Food and Agriculture
Organization of the
United Nations

SAVE FOOD FOR A BETTER CLIMATE

CONVERTING THE FOOD LOSS AND WASTE CHALLENGE INTO CLIMATE ACTION

SAVE FOOD FOR A BETTER CLIMATE

CONVERTING THE FOOD LOSS AND WASTE CHALLENGE INTO CLIMATE ACTION

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2017

ISBN 978-92-5-109989-6

Cover photograph: © UN Photo/Logan Abassi

CONTENTS

ACKNOWLEDGEMENTS

This paper was written by Emilie Wieben (ESN) from the Food and Agriculture Organization of the United Nations (FAO).

The author is grateful for valuable comments and guidance provided by Yvette Diei-Ouadi (FIAM), Olivier Dubois (CBC), Jorge Fonseca (ESN), Alexandre Meybeck (AGD), Robert van Otterdijk (REU), Rosa Rolle (ESN) and Jogeir Toppe (FIAM).

Special thanks goes to Andrew Morrow (ESN) for his work on screening the INDCs as well as to Luciana Ianiri (ESN) for coordinating the publication production process and Simone Morini (ESN) for the layout and cover design.

Finally, the author is thankful for the overall guidance of Anna Lartey, Director of the Nutrition and Food Systems Division (ESN).

ACRONYMS AND ABBREVIATIONS

CSA	climate-smart agriculture
CO_2	carbon dioxide
FAO	Food and Agriculture Organization of the United Nations
FI	Financial Institution
FLW	food loss and waste
GCAA	Global Climate Action Agenda
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	greenhouse gas
Gt	gigatonne (billion tonnes)
Gt CO_2eq	Gt of carbon dioxide equivalent
HFC	hydrofluorocarbon
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
LDC	least developed country
LULUCF	land use, land-use change and forestry
NDC	Nationally Determined Contribution
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
SME	small and medium-sized enterprises
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

There is emerging recognition globally of food loss and waste as a considerable issue in the context of climate change. Accounting for about 8 percent of global anthropogenic GHG emissions, food loss and waste levels represent a significant contributor to climate change. Food losses also undermine the adaptive capacities of vulnerable populations to cope with climate change, through decreased food availability and reduced income. Moreover, food losses could further increase due to more frequent and intense climate variability and associated outbreaks of pests and diseases. On the other hand, as more countries reach middle-income status, changes in consumer behaviour are expected to lead to an increase in the per capita amount of food wasted at consumption level.

Responding to the food loss and waste challenge presents a cross-cutting opportunity to drive climate action forward by cutting GHG emissions and boosting resilience and productivity in food systems. In addition, reducing food loss and waste through the deployment of climate technologies along the value chain offers an important pathway to enhance the mitigation and adaptation potential and to mobilize climate finance to fund investment costs. The technologies and interventions needed to reduce food loss and waste during post-harvest activities (e.g. for storage, processing and refrigeration) have been specified as priorities in multiple Intended Nationally Determined Contributions (INDCs) submitted by developing countries.

The issue of food loss and waste is, however, extremely complex and extensive, and collective action through integrated approaches involving all actors in the food value chain will be necessary, if sustained reductions are to be achieved. Developing countries in particular will require support to enhance their institutional, financial, organizational and technical capacities in addressing food loss and waste and their underlying causes, in ways that can accelerate climate action.

This paper aims to inform on the interrelationship between food loss and waste and climate change. In this context, the paper highlights the related impacts, and outlines the recent global frameworks adopted by the international community, and how they have been translated into national priorities and targets. Climate technology options are explored, along with the challenges and opportunities related to financing needs. Finally, this paper will identify ways and enabling factors to reduce food loss and waste as part of the collective effort to enhance ambition for climate action while simultaneously delivering the other objectives of the sustainable development agenda.

1 | INTRODUCTION

In recent years, the issue of food loss and waste has received increasing attention as a central feature of the challenges and inefficiencies which characterize the global food system and consequently its social, economic and environmental implications (FAO, 2011; HLPE 2014). Food losses and waste are of particular concern as drivers of climate change and environmental degradation, and for increasing vulnerability to food insecurity. Food that is produced but ultimately never consumed represents a significant contributor to global greenhouse gas (GHG) emissions and diminishes the productive output of food systems, which in turn could potentially undermine both human and ecological capacities to cope with climate change.

Reducing the enormous amounts of food that are lost or wasted is one of the key priorities for improving sustainability within the food system, meeting the growing demand for food and driving climate action forward. This is emphasized in the 2030 Agenda for Sustainable Development, which sets a global target for food loss and waste reduction. The Paris Agreement also recognizes the importance of food security and food production systems in the response to climate change, while multiple countries have explicitly prioritized food value chain interventions in their Intended Nationally Determined Contributions (INDCs). This affirms a growing international recognition that actions within the food system will be central to meeting the global ambitions for sustainable development and climate stabilization.

© Chris Steele-Perkins/Magnum Ph

© FAO/Jonathan Bloom

Building on this momentum offers a key opportunity to respond to the food loss and waste challenge by aligning solutions with the broader objectives for sustainable development and climate ambitions. However, reducing global levels of food loss and waste is a multidimensional and complex challenge. The causes and drivers of food loss and waste are closely tied to unsustainable production and consumption patterns and a global inequity, which all together constitute fundamental barriers to sustainable development and action on climate change. Food losses principally occur because of infrastructural and capacity limitations along the food supply chain and the solutions often necessitate financial investments, which remain insufficient. Food waste on the other hand, is in most cases driven by consumption patterns and demands, which are shaped by commercialization, economic wealth and culture. Preventing food waste is therefore mainly related to addressing these systemic causes and enabling changes in consumer behaviour, along with promoting responsible valorization of food.

Tackling the food loss and waste issue at global level calls for multiple interventions and requires collective action towards integrated food system approaches that consider all risks, challenges, opportunities and potential trade-offs. This is also pertinent to advancing global climate action and many of the responses to food loss and waste present an opportunity to scale up climate technologies and climate-smart practices within the food system. In developing countries where value chain infrastructure, coordination and capacity constraints are major causes of food losses and waste, targeting climate-smart solutions across the food system could potentially help to unlock increased financial flows needed for their implementation. However, this will require strengthened regulatory frameworks along with policy coherence to underpin the incentives needed to mobilize investments, especially from private sources. In this respect, targeted support will be critical to ensure that policy frameworks and economic incentives are consistently aligned with the goals for food loss and waste reduction and climate action.

The aim of this paper is to inform policy-makers, food value chain actors and the climate change community of the interlinkages between food loss and waste and climate change. Within this context, it provides an information note on the opportunities for addressing them concurrently and outlines the logic of further integrating food loss and waste considerations into climate change planning processes. In particular, this paper aims to serve as a guide to understanding the technological options for reducing food loss and waste and for improving value chain infrastructure in developing countries, and to do so in ways that can catalyse climate action and enhance Nationally Determined Contribution (NDC) implementation.

2 | FOOD LOSS AND WASTE AND CLIMATE CHANGE: AN INTERDEPENDENT RELATION

2.1 GLOBAL CONTEXT AND IMPLICATIONS

According to estimates by the Food and Agriculture Organization of the United Nations (FAO), approximately one-third of food produced for human consumption globally is either lost or wasted, amounting to about 1.3 billion tons per year (FAO, 2011). When the inedible parts of food are accounted for, this figure rises to an annual 1.6 billion tons of food and by-products that are produced in vain (FAO, 2013a), with serious and far-reaching environmental, social and economic impacts. Food is lost or wasted throughout the food system, from the initial production to final household consumption. This is due to inefficiencies and constraints in global food production and supply systems, together with unsustainable consumption patterns. Box 1 provides a definition of food loss and waste and highlights some of their main drivers and causes.

