrastructure to collect human waste and turn it into a resource can reduce soil, air, and groundwater pollution and avoid the spread of diseases by insects, rodents or contaminated water (Zurbrugg 2002; Rodriguez et al. 2020).

Organic fertilizers derived from manure and food waste (pre- and post-consumption) can recycle biomass and nutrients that would otherwise be lost to food production (Van Zanten, Van Ittersum, and De Boer 2019). Such fertilizers can provide potassium, nitrogen, and phosphorus as well as carbon and other nutrients to soils. Agricultural operations using animal manure as fertilizer present higher levels of soil health than conventional systems (Gomiero, Pimentel, and Paoletti 2011). When waste is used as fertilizer, attention should be paid that micro-pollutants do not accumulate in the soil (Harder et al. 2019). Micro-pollutants, essentially metals, present as traces in compostable products (e.g. food waste and byproducts, paper and board products, packaging) could bio-accumulate in soils where the fertilizer is used.

ECONOMIC WELLBEING

Using food waste as a resource in cities is estimated as an economic opportunity of $700 billion annually (Ellen MacArthur Foundation, 2019). Productive use of commonly wasted resources will create new local businesses and increase supply chain resilience (Green for All 2011). For instance, sanitary human waste recovery business models in Latin America and the Caribbean can tap into a potential market volume of up to $62 million (World Bank 2019). Overall, more quantitative economic modelling research is needed.

DECENT WORK

New jobs are expected to be created from biowaste valorisation through local enterprises that engage in the full waste-to-value chains, including resource collection (including container-based sanitation), aggregation, transformation, and utilization. There is great potential for new jobs in compost and biogas (Green for All 2011). The ReFED (2016) roadmap is projected to generate 15,000 direct and indirect new jobs in the US, mostly derived from centralized composting. Targeted efforts are needed to ensure the quality of these jobs. Alternatively, the transition would lead to fewer jobs in, for instance, synthetic fertilizer production. More research is needed overall.

It should be noted that actual impacts, in any of the five areas assessed, are affected by many different factors and trends in society, for example global population, behavioral and consumption patterns, and cultural and socio-economic context. How each of the impact areas will change over time is an aggregated result of forces often pulling in different directions. A circular transition is just one of these forces, and by itself cannot guarantee the net impact will move in a certain direction. This report analyzes possible impact from increased circularity alone, without considering other ongoing changes.

ENDNOTES

1. Interested readers can refer to the work of the Food and Land Use Coalition, the World Resources Institute and the Ellen MacArthur Foundation.

2. Food system is defined by FAO as the "entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption, and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded" (Nguyen 2018).

3. Ellen MacArthur Foundation's three circular economy principles: design out waste and pollution; keep products/materials in use; regenerate natural systems.

4. Planetary health refers to the "the health of human civilization and the state of the natural systems on which it depends." Planetary health diets "highlight the critical role that diets play in linking human health and environmental sustainability and the need to integrate these often-separate agendas into a common global agenda." For more background on what has become known as a planetary health diet, please see the EAT-Lancet Commission on Food, Planet, Health.

5. All five impact categories are affected by many different factors and trends in society. How each of them will change over time is an aggregated result of forces often pulling in different directions. Circular transition is just one of these forces, and by itself cannot guarantee the net impact to move in a certain direction. This report analyzes possible impact from increased circularity alone, without considering other ongoing changes.

6. A full definition of decent work by the International Labour Organization is: "Decent work sums up the aspirations of people in their working lives. It involves opportunities for work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives, and equality of opportunity and treatment for all women and men."

7. According to the International Union for Conservation of Nature (IUCN), nature-based solutions "are actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits."

8. Encouraging development that starting in 2023 all EU member states will be required to report food loss and waste.

9. Note, this is not a call to eliminate animal-based protein, only that in a planetary health diet it is a smaller share than currently consumed in more developed markets, and diets are trending towards in less developed markets. Livestock can be a key component of productive and regenerative agriculture.

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