Addressing Food Loss and Waste: A Global Problem with Local Solutions
Executive Summary

This report focuses on the role that food loss and waste (FLW) could play in reducing the environmental footprint of food systems while attempting to meet the caloric and nutrient needs of a population expected to increase by 3 billion people in the next 30 years.

1. The performance of the global food system over the last century has been extraordinary. From a global population of 1.6 billion people in 1900 to nearly 8 billion in 2020, the agri-food sector has risen to the challenge of providing global caloric sufficiency, mainly by increasing yields of a few principal staple crops. However, this path is no longer sustainable.

THE CURRENT SITUATION

2. The success of food systems has not been without costs. Notwithstanding the extraordinary success during the past century in making food more accessible, affordable and safe, food systems have contributed to unsustainable land use practices, depletion of fresh water, pollution from chemicals, disruption of nitrogen and phosphorus cycles, biodiversity loss, and climate change. The world is transgressing key planetary boundaries, in part due to food systems that are endangering the environment while still failing to fulfill the caloric and nutrient needs of a large population. Approximately 678 million people around the world (FAO et al. 2020) still go hungry every day, and one in three is malnourished.

3. The pressures will continue to increase. In the next three decades, we will need a 30-70 percent increase in food availability to meet the demand for food by an increasingly large, urbanized and affluent population. However, the evidence is clear that today’s global food and land use system is already failing on multiple fronts, from persistent undernourishment and hunger in certain pockets of the world to the global depletion of natural resources and immense carbon dioxide emissions, all while a large number of poor farmers are excluded from the wealth created by food systems. Business as usual will not be good enough. Only a transformation of the global food system will ensure that the world is not worse off in the future.

4. While food systems generate an unsustainable environmental footprint, the amount of food lost or wasted is, according to some estimates, about 30 percent of the total world food supply. Advocates of food systems transformation increasingly see reducing FLW as a promising strategy for helping feed the planet while reducing the associated environmental footprint. From the G20 to many national governments, local governments and international agencies such as the World Bank, IDB, UNEP and FAO, along with think tanks and NGOs, there are many analyses, recommendations and a myriad of initiatives offering numerous solutions for reducing FLW. The private sector is also increasingly adopting measures to reduce FLW, viewing FLW successes as both a business opportunity and key to meeting corporate social responsibility objectives.
5. **The COVID-19 pandemic exemplifies the risks inherent in our current food systems and offers an opportunity to rebuild in better ways.** The disease is of zoonotic origin and may have crossed over to infect humans at a wet market where vendors, buyers, and live and slaughtered animals interact in proximity. The widespread illness and death as a result of COVID-19 have brought tragedy and massive economic disruption. Food supply chains are particularly interrupted; necessary efforts to slow the spread of the disease through movement restrictions and business closures have ruptured traditional links along value chains and revealed rigidities that impede rechanneling of supply. Domestic food has replaced away-from-home consumption as social distancing and lockdowns have shut down much of the hospitality industry. However, the switch from hospitality to home-oriented supply chains has not been easy. Consumers face shortages while unsellable products swamp suppliers, and losses and waste mount. The global recession or depression that will follow the disruptions of 2020 will exacerbate poverty and increase food insecurity. Despite the huge social and economic costs of the pandemic, the crisis creates the space to tackle head-on necessary food systems reforms.

### THE CHALLENGE

6. **Food systems need to be transformed to enhance their resilience, sustainability and contribution to the health of people, economies, and our planet.** They need to meet the multi-dimensional challenge of generating safe, affordable and nutritious diets, while avoiding zoonotic diseases; reversing the degradation and overuse of land, water and minerals; reducing greenhouse gas emissions (GHGEs); and increasing productivity, generating jobs and strengthening trade flows.

7. **Reducing FLW is key to making food systems significantly more sustainable.** The magnitude of current and projected FLW is undeniable. If we maintain business as usual, the amount of FLW will grow from today’s 1.3 billion tons per year (FAO 2011) to 2.1 billion tons by 2030 (Hegnsholt et al. 2018) and even more by 2050 (Searchinger et al. 2018). One estimate argues that if we could halve FLW globally, environmental impacts could be reduced by up to one-sixth (16 percent). Multiple global goals would be advanced, such as combatting hunger, supporting sustainable food production, and ultimately climate change, given that FLW generates 8 percent of annual global GHGEs.