2.2 CONTRIBUTIONS TO CLIMATE CHANGE

Food production is supported by a natural resource base along with the goods and services provided by global ecosystems. Energy, water and other inputs are also needed to sustain the process and each activity within the food system withdraws from natural capital and generates GHG emissions that contribute to climate change. When accounting for the aggregated GHG emis-

© FAO/Tamiru Legesse

BOX 1
DEFINING FOOD LOSS AND WASTE

Food loss is defined as a decrease in quantity and quality of agricultural, forestry and fisheries products intended for human consumption that are ultimately not eaten by people. Food losses occur along the supply chain from production, to harvest, post-harvest handling, to storage and processing, and during transportation. Food losses are largely unintentional and are caused by inefficiencies in the food system, such as insufficient access to technologies and energy, poor infrastructure and logistics, inadequate market access as well as managerial limitations and capacity constraints of supply chain actors. Climatic factors and variability such as extreme events, along with pests and diseases, are also causes of food losses.

Food waste refers to food appropriate for human consumption being discarded, either by choice or after the food has been left to spoil or expire as a result of negligence or oversupply. Food waste occurs predominantly, but not exclusively, at consumption level and is often related to consumer behaviour as well as being policy and regulatory driven.

Food loss and waste is defined as a decrease, at all stages of the food system from production to consumption, in mass and/or quality, of food that was originally intended for human consumption, regardless of the cause.

Source: FAO, 2014 and HLPE, 2014.

sions embedded throughout its life cycle, uneaten food is estimated to emit 3.6 Gt of CO_2eq per year with an additional 0.8 Gt of CO_2eq resulting from associated land use, land-use change and forestry (LULUCF) activities.[1] This makes global food loss and waste a major contributor to climate change, accounting for around 8 percent

© FAO/Jonathan Bloom

of global anthropogenic GHG emissions (FAO, 2015a). As a reflection of this magnitude, if the combined GHG emissions associated with food loss and waste were integrated into a country, food loss and waste would rank as the third largest emitter after China and USA (see figure 1). Translating these figures into land area, it is estimated that nearly 30 percent of the world's agricultural land is currently occupied to produce food that is ultimately never consumed by people (FAO, 2013a). When expressed in terms of energy usage, 38 percent of total energy consumption in global food systems is utilized to produce food that is either lost or wasted (FAO, 2015a).

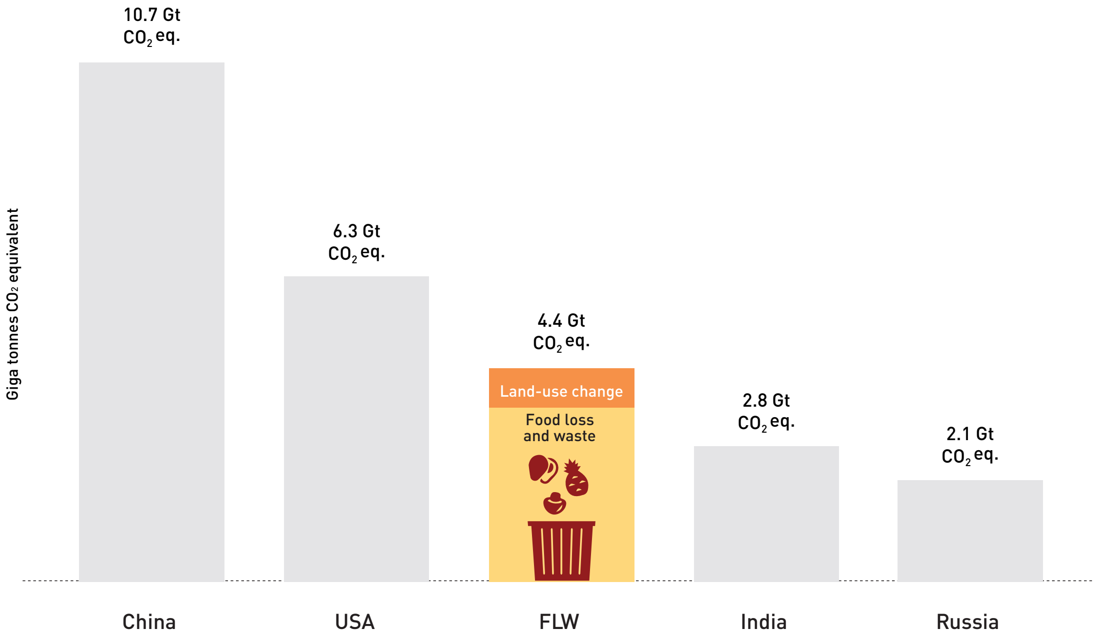
Furthermore, it is expected that in certain parts of the world where food availability exceeds nutritional requirements, food surplus along with a dietary shift towards more consumption of livestock products could lead to further increases in the aggregated GHG emissions from food waste (Hiç *et al.*, 2016). Additionally, under a business-as-usual scenario, food systems are likely to become more emission-intensive due to elongated value chains requiring more inputs before food reaches the consumer.

Estimations of the GHG emissions associated with uneaten food consider all the embedded emissions generated throughout the product's life cycle, and its end-of-life when it leaves the food supply chain. A considerable part of the GHG emissions embedded in food loss and waste are generated during production due to the emission intensity of these activities. Except for fertilizer production, emissions at this stage are predominantly non-energy related and arise from

[1] Estimations are based on an assessment of food loss and waste volumes (FAO, 2011) and IPCC emission factors for 2007. These figures have been updated using the most recent Food Balance Sheets for 2011 (FAO, 2015a).

FIGURE 1

Total global GHG emissions from food loss and waste (including emissions from associated land-use change - LULUCF) **compared to the total GHG emissions of the four largest emitting countries** (including LULUCF)**, based on data from 2011 and expressed in Gt CO_2 eq/yr**



Source: FAO, 2015a and CAIT Climate Data Explorer (2017).

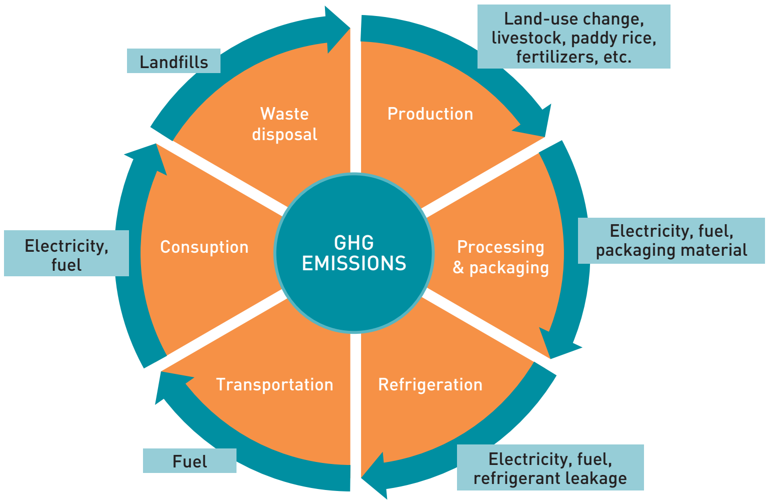
agriculture and other land-use practices. The sources stem from direct methane (CH_4) and nitrous oxide (N_2O) emissions from enteric fermentation, fertilizers (organic and synthetic), rice cultivation, biomass burning and manure management. Indirect carbon dioxide (CO_2) emissions at production level are related to changes in land-use cover from deforestation as well as forest and peatland degradation due to agricultural expansion. In the post-harvest phase, energy usage for processing, transportation and particularly refrigeration are the main emission-generating components of the food system (Vermeulen, 2012). With regards to GHG emissions from fish losses and waste, fuel consumption in fishing vessels followed by energy for cold chains and processing are the major emission sources (FAO, 2012). Emissions generated at consumption level primarily originate from the energy used for cooking as well as from refrigeration, with the consumption-related emissions constituting a significant share of the food life cycle emissions (FAO 2013a). Food waste decaying in landfills also emits GHGs in the form of methane. Due to the aggregated impact of GHG emissions arising throughout the life cycle, the later a product is lost or wasted along the supply chain, the larger is its carbon footprint (see figure 2).

2.3 FOOD LOSSES, FOOD INSECURITY AND VULNERABILITY TO CLIMATE CHANGE

Food loss and waste represents a severe concern to global food security and nutrition by directly reducing food availability and negatively impacting access to food. In addition to a decrease in food volume, quality and nutrient losses can lead to reduced nutritional value of food, with adverse impacts on the stability of food systems (HLPE, 2014). At the same time, the widespread and cascading effects of climate change are expected to have profound impacts on food production activities and threaten to exacerbate vulnerability, hunger and malnutrition (FAO, 2016). The impacts of food loss and waste compound those of climate change and pose serious challenges to food systems and their ability to deliver adequate and nutritious food to meet the demands of a growing population. As such, food loss and waste not only represents a missed oppor-

FIGURE 2

Main GHG emitting sources that contribute to the carbon footprint of food loss and waste at each stage of the food system, from production down to final waste disposal



Source: author's elaboration.

tunity towards ensuring food security and nutrition for the world's poorest but also in terms of food system vulnerability to climate change, which is likely to be aggravated due to increasing climatic variability, along with outbreaks of pests and diseases. Furthermore, post-harvest losses could also undermine adaptation, risk-reduction and resilience measures at production level, all together jeopardizing capacities to cope with climate change, particularly in vulnerable regions.

The socio-economic impacts of food losses and waste are also significant, especially in the context of climate and non-climate related risks and vulnerabilities. Based on 2005-2009 food prices, FAO estimates that the global economic value of food loss and waste amounted to nearly USD 1 trillion in 2012 or USD 2.6 trillion annually, if the social and environmental costs are factored in (FAO, 2013b). In sub-Saharan Africa alone, the approximate value of post-harvest losses in grains is estimated to reach nearly USD 4 billion annually, which is almost equal to the annual value of cereal imports in the region (World Bank, 2011). While the relationship between food loss and waste and the socio-economic dimension is complex, uneaten food directly translates into losses in economic value for both producers and consumers. As a consequence of the economic losses, income is reduced for farmers and value chain actors while labour and capital for agricultural inputs and energy are spent in vain, all in all reducing the return of the investment (HLPE, 2014). The economic costs of food losses and waste along the value chain also have impacts on consumers through higher food prices, meaning that food expenditure constitutes a higher share of the household budget. Additionally, food losses can also trigger food price volatility, with severe adverse consequences for poor and marginalized consumers. Overall, the economic losses resulting from food loss and waste are expected to have disproportionate effects on poor producers and consumers, often in rural areas (but also urban dwellers) that are already vulnerable to climate change and where the prevalence of food insecurity and undernourishment are highest. As a consequence, food loss and waste could add to the triple burden of hunger, poverty and climate change by hampering development progress and poverty alleviation.

2.4 IMPACTS FROM CLIMATE CHANGE AND VARIABILITY

Food losses across the food system are influenced by a variety of dynamics, including climatic-related factors. Future changes and variability in climatic conditions are projected to increase in frequency and intensity, which could potentially spark further increases in


© FAO/Sia Kambou

post-harvest losses (CDKN, 2014). Extreme weather events such as droughts or floods, can destroy crops and livestock along with damage to the supply chain infrastructure while erratic rainfall can cause losses in the harvested produce, impair drying processes and create thriving conditions for moisture-reliant pathogens (HLPE, 2012). Higher temperatures and greater humidity are likely to be followed by an increase in outbreaks of transboundary pests and diseases, which can lead to devastating losses in crop, livestock, fish and forest products. For instance, changes in precipitation and humidity patterns can lead to increases in mycotoxin contamination and insect attacks, posing significant risks to food safety and consequently losses during storage (IPCC, 2015). Temperature increases can also accelerate the spoilage process in products, adding to the concerns for food safety aspects. Finally, without addressing current levels of food loss and waste, an increase in climate-induced food losses along with declines in yields could potentially also trigger further agricultural expansion at the expense of forest lands, leading to deforestation and subsequent increases in GHG emissions.

3 | ADAPTATION AND MITIGATION POTENTIAL OF FOOD LOSS AND WASTE REDUCTION

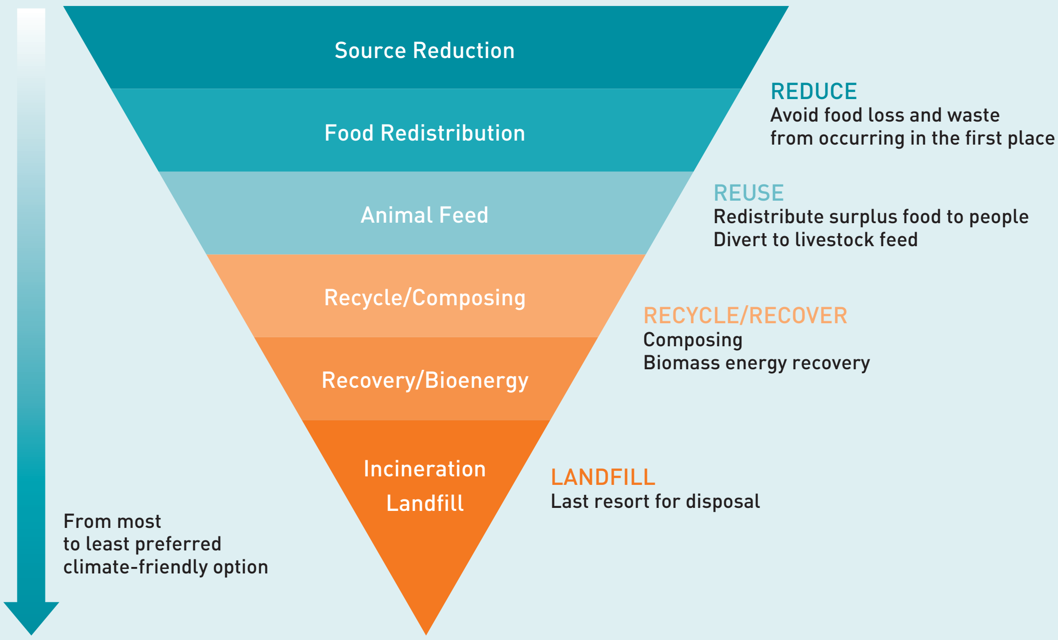
Reducing food loss and waste (see box 2) represents a cross-cutting opportunity in the context of climate action, as it addresses both adaptation and mitigation objectives with its collective contributions towards enabling more productive, resilient and low-emission food systems. The synergies between preventing food from being lost or wasted and climate change mitigation and adaptation were acknowledged and included as part of the climate-smart agriculture (CSA) approach, when CSA was introduced in 2010 at The Hague Conference on Agriculture, Food Security and Climate Change (FAO, 2010). Food loss and waste reduction directly contributes to the three objectives of CSA:

I. increasing net production output;
II. strengthening adaptive capacities at multiple levels;
III. reducing GHG emissions from food systems.

Increasing food availability through food loss and waste reduction is crucial for ensuring food security and nutrition for the most vulnerable, while simultaneously reducing rural poverty and helping to enhance adaptation efforts to strengthen resilience beyond farm level. Preventing food loss and waste would also abate the impacts of agriculture and fisheries as drivers of terrestrial and aquatic ecosystem degradation and deforestation. Moreover, reducing the amount of food that is lost or wasted through the application of

BOX 2
WHAT IS MEANT BY FOOD LOSS AND WASTE REDUCTION?

Food loss and waste reduction refers to the result of actions and interventions that ultimately prevent or avoid food produced for human consumption from being lost or going to waste. This essentially means that measures are taken to prevent food loss and waste from occurring in the first place and can be referred to as source reduction. While this paper focuses primarily on food loss and waste reduction at the source, there are other strategies that can help to abate the environmental, economic and social impacts of uneaten food. Based on the reduce-reuse-recycle principle, options for food loss and waste utilization can be classified according to their GHG emission avoidance potential. Following reduction and prevention at the source, the second most efficient way to minimize the impacts is to ensure that food stays within the human food chain. Redistribution of surplus food fit for human consumption, mainly through food donations (food banks, shelters, etc.) but also through new markets, should be encouraged whenever possible. Once food is no longer safe for human consumption and provided that regulations permit, the resource can be diverted and utilized as animal feed. From an environmental perspective, reusing lost or wasted food as feed for livestock tends to be prioritized over recycling/recovery as it does not involve any further treatment. Recycling the resource through composting (soil amendment and nutrient recycling) or for energy recovery (such as biogas from anaerobic digestion) are other alternatives for food loss and waste valorization. Whether recycling is more beneficial than recovery, or vice-versa, is often context-specific, but both options are preferred to incineration of uneaten food, while landfilling ranks as the last resort. The inverse pyramid below proposes a hierarchy of measures in this respect and concrete examples of different strategies are described in the FAO Wastage toolkit (FAO, 2013c).



Source: Adapted from FAO, 2013c.

climate-smart practices and technologies is expected to have a significant impact on curbing global GHG emissions (HLPE, 2012). The Intergovernmental Panel on Climate Change (IPCC) identified the mitigation potential of food loss and waste reduction measures to be 0.6-6.0 Gt CO_2 eq/yr of GHG emission savings in 2050[2] (Smith *et al.*, 2016). In addition, addressing the food loss issue in the least developed regions calls for improved access to reliable and sustainable energy, technologies, markets and infrastructure, which are all key components of strengthening sustainability and green growth in food systems (this is examined further in section 5).

© FAO/Dan White

© FAO/Sergey Kozmin

[2] Based on a 25 percent reduction in estimated levels of food loss and waste for eight commodity groups (according to FAO, 2011).

4 | ENABLING FRAMEWORKS FOR CONCERTED ACTION

The year 2015 marked a turning point in the international response to the greatest and most urgent challenges of our time. With the adoption of the 2030 Agenda for Sustainable Development and the landmark Paris Agreement on climate change, the fundamental role of food systems for sustainable development and in response to climate change was clearly articulated, including the food loss and waste challenge.

4.1 SUSTAINABLE DEVELOPMENT GOAL 12.3

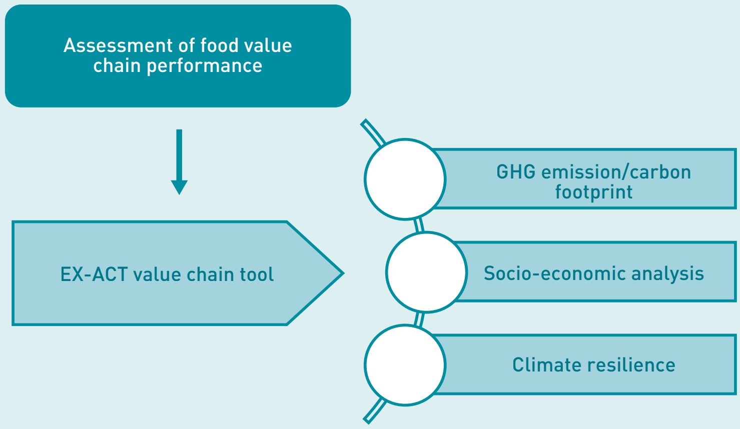
Food loss and waste is addressed under Sustainable Development Goal (SDG) 12, which seeks to "ensure sustainable production and consumption patterns". The third target under this goal, SDG 12.3, aims to "by 2030 halve per capita food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses". Achieving SDG 12.3 is a multidimensional task, which will undoubtedly require fundamental changes in supply-demand-trade linkages, while also addressing broader development and behavioural challenges. However, due to its multiple synergies, actions towards delivering SDG 12.3 could potentially have more extensive impacts, that would help facilitate progress in achieving several other goals and targets such as those relating to poverty reduction (SDG 1), food security and nutrition (SDG 2), energy (SDG7), climate action (SDG 13), as well

© FAO/Asim Hafeez

BOX 3

EX-ANTE APPRAISAL CARBON-BALANCE TOOL FOR VALUE CHAINS (EX-ACT VC)

The EX-ACT Value Chain tool is an excel-based model that provides multi-impact appraisal of food value chain performance, in terms of GHG emissions, socio-economic factors and climate resilience. The EX-ACT VC is applicable to agricultural value chains, primarily in developing countries, and covers crops, livestock, fisheries and aquaculture. The tool analyses the current situation of a value chain and compares different options in an upgraded project scenario, by generating ex-ante estimations of potential interventions along the value chain. The tool incorporates food loss and waste percentages at each stage of the value chain, from production up until retail. The impacts of the potential value chain interventions are estimated in GHG emission reductions, climate resilience indicators and in terms of income generation.



Source: Adapted from Bockel *et al.*, 2017.

The EX-ACT VC tool and supporting information are accessible at:
http://www.fao.org/tc/exact/ex-act-tool-for-value-chains/en/

as those concerning natural resources and supporting ecosystems (SDG 6, SDG 14 and 15) (Wieben, 2016). The Global Food Loss Index (GFLI) developed by FAO is the official indicator for SDG 12.3 and is a voluntary reporting mechanism available to countries for monitoring and tracking their progress towards delivering SDG 12.3. Additional tools and methodologies have been developed and are available for food loss and waste quantification and assessment at different supply chain levels[3] (see also box 3).

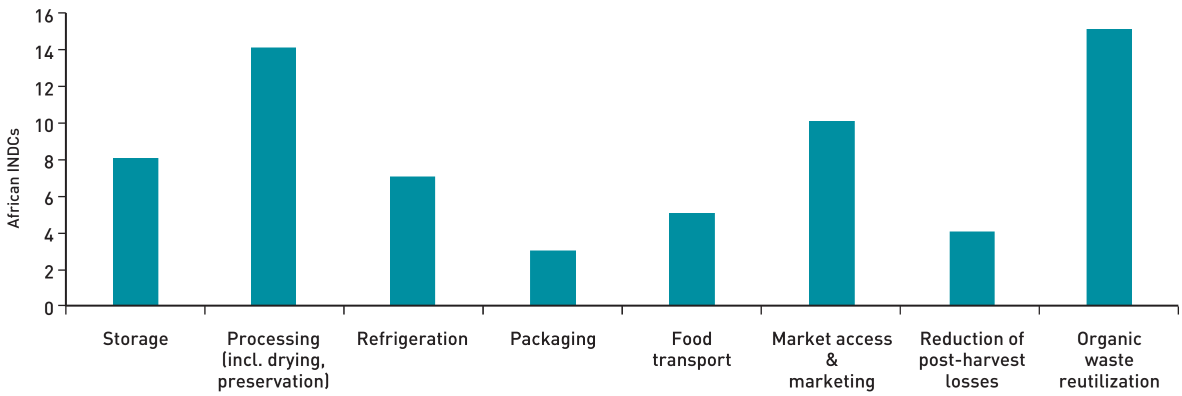
[3] For example: Food Loss and Waste Standard, Food Loss Analysis Methodology, APHLIS+, etc.

4.2 PRIORITIZATION OF FOOD VALUE CHAIN INTERVENTIONS IN THE INDCs

Ahead of the 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) in Paris, Parties put forward their pledges outlining how they plan to address the drivers and impacts of climate change, which were communicated in the form of Intended Nationally Determined Contributions (INDCs). The INDCs reflect each country's objectives for post-2020 climate targets, based on their national priorities, circumstances and capabilities. This country-driven process to formulate national road maps for climate action highlighted important ambitions from both developed and developing coun-

FIGURE 3

Number of African States that refer to concrete interventions and measures in their INDCs, which have relevance to food loss and waste prevention



Source: author's elaboration.

tries, which all together served as the foundation for the Paris Agreement.

The INDCs emphasize the importance of improving food value chain infrastructures in the context of national priorities for climate action. A recent analysis of the INDCs (forthcoming) highlights that numerous countries have made references to food value chain components in their submissions, which have relevance for food loss and waste prevention. These include direct references to post-harvest loss reduction, as well as prioritizing different post-harvest technologies along the value chain for food preservation (processing, storage, cooling, etc) and for improving market linkages and agribusiness development. Other indirect measures refer to the reutilization of organic/agricultural waste for energy production and composting along with pest and disease management. While the mention of relevant interventions features in several of the INDCs from across Africa, Asia and Pacific, the Middle East, Latin America and the Caribbean, a considerable amount of pertinent references come from Least Developed Countries (LDCs) and Small Island Developing States (SIDS) Parties. This highlights the importance of the agri-food sector, including in the context of ensuring food security, in the national response to climate change. Many Parties have featured their food value chain priorities as part of their adaptation objectives, although several are also included as mitigation actions or under technology transfer requirements. In terms of regional distribution, the highest number of relevant references were featured in the African submissions (80 percent of the African INDCs) where value chain aspects were specified (see figure 3), mainly as part of their adaptation priorities and technology needs but also under their mitigation objectives.

Since the Paris Agreement's rapid entry into force, countries are preparing to turn their commitments into implementation, taking into consideration national priorities for mitigation and adaptation as well as financing and capacity needs. As Parties submit their instrument of ratification, acceptance or approval of the Paris Agreement, each country's respective INDC becomes its first Nationally Determined Contribution (NDC), which is expected to be updated every five years. The NDCs along with other implementing vehicles such as Nationally Appropriate Mitigation Actions (NAMAs) and National Adaptation Plans (NAPs) provide important national roadmaps where the climate contributions of value chain improvements and food loss and waste reductions can be further integrated. However, in order to mainstream food loss and waste reduction into domestic climate change planning processes there is a need to increase support for delivering technical and institutional capacity building to strengthen policy frameworks and identify financing opportunities. This is discussed further in subsequent sections.

4.3 FOOD LOSS AND WASTE AND THE GLOBAL CLIMATE ACTION AGENDA

Parallel to the formal UNFCCC negotiation process, additional efforts are urgently needed to enhance the implementation of climate action and to bridge the gap between the combined INDC pledges and the well below 2 °C target.[4] This is addressed by the Global Climate Action Agenda (GCAA), which aims to strengthen the interface between Parties and voluntary initiatives to scale up pre-2020 action. The GCAA has emerged as an important catalyst for governments, cities, businesses, investors and citizens to accelerate climate action on the ground. Building on the achievements of the Lima-Paris Action Agenda (LPAA), the Marrakech Partnership for Global Climate Action provides the framework to enhance cooperative action between state and non-state actors to curb emissions rapidly and help vulnerable nations adapt to climate change. As such, there is an emerging opportunity for coalitions to play a key role in driving climate action forward to strengthen NDC implementation and deliver the SDGs, in ways that are transparent, credible and trackable.

The Global Initiative on Food Loss and Waste Reduction (SAVE FOOD) is one of the cooperative initiatives included under the LPAA, and has helped to bring the food loss and waste issue into the international climate dialogue. Spearheaded by FAO, the SAVE FOOD Initiative is a global partnership of actors and stakeholders engaged in food loss and waste reduction measures and in improving the sustainability of food systems. The initiative follows an integrated approach spanning the entire food system involving farmers, industry, policy-makers and civil society in an attempt to make significant progress in ensuring that food is handled and utilized more efficiently. Serving as a coordinating platform, the SAVE FOOD Initiative aims to facilitate the exchange of knowledge and experience at global, regional, national and subnational levels, and to promote collaboration among partners – including south-south cooperation. The SAVE FOOD Initiative operates within four work pillars to support global efforts to reduce food loss and waste:

I. Awareness-raising and advocacy;
II. Strengthening collaboration and coordination through public-private partnerships;
III. Research to enhance the evidence base for policy, programme and strategy development;
IV. Capacity building and technical support to investment projects and programmes.

As one of the cooperative initiatives to the GCAA, SAVE FOOD aims to ensure alignment of food loss and waste reduction measures with the objectives of the SDGs and the Paris Agreement. SAVE FOOD recognizes food loss and waste reduction as an important opportunity to enhance climate action and concurrently to ensure more sustainable food systems for improved food security and nutrition. Addressing the food loss and waste challenge as part of climate action can help to scale up investment in value chain infrastructure and capacities to improve market linkages, and ultimately to reduce poverty and increase food availability. Activities under SAVE FOOD aims to support countries in realizing their commitments related to food value chain interventions as outlined in their NDCs while ensuring compliance with transparency arrangements for tracking progress.

As part of the Global Climate Action on Agriculture and Food Security at COP22, an additional two initiatives with food loss and waste as one of their target areas were added to GCAA: The Milan Urban Food Policy Pact, which includes commitments from 138 mayors worldwide towards achieving more sustainable food systems in cities. The pact is operationalized by a voluntary framework for action where food waste reduction is one of the six intervention areas. FAO also launched the multi-stakeholder initiative "Coping with water scarcity in agriculture: a global framework for action in a changing climate", which highlights food loss and waste reduction as one of ten key areas for collaborative action to address water scarcity. Additionally, a number of influential companies from the food industry joined efforts at COP22 to highlight their commitments to the implementation of the Paris Agreement through actions in the agri-food sector. Specifically, these companies in a joint statement pledged to scale up their efforts to cut down on food loss and waste, reduce the environmental impacts of agriculture, improve livelihoods and resilience of smallholder farmers and promote more nutritious and sustainable diets.[5]

[4] The Paris Agreement's overarching goal is to strengthen the global response to climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (UNFCCC).

[5] http://tools.ceres.org/files/agriculture-statement-cop22/view

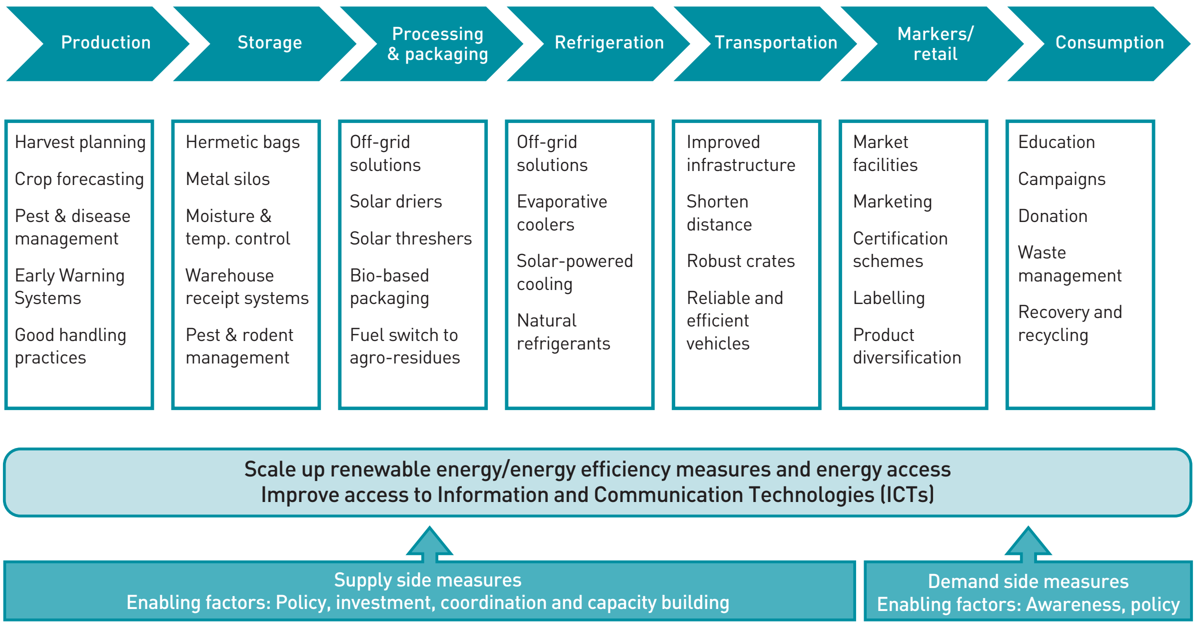
5 | PROMOTING CLIMATE TECHNOLOGY OPTIONS

In developing countries, food losses predominantly occur between the production and distribution stages of food supply chains (FAO, 2011). Food gets spoiled due to various reasons and often interrelated causes such as untimely harvesting, poor practices and techniques, insufficient value chain infrastructures and limited access to markets. For instance, lack of storage facilities and proper drying are major causes of grain losses, while it is estimated that in developing nations 23 percent of perishable foodstuffs are lost due to lack of refrigeration (IIR, 2009). Inadequacy of processing facilities, inappropriate packaging and handling, transportation limitations and poor logistics, along with knowledge gaps, are also important underlying causes of post-harvest losses. In the poorest regions of the world and particularly in rural areas, food losses are often connected to insufficient access to reliable energy infrastructure and technologies, particularly for the value-adding activities such as processing and cooling (Puri, 2016). This presents a significant barrier to food loss reduction and value chain development, especially considering that about 1.2 billion people worldwide still do not have access to electricity, and many more suffer from a poor supply (IEA, 2016). Out of this proportion, the majority are located in sub-Saharan Africa and Asia, mainly in rural areas where livelihoods are closely

© FAO/Antonello Proto

FIGURE 4

Selected examples of climate technologies at the different stages of the food value chain, which can help to reduce food loss and waste



Source: author's elaboration.

tied to the agriculture sectors.[6] The challenges related to energy access are therefore strongly connected to those of increasing the efficiency and value along the food supply chain.

Improving access to reliable and sustainable energy, technologies (including Information and Communication Technology (ICT) services), along with physical infrastructure (such as roads) is imperative for agri-business development and to facilitate the connection and coordination between value chain actors. Strengthening these linkages, partially through technology, are all key aspects of building resilience into food value chain infrastructure, increasing efficiency and preventing food loss and waste. Post-harvest technologies that require modern energy for refrigeration, processing, packaging and distribution are important solutions to reduce losses in developing countries (Puri, 2016). However, many of these technologies rely on fossil fuel combustion to generate electricity or heat for the different stages of the supply chain. In order to make the transition towards climate-smart food systems that reduce both food loss and waste as well as fossil fuel-dependence in value chain activities, increased deployment of clean technologies is required.

Responding to the food loss and waste challenge through technological improvements along the value chain offers an untapped opportunity to promote the transfer, dissemination and adoption of climate technologies.[7] Scaling up renewable energy and energy efficiency measures, optimizing resource efficiency along with technology transfer to effectively reduce food loss and waste presents a pathway to enhance mitigation actions and boost resilience in food systems. Many developing countries have a high potential for renewable energy sources, such as solar, wind, hydro, biomass and geothermal resources. Additionally, in rural areas that are challenged by little or no access to grid electricity, deploying off-grid solutions such solar-

[6] Including crops, livestock, forestry, fisheries and aquaculture.

[7] Any equipment, technique, practical knowledge or skills needed to reduce GHG emissions and/or adapt to climate change (UNFCCC).

© FAO/Liliane Kambirigi

BOX 4

CASE STUDY. ENABLING ACTION ON THE GROUND: REDUCING FISH LOSSES THROUGH IMPROVED SMOKE OVENS

Fish smoking and drying are preservation techniques that are widely used in small-scale fisheries communities in developing coastal regions. Fish processing is also an important strategy to reduce losses by significantly increasing the shelf-life of the product. Smoked fish is advantageous compared to fresh or frozen fish which require cold storage that is largely inaccessible due to electricity scarcity in rural areas. Fish-smoking techniques in West and Central Africa are traditionally based on open kilns using mangrove wood as the main source of fuel. However, open kilns are highly energy inefficient; they release contaminants and the dependence on mangrove fuel has been a significant driver of degradation of mangrove forests in the region ([UNEP-WCMC, 2007] in: Ajonina *et al*., 2014).

A fish smoking and drying technology pioneered by FAO has been developed to improve, among others, the energy efficiency in rural communities by using 50 percent less woodfuel compared to traditional open-type smoking rafts (Ndiaye, Komivi and Ouadi, 2015). The FAO-Thiaroye fish processing technology (FTT-Thiaroye) is helping to reduce health hazards, improve food safety and quality, improve working conditions for women in particular, and to cut down fish losses in many small-scale fishing communities. The FTT-Thiaroye consists of a dual-functioning smoking oven and mechanical drier and is specifically designed to improve fuel-efficiency in small-scale fish smoking by encapsulating heat and smoke. Agricultural residues such as coconut husks, sugar-cane bagasse or manure can also be utilized as fuel in substitution for mangrove wood. Reducing the intensity of mangrove wood harvesting is expected to benefit the mangrove ecosystems and biodiversity through reduced deforestation and degradation of mangroves. Furthermore, this also contributes to climate change mitigation, as mangroves have some of the highest carbon sequestration potential of all forests (Donato *et al*., 2011), while building resilience to climate impacts through coastline protection. The FTT-Thiaroye technology prevents tar deposition and contamination of products by carcinogens such as the polycyclic aromatic hydrocarbons, and is therefore in compliance with international food standards and other safety requirements for reducing quality losses in the smoking process. Additionally, processing operations can be conducted in any season, thereby enabling drying activities during rainy and cloudy periods, which prevent losses that would otherwise occur due to insects, pests and spoilage from open air exposure. This in turn protects businesses and commercial activities of small-scale fish operators from quality and market force losses.

© FAO/Roberto Faidutti

© FAO/Horst Wagner

powered cooling, drying or other types of standalone technologies, can help to reduce food losses while simultaneously delivering climate benefits (a case study is provided in box 4). A selection of potential climate technology options to reduce food loss and waste is presented in figure 4, which provides an overview of a simplified food value chain, where technologies at the various stages are identified along with the enabling factors to ensure increased efficiency, sustainability and higher value addition.

Reducing post-harvest losses in a climate-smart way is contingent upon the deployment of appropriate technologies along the value chain. There are many options available for both mitigation and adaptation technologies that can reduce food loss and waste in developing countries, and there is an apparent need for increased development, transfer and uptake of climate technologies in the post-harvest phase. Considering the total number of requests for technical assistance on climate technologies (covering all sectors) submitted by developing countries to the Climate Technology Centre & Network (CTCN), 13 percent of the requests contain aspects that relate to food value chain technology needs.[8] The same is evident from several of the INDCs, in terms of the identification of technology priorities for food value chains (as outlined in section 4.2). Climate technology solutions to improve food system infrastructure therefore present a key area for targeted support, due to the potential for delivering mitigation and adaptation synergies along with other co-benefits. As such, responding to the food loss and waste challenge offers a compelling investment opportunity to scale up technology transfer and deployment for value-adding infrastructure in developing regions. This includes technologies all along the value chain, but in particular, cold chains (see box 5) and food processing are of high priority because of their large mitigation potential and significant impact on post-harvest loss prevention. Improving storage and packaging facilities, as well as effective pest and disease control, will also be critical as part of promoting adaptation, resilience and risk reduction mechanisms to minimize climate impacts on food systems.

8 https://www.ctc-n.org/technical-assistance/data (Accessed in December 2016).

BOX 5

CLIMATE TECHNOLOGIES TO REDUCE FOOD LOSS AND WASTE: THE CASE OF THE COLD CHAIN

Refrigeration is an effective means of food preservation and prevention of rapid food deterioration caused by ambient temperatures. This is particularly the case for perishable foods such as fruits, vegetables, meat, fish and dairy products, where proper cold storage is essential to increase storage life, maintain quality and prevent spoilage. A cold chain refers to the uninterrupted handling of the produce in a low temperature environment throughout the various stages of a food supply chain. Temperature management along the chain is the most effective means to prevent post-harvest losses arising from the biological processes, physical deterioration and microbial growth in perishable food, particularly in hot climates. This is especially true for developing countries, where access to a functioning cold chain plays a key role in ensuring food safety aspects in perishable foods. Cooling and freezing also offer opportunities to food suppliers to store products for a longer period, allowing to benefit from more market opportunities (Kitinoja, 2013).

As the middle class in emerging economies continues to grow, cold chain systems are expected to become more widespread, along with changes in consumption patterns towards more meat-based diets and more fresh products. However, the development of cold chain infrastructure based on the use of fossil fuels and hydrofluorocarbon (HFCs) refrigerants, which are powerful GHGs, would result in a rapid increase in associated emissions and impacts to climate change. Cold chains are already considered as a significant contributor to global GHG emissions even though less than 10 percent of perishable foods are currently being refrigerated (James and James, 2010). About a third of the total GHG emissions from refrigeration are from direct emissions due to leakage, especially of HFCs. Indirect emissions (the remaining two-thirds) arise from extensive global use of inefficient refrigerator appliances that have high energy demand generated from fossil fuels (GIZ, 2015).

Addressing food loss and waste through cold chain extension without any technology improvement would have serious adverse effects on climate change as a result of increased GHG emissions. Therefore, targeted support should be aimed at phasing out HFCs in cooling infrastructures by promoting a shift towards technologies based on climate-friendly refrigerants. In addition to a technology upgrade, energy efficiency measures in cold chains and renewable energy applications for generating cooling power should also be encouraged. In this context, reducing food loss and waste though the use of low-emission cold chains presents a significant mitigation potential. As such, their implementation offers an opportunity to mobilize the necessary investments through climate finance, carbon pricing instruments and other appropriate fiscal and regulatory measures.

6 | INVESTING IN FOOD LOSS AND WASTE SOLUTIONS: A BUSINESS OPPORTUNITY FOR CLIMATE ACTION

Increased financial flows are urgently needed to invest in food systems that can sustainably reduce food loss and waste while delivering adaptation and mitigation benefits. Unlocking both public and private sector finance is essential for enabling this transformation, however, current flows of finance do not match the investment needs of developing countries. While estimations of the financial resources needed to reduce food loss and waste through value chain interventions are lacking, they are expected to be of significant proportions. Schmidhuber *et al.*, 2009 (in: Branca *et al.*, 2011) estimated that out of the cumulated agriculture investment needs up to 2050 for Africa and the Near East, about half of the investment demand is related to post-harvest handling (cooling, storage, processing and marketing). Therefore, when considering the main causes of food losses and the INDC priorities related to food value chains, catalysing investments in post-harvest infrastructure, together with pest and disease management is critical for achieving food security and strengthening agri-business development. Smallholder farmers and food producers (women in particular) but also small and medium-sized enterprises (SMEs) often face the greatest barriers in accessing finance as they lack sufficient collateral, financial capacity, and tend to be dispersed and disenfranchised. Bank lending is typically low and often with high interest rates due to perceptions of the

© FAO/Daniel Hayduk

agriculture sectors as low profit generators that involve high risks and transaction costs (FAO, 2016). Improving the investment climate and enhancing capacities and skills in value addition is therefore of high priority and also critical to effectively reducing food losses.

The public sector has a key role to play in creating an enabling environment in which the private sector can invest. This includes identifying and potentially increasing existing financial resources from domestic budgets towards food loss and waste reduction measures, and for integrating them into national climate change planning processes. However, doing so will require enhanced capacities to identify enabling regulatory frameworks and encourage appropriate economic incentives, while ensuring their coherence at an inter-ministerial and cross-sectoral level. Nevertheless, increasing awareness of the co-benefits of climate-smart food loss and waste reduction could act as a driver for budgetary re-allocations needed to overcome barriers for technology uptake and deployment. For instance, introducing programmes for solar-powered refrigeration or processing technologies could induce savings on energy subsidies, particularly in rural off-grid areas with fuel (diesel, kerosene and biomass) dependence. Revising and adjusting certain trade mechanisms, such as agriculture and fisheries subsidies that incentivize surplus food production, could also help to make more efficient use of domestic budget allocations while reducing food waste.

Unlocking private capital will be fundamental to realizing the opportunities that food loss and waste prevention have to offer. The majority of the required investment is expected to come from private sector sources as food value chain actors (farmers, producers, industry but also consumers) themselves are largely private and would have the strongest incentive to invest in food loss and waste solutions. Investment costs vary greatly and can range from low-cost storage options or simple evaporative coolers to large-scale expansions of cold chain infrastructure. However, all value chain actors will require access to capital in order to fund investments for implementing these interventions. Financial Institutions (FIs) can play a central role in activating the value chain actors' financing capacity to realize appropriate food loss and waste interventions. Increasing the awareness among the private sector actors (including through the involvement of banks) of the options that have tangible benefits in terms of sustainable food loss and waste reductions and income generation, can help to overcome barriers to implement action. This would also help tighten the link between FIs and smallholder food producers and SME agribusinesses faced with infrastructural constraints to increasing the flow of capital. Producer organizations can play an important role in this coordination, such as through the establishment of warehouse receipt systems, which are described in box 6. Ultimately though, ensuring the private sector of positive expected returns on their value chain investments would again depend on whether the economic incentives are backed up by supporting policies and regulatory frameworks.

6.1 THE ROLE OF CLIMATE FINANCE

Climate finance can be catalytic in leveraging additional sources of finance for climate actions across the food system, provided that the enabling policies and institutional frameworks are in place. Although there is yet no unified definition, climate finance is broadly organized into two types of capital: grants and concessional finance (such as debt, equity, guarantees, etc.), with the latter constituting the bulk share of the sources. Climate finance, whether national or international, public, private or a hybrid, seeks to mobilize additional capital from especially private sources, to fund investment costs of climate solutions that demonstrate transformation potential. While current flows of climate finance to the agriculture sectors

BOX 6
WAREHOUSE RECEIPT FINANCING

Smallholder farmers often struggle to preserve their harvest until optimal market prices and profits are met. They also tend to face higher food losses due to the lack of adequate storage facilities to prevent diseases, pest and rodent infestations and with little or no credit history or assets, smallholders often have little means of accessing finance to invest in improved storage. A warehouse receipt scheme is an agricultural financing model designed to help address these constraints. Warehouse receipt finance is based on a collateralized commodity transaction, by which farmers deposit their commodities in a licensed warehouse that, in return, issues receipts. Farmers can then use the receipts as collateral to obtain loans from local FIs. Warehouse receipt financing allows farmers to access credit and to manage market risks by avoiding the sale of their produce directly after harvest, when prices are low. Furthermore, by placing grain and other agricultural commodities in a safe and secure storage facility, quality is maintained and post-harvest losses are reduced.

Warehouse receipt systems function through the involvement of several value chain actors and if organized properly, they can deliver multiple benefits. Their operation, however, requires a coherent institutional and regulatory framework set up by the government in order to guarantee that warehouses are licensed and supervised properly, and to minimize transaction costs. This, though, provides insurance to the FIs involved who will gain by lowering their risk exposure through the utilization of collaterals that can be easily liquidated. Warehouse receipt finance can help farmers to increase their access to affordable and timely credit, allowing them to invest and build their assets over the long term. It would also benefit processors, traders and exporters in increasing their economic returns by assuring supply continuity and quality, and market linkages, while reducing procurement costs and time. Warehouse receipt financing can help to increase the resilience of both farmers and SMEs by insuring their produce and assets and thereby reducing vulnerability to climate and non-climate related risks and hazards. Reducing the post-harvest losses would also avoid the GHG emissions, otherwise associated with food losses from inadequate storage. The climate benefits of the warehouse receipt system could therefore provide an opportunity to attract climate finance to support the implementation of piloting schemes.

remain inadequate compared to actual investment needs, opportunities within the climate finance landscape have been increasing. Most notably through the Green Climate Fund (GCF), which has the mandate to be the largest supplier of climate finance, and aims to mobilize up to USD 100 billion annually for investments in mitigation and adaption actions in developing countries. The GCF aims to balance its allocations of resources equally between mitigation and adaptation investments. It also seeks to ensure a 50 percent share of the adaptation resources for the most vulnerable countries, including LDCs, SIDS and African States (GCF, 2016). In addition, cross-cutting activities that address both adaptation and mitigation are also considered as interesting to the GCF.

One of the major goals of the GCF, the Global Environment Facility (GEF) and other international financial mechanisms is to ensure a country-driven approach, by which funding is appropriately integrated into national planning processes. This is also reflected in the requirements related to national co-financing, which are perceived as strong signals of country ownership. The priorities specified in the INDCs/NDCs and other national climate plans and strategies are expected to provide an important foundation for country ownership recognition. As such, actions and interventions to reduce food loss and waste while simultaneously delivering climate objectives, could potentially present a new and transformative investment opportunity that would be attractive to the bilateral and multilateral climate funds and donors. However, in order to realize the potential that food loss and waste prevention measures have to offer, coordinated and comprehensive support is required to strengthen the technical, financial and institutional capacities of value chain

© FAO/Ezequiel Becerra

actors and stakeholders. Shifting from fragmented investments towards more integrated programmes will be critical to enable the large-scale investments and coordination needed to reshape food systems, which is also increasingly reflected in the portfolio of the GEF and other multilateral financing mechanisms.

Multi-stakeholder partnership approaches that bring together governments, food producers, industries, climate funds and investors can help to identify opportunities for responding concurrently to the food loss and waste and climate challenge in ways that can mobilize private sector investments.

7 | WAY FORWARD TO ENHANCE GLOBAL CLIMATE ACTION THROUGH FOOD LOSS AND WASTE REDUCTION

The 2015 milestone achievements have established clear objectives for sustainable development and in response to climate change. The challenge in moving forward, however, will be to turn these commitments into concrete action. Collective efforts and integrated approaches will be key to identifying pathways that can enable structural changes in production systems and consumption patterns, and catalyse financial flows. This is also emphasized by the food loss and waste issue, which is a clear manifestation of the broader development and behavioural challenges that characterize the global food system. Ensuring that food is handled and consumed more sustainably now and in the future requires coordinated and concerted action, and transformational change is needed to achieve impact at scale. Developing countries in particular will require support to build their technical, institutional and financial capacities to adequately respond to the food loss and waste challenge across the entire food system.

Addressing the underlying causes of food loss and waste presents a transformative opportunity to enhance ambition for climate action, while simultaneously delivering on multiple targets under the sustainable development agenda. The technological and infrastructural solutions to reduce food loss and waste have been pinpointed in numerous INDCs from developing countries as part of their priorities for the agri-food sector. However,

© FAO/Daniel Hayduk

© FAO/Vyacheslav Oseledko

the mitigation potential from reducing food loss and waste through value chain interventions has not been accounted for in the INDCs, and is therefore not included in any of the emission reduction pledges. As such, prioritizing support to these interventions could potentially have significant importance towards narrowing the emissions gap between national and global goals, through the emission reductions from avoided food loss and waste.

The increased prominence of agriculture and food systems in the international climate arena could help to encourage further dialogue and commitments from businesses, investors, climate funds and donors to scale up support for actions on food loss and waste, in ways that can strengthen NDC implementation. Through the GCAA, coalitions such as the SAVE FOOD Initiative can also help to build public-private partnerships and foster multi-stakeholder collaboration to identify food loss and waste solutions and opportunities that can catalyse private sector investments. By promoting integrated approaches and ensuring the involvement of all actors across the value chain, efforts to reduce food loss and waste could potentially facilitate the transition towards achieving more productive, climate-resilient and low-emission food systems.

8 | REFERENCES

Ajonina, G., Kairo, J. G., Grimsditch, G., Sembres, T., Chuyong, G., Mibog, A. & FitzGerald, C. 2014. *Carbon pools and multiple benefits of mangroves in Central Africa: Assessment for REDD+*. Nairobi, UNEP.

Bockel, L., Debrune, O., Toudert, A., Doro, E. & Schiettecatte, L-S. 2017. *Practical Guidance on EX-ACT VC*. Rome, FAO.

Branca, G., Tennigkeit, T., Mann, W. & Lipper, L. 2011. *Identifying opportunities for climate-smart agriculture investments in Africa.* Rome, FAO.

CDKN. 2014. *The IPCCs Fifth Assessment Report | What's in it for Africa?* Overseas Development Institute & Climate and Development Knowledge Network.

Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., Stidham, M. & Kanninen, M. 2011. Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience,* 4(5), 293–297. Available at http://doi.org/10.1038/ngeo1123

FAO. 2010. *"Climate-smart" agriculture: policies, practices and financing for food security, adaptation and mitigation.* Rome, FAO.

FAO. 2011. *Global food losses and food waste – Extent, causes and prevention*. Rome, FAO.

FAO. 2012. *Fuel savings for small fishing vessels*. A manual. Rome, FAO.

FAO. 2013a. *Food wastage footprint. Impacts on natural resources*. Summary Report. Rome, FAO.

FAO. 2013b. *Food wastage footprint. Full-cost accounting*. Final Report. Rome, FAO.

FAO. 2013c. Toolkit. *Reducing the Food Wastage Footprint*. Rome, FAO.

FAO. 2014. *Definitional Framework of Food Loss*. Rome, FAO.

FAO. 2015a. *Food Wastage Footprint & Climate Change*. Rome, FAO.

FAO.2015b. *Post-2015 and SDGs - Nourishing people, Nurturing the planet*. Rome, FAO.

FAO. 2016. *The State of Food and Agriculture 2016 – Climate Change, Agriculture and Food Security*. Rome, FAO.

GCF. 2016. *Insight: An Introduction to GCF*. Green Climate Fund. Songdo, Democratic People's Republic of Korea.

GIZ. 2015. *Climate-Friendly Refrigeration and Air Conditioning – A Key Mitigation Option for INDCs*. Working Paper Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

Hiç, C., Pradhan, P., Rybski, D. & Kropp, J. P. 2016. Food Surplus and Its Climate Burdens. *Environmental science & technology,* 50(8), 4269-4277

HLPE. 2012. *Food security and climate change*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, FAO.

HLPE. 2014. *Food losses and waste in the context of sustainable food systems*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome, FAO.

IIR. 2009. *The role of refrigeration in worldwide nutrition*. International Institute of Refrigeration. Paris.

IPCC. 2015. Meeting Report of the Intergovernmental Panel on Climate Change Expert Meeting on Climate Change, Food, and Agriculture. *In:* M.D. Mastrandrea, K.J. Mach, V.R. Barros, T.E. Bilir, D.J. Dokken, O. Edenhofer, C.B. Field, T. Hiraishi, S. Kadner, T. Krug, J.C. Minx, R. Pichs- Madruga, G.-K. Plattner, D. Qin, Y. Sokona, T.F. Stocker & M. Tignor, eds. Geneva, World Meteorological Organization (WMO), 68 pp.

IEA. 2016. *World Energy Outlook 2016*. Executive Summary. International Energy Agency. Paris.

James, S. J. & James, C. 2010. The food cold-chain and climate change. *Food Research International,* 43(7), 1944–1956. Available at http://doi.org/10.1016/j.foodres.2010.02.001

Kitinoja, L. 2013. *Use of cold chains for reducing food losses in developing countries.* PEF White Paper No. 13-03.

Ndiaye, O., Komivi, B. S. & Ouadi, Y. D. 2015. *Guide for developing and using the FAO-Thiaroye Processing Technique (FTT-Thiaroye)*. Rome, FAO.

Puri, M. 2016. *How access to energy can influence food losses – A brief overview*. Rome, FAO.

Smith P., Bustamante, M., Ahammad, H., Clark, H., Dong, H., Elsiddig, E.A., Haberl, H. Harper, R., House, J., Jafari, M., Masera, O., Mbow, C., Ravindranath, N.H., Rice, C.W., Robledo, C., Abad, A., Romanovskaya, Sperling, F. & Tubiello, F. 2014. Agriculture, Forestry and Other Land Use (AFOLU). *In:* O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel & J.C. Minx, eds. *Climate Change 2014: Mitigation of Climate Change.* Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK & New York, NY, USA, Cambridge University Press.

Vermeulen, S. J., Campbell, B. M. & Ingram, J. S. I. 2012. Climate Change and Food Systems. *Annual Review of Environment and Resources,* 37(1), 195–222.

Wieben, E. 2016. *The Post-2015 Development Agenda: How Food Loss and Waste (FLW) Reduction Can Contribute Towards Environmental Sustainability and the Achievement