8. **In this report, we investigate the economic rationale for reducing FLW and options for doing so.** Some amount of FLW will always exist because it does not pay for producers or consumers to incur the costs of eliminating all FLW. So, is there a way of determining if current levels of FLW are too much and should be reduced? In principle, markets will allocate resources, including FLW, in ways that maximize social welfare. However, markets often fail to achieve this goal due to market or policy failures. We use a market and policy failure lens to assess if current levels of FLW may be too high and if interventions to reduce them are warranted.

9. **A key market failure is the perceived disconnect between FLW and GHGEs generated by FLW.** FLW is responsible for about 8 percent of global GHGEs. If FLW were a country, it would be the world’s third largest emitter of GHGEs. As long as producers and consumers are not paying for the impact of these emissions on global warming, levels of FLW will be too high.
10. **However, other than its role in generating GHGEs, FLW is not a cause of other environmental problems.** While land, water and other resources are consumed in the production of food that may ultimately be lost or wasted, FLW is at most a symptom of environmental degradation and not the principal cause of it.

11. **A basic market failure is the failure to account for environmental impacts associated with the use of land, water and chemicals for food production.** Since farmers do not fully pay for lost environmental values that result from farming, they may farm too much land, use technologies that waste natural resources, contribute to pollution, and ultimately generate more FLW. The direct approach for addressing environmental externalities would be to make producers and consumers pay for the lost values when these resources are used for food production, as well as for the external costs of GHGEs. Under this approach, less land and water would be farmed, and since food would become more costly, FLW would most likely decline as well, a double dividend. Food would be seen as scarcer, justifying an increased effort to reduce FLW. But this “polluters pay” approach is not practical or politically feasible in most situations. To compound the problem, food production and consumption are often subsidized, leading to lower food production and consumption costs, the associated overuse of natural resources, and more FLW.

12. **Could there be a case for reducing FLW to lessen social welfare losses from environmental externalities related to the use of land, water and chemicals?** Addressing the underpricing of environmental externalities to maximize social welfare is a complicated challenge. The full range of environmental benefits accruing from forests and wildlands, biodiversity, water and reduced pollution is only partially understood. Even more challenging is putting a value to these benefits or creating markets for them. Moreover, there are many episodes of open rebellion against higher food, water or energy prices, a likely outcome of more balanced resource pricing. Given that implicit food subsidies and natural resource underpricing may be politically needed and will likely continue, could strategies to reduce FLW lessen pressure on the environment by helping to save land, water and energy while supplying food to a burgeoning population? Although FLW is not the cause of environmental degradation, except for GHGEs and other pollution, could reducing FLW improve the environmental footprint of food systems? Reducing FLW is essentially a demand-side solution, since it would reduce the demand for food thanks to reduced losses and more waste recovery in the supply chain. This contrasts with pricing of natural resources, a supply-side solution, which would reduce the supply of food by making it more expensive to produce. In this report we investigate the role that FLW could play in reducing the environmental footprint of food systems.

13. **In addition to improving social welfare through better use of natural resources, societies are also interested in distributional outcomes, especially food security, farmers’ incomes, and trade.** Most countries have policies for improving access to and affordability of food to improve food security for poor people. Many also give priority to improving farmers’ incomes as part of addressing rural poverty. Small open economies may also be interested in increasing exports or reducing imports for macroeconomic or structural development reasons, and may consider the food system as an instrument to do so. The bottom line is that policy goals often comprise a complex mix of trade-offs and tough decisions. In this report, we also investigate the extent to which reducing FLW can contribute to key distributional goals — food security, farmers’ incomes and value of trade — as is often claimed in FLW literature.
**THIS ANALYSIS**

14. While the assertion that reducing FLW can lessen environmental degradation while helping meet food needs is appealing, it demands empirical confirmation. Surprisingly and despite substantial literature on FLW, there is a lack of studies into the relationship between changes in FLW and the behavior of food systems. This report looks at the food supply chain to analyze in greater depth what drives FLW, how reducing FLW would reverberate through the food system, and how it would contribute to policy goals of economic efficiency, food security, farmers’ incomes, and trade.

15. This analysis captures the complexity of the food supply chain and interdependence between its various stages (Figure below). We consider a food supply chain comprised of seven stages from farm to fork to landfill. These include post-harvest at the farm level, transportation, handling and storage (THS), processing, food services (restaurants, hotels and institutions), retailing, and away-from-home consumption, and at-home consumption. After the consumption stage there are three dispositions for waste: waste can be recovered as food, recovered as non-food for other uses, or sent to a landfill or incinerated. This analysis acknowledges that any shock to the system, for example, through reduced FLW at the consumer level, will have direct and indirect effects as prices change, and in turn trigger more changes in food supplies and demands throughout the supply chain. This analysis attempts to quantify the impacts of external shocks through their direct and indirect effects.

**FIGURE:** The food supply chain, policy objectives and policy inputs
We base our analysis on a simulation model of the food supply chain. Unfortunately, there is a dearth of data and empirical economic studies that would allow us to understand the phenomenon of FLW and its impacts through empirical analysis with real-world data. We therefore use a simulation model of the food supply chain to run “experiments” on how shocks to the system affect food production, consumption, prices, levels of FLW, and key policy goals including environmental impacts, food security, farmers’ incomes, and trade. The model is then applied to four commodities in the UK — chicken, bread, fruit and milk — since the UK is the only country for which a comprehensive data set could be obtained. More recent simulations with reduced data sets for Rwanda covered maize, rice and tomatoes; for Vietnam rice and catfish; and for Nigeria maize, tomatoes and catfish.

**INSIGHTS AND CONSIDERATIONS**

17. The first insight of the analysis is that the large amount of FLW is probably caused by food prices that are too low. If food prices, or equivalently food production and consumption costs, reflected the opportunity costs of natural resources consumed or of GHGEs, the amounts of FLW would be considerably lower, both from less production and consumption, as well as reductions in the rates of FLW (percentage of food that is lost or wasted). This is because food would be more expensive and seen as scarcer, incentivizing greater conservation of food, and encouraging lower production, consumption and waste levels.

18. A related result is that policies that lower food prices or costs, such as production and consumption subsidies, are also drivers of FLW. Food prices and costs are low because producers and consumers do not pay for the environmental costs that food systems generate. To exacerbate the problem, societies often subsidize consumption in developing countries and production in developed countries. They also subsidize inputs such as energy and water. These subsidies have the same effect as lower food prices. They contribute to increasing the production and consumption of food and the levels of FLW by reducing incentives to save food.

19. The second insight is that reducing FLW would indeed help reduce the environmental footprint and GHGEs of food systems, while at the same time improving food security. Different strategies to reduce the environmental footprint of food systems have different social welfare implications. A strategy of pricing environmental externalities and future scarcity correctly would result in higher production and consumption costs. While it would decrease production and thus save natural resources and reduce the environmental footprint of food systems, it would also worsen food security, since food would become more costly. In contrast, a strategy of reducing FLW would also decrease the environmental footprint of food systems, but it would improve food security. This is because demand for food would decline since more is obtained from saved waste, and although production could also decline, food supply could increase since more sales would be generated by reducing food losses. Less demand and more supply would make food cheaper for consumers, without the need to subsidize production or consumption. However, a decline in FLW would not necessarily substitute for an equivalent amount of food. One ton of saved waste does not
automatically replace one ton of food produced. The relationship depends on the commodity, the nature of exogenous shocks, and assumptions regarding demand (elasticities) and openness of the economy.

20. The third insight is that the best stage of the supply chain for policy to reduce FLW depends on the specific circumstances of the country. Should policy focus on the farmer, consumer, processor, or any of the other stages of the supply chain? There are five important factors to consider: the cascading effect, whom to hold responsible for GHGEs from FLW, the policy objective, the commodity, and the trade situation of the country.

21. The first consideration, the cascading effect, would suggest prioritizing FLW at the consumer level, but this is not always ideal. A one-ton reduction of FLW at the farm level increases the amount of food in the supply chain and therefore increases FLW at all stages of the supply chain. It has a positive, cascading effect throughout the supply chain, which works in opposite direction to the initial FLW reduction at the farm level. A one-ton reduction of FLW at the consumer level decreases the amount of food in the supply chain, and therefore decreases FLW at all stages of the supply chain. It has a negative cascading effect back through the supply chain. This would suggest the consumer level as the first candidate to reduce FLW. This implication might not be valid, however, in developing countries, where most loss and waste are generated at the farm level. Here it would be easier to achieve a larger reduction at the farm level, possibly more than compensating for the increases in FLW triggered downstream.

22. The second consideration, whom to hold responsible for GHGEs from FLW (“wasted emissions”), would suggest attributing responsibility to those emitting GHGEs. The challenge for policy arises from the fact that emitters of GHGEs generated by FLW are not the same as the wasters. The question becomes whether to enact policies, such as a carbon tax, targeting the emitter level or the waster level. One ton of waste at the consumer level can generate GHGEs at the landfill, but also generate GHGEs at the farming, transport, processor and retailing levels where food that will later become consumer waste is produced. The best approach would be to introduce a carbon tax (or other measures) at the emitter level, covering not only emissions from loss and waste but across the entire production system. This could, however, be politically unpalatable. Wasters, such as consumers, could be seen as tricking producers, such as farmers, into producing food that consumers later decide to discard. The carbon tax at the waster level might be more easily accepted, although it would have a higher probability of missing the desired outcome. The same considerations apply to the use of natural resources such as land and water in producing food that is wasted downstream.

23. The third consideration is the trade-offs in policy goals when choosing where to intervene along the loss and waste supply chain. The question is at which of the seven stages of the food supply chain would interventions lead to the highest desired impact. The answer varies. For example, in the case of chicken in a closed economy, if the policy goal is to decrease farm production to reduce stress on natural resources, intervention at the processor level would be best. However, this would have the worst effect on farm welfare and only the second best effect reducing GHGEs. To improve farm welfare, on the other hand, the best option would be to intervene at the away-from-home consumption stage and the worst at the processor level. To improve food affordability, an element of food security, the best option would be to intervene at the retail level, although this would lessen reduction of GHGEs.

24. The fourth consideration is the trade characteristics of the country — closed, small open, or large open economy. Returning to the example of chicken, if the goal is to reduce farm production to
lower the stress on natural resources, the best course of action would be to reduce FLW at the processor level in a closed economy, and at the food services level in both a large open economy and a small-open economy. When considering GHGEs, the best choice for all economies would be to reduce FLW of chicken at the processor stage, followed by food services and at-home consumption for a closed economy, but at the processor stage followed by transport/handling/storage (THS) and farm levels in a small open economy.

25. The fifth consideration is the specific commodity in question, or fruit, bread, milk and chicken in the case of the UK. Consider as an example only one policy objective: reducing GHGEs. To maximize the impact on GHGEs of reducing FLW, the best course of action would be to intervene at the THS stage followed by at-home consumption for fruit, at the processor stage followed by food services for chicken; at the at-home consumption stage followed by away-from-home consumption for bread; and at the at-home consumption stage followed by retailer for milk.

POLICY CONSIDERATIONS

26. How can a reduction in FLW be achieved? There are two main approaches to FLW policy. One approach is to target food systems as a whole to lead them towards policy goals, including, but not limited to, less FLW. A tax on farming or on consumption, for example, would fall into this category. Better information systems to reduce weather risks would also fall into this category. The other approach is to target FLW directly, as a subset of the larger food system. Within these options are two types of interventions: those directed at preventing or abating loss and waste, such as financing storage systems or cold chains; and those aimed at bringing waste back into the supply chain, whether as edible food for purposes such as donations for charities, or for altogether different functions, such as biogas, compost or animal feed.

27. Policies could include taxes, subsidies, regulatory support to waste markets, and regulations. These policies could work by reducing overall production or consumption or reducing the rate of waste, thereby decreasing FLW, decreasing the costs of FLW abatement, increasing the costs of sending FLW to a landfill, or increasing the market value of waste sold (or donated) as food, or recovered as non-food. This report highlighted how the various stages of the food supply chain are deeply interlinked and an intervention at one level would resonate at other levels. Policies that affect the three main dispositions (donations or use in secondary markets, waste sent to a landfill or incineration, and recovered and recycled food waste) can have important impacts on the vertical food supply chain. The fact is, no one policy intervention is best suited to all situations; rather, each intervention needs to be chosen depending on the policy goal, commodity, and other factors outlined above.

28. Trade effects in open economies can be relevant for some policy actions. In general, interventions that make production more costly, such as environmental pricing, make exports more expensive and reduce trade competitiveness. In addition, increasing imports shifts a country’s food deficit elsewhere in the world, ‘exporting’ its natural resources stresses and GHGEs. These strategies
should therefore be pursued in a coordinated fashion at the global level, balancing the various possible impacts of reducing FLW, such as improving the value of trade (exports minus imports), reducing the environmental footprint of large economies, and improving food security elsewhere.

29. **Finally, reducing FLW needs to be but one element of a strategy to improve food systems, and should not be pursued in isolation.** While reducing FLW can improve GHGEs, the environmental footprint of food systems, food security, farm welfare, and trade while improving diets through less loss and waste (for example, of healthy fruits and vegetables), this policy goal needs to be considered in the context of broader strategies. Countries need to pursue other mechanisms to address environment depletion, food security, and farm welfare, and view FLW as a complementary approach that can bring additional co-benefits. Reducing FLW should be part of any strategy to transform food systems to achieve healthier people, a healthier planet, and prosperity, given the many win-wins it can generate.

30. **Research will play a key role: it is necessary that research agendas consider the entire food supply chain and explore ways to reduce FLW.** Research tends to be split institutionally, and focus on specific areas of the food supply chain missing, opportunities for a more holistic approach that will have a greater impact. As has been identified in many FLW reports, there is a critical need for a food supply chain approach to prioritizing research agendas.

31. **Better information and distribution networks are likely to be key, not only for reducing food losses, but also for recovering waste as food or non-food.** New technologies including “disruptive” technologies have the potential to help reduce FLW, in particular in the areas of information and distribution. However, food systems seem to be lagging in the creation, adoption and use of new technologies. The key sector in food systems is agriculture, where food is created. But despite being one of the largest employers and a key contributor to developing countries GDP, agriculture pales with other sectors (for example the health sector) in number of related start-ups and level of investment.

32. **The level of financing needed to address FLW on a significant global scale is large and requires both significant public financing, internationally and nationally, and private capital.** The history of public financing for climate initiatives offers a parallel model that could be adopted for a global FLW reduction strategy. In climate finance, an initial seed fund, the Climate Investment Fund, signaled to financiers both the importance of a climate change mitigation and adaptation agenda and the opportunities and need for public financial support. In parallel, the capital markets can be tapped, given the magnitude of financing needed, perhaps appealing to investors’ growing interest in including social returns in their investment profiles.
SUMMARY

33. **Research.** Reducing FLW should be an important component of any strategy for feeding the planet and reducing the environmental footprint of food systems. However, there are critical policy goal trade-offs between various strategies, and there is ambiguity on the best course of action to take. These questions need to be resolved through empirical investigation of the circumstances. The global framework of this study can be a useful approach for addressing these issues at the country level. These efforts should be complemented by performing detailed cost/benefit economic analyses of alternative strategies and by raising necessary public and private financing to create appropriate incentives and to fund necessary investments. The cost/benefit financial and economic analyses of the various options should identify the level of public support (justified by the extent of externalities and public good elements) and the related roles of private versus public financing.

34. **Action.** Key elements for action when developing a country-level FLW strategy might include:

- Conduct country diagnostics to identify priority commodities, hot spots (of high rates of FLW) and stages of intervention for reducing FLW. The model developed for this analysis is designed to be applicable to a wide range of diverse situations, and could be used for the initial analysis, as was done for Rwanda, Vietnam, Nigeria and Guatemala.
- Develop FLW databases to support more detailed behavioral investigations and to monitor progress. The work of Waste & Resources Action Programme (WRAP) in the UK shows ways to develop the information needed.
- Develop a menu of potential interventions that are technically and politically feasible, and include financial and economic analyses of the interventions. A list of interventions suggested by the literature is in Annex A of this report.
- Define roles of the public and private sectors, as well as the roles of horizontal and vertical levels of Government.
- Define the complementary role of FLW reduction in the context of strategies that address other policy goals, such as improving the environmental footprint of food systems, addressing food security, or improving farm welfare.
- Consider the need to rely on safety nets, including unconditional and conditional cash transfers, to support some of the policy goals of reducing FLW or potential negative impacts that may result from them.
- Develop coalitions to support reform efforts.
- Develop a plan to promote FLW reduction start-ups and innovation.
- Develop sources of financing and financial instruments to support private and public FLW reduction action, including support for research and knowledge-based organizations.
- Include FLW reduction in nationally determined contributions (NDCs) for climate mitigation, and in sources of climate mitigation financing.
- Consider instruments to sustain financial support for FLW reduction, including taxes on waste or non-recovery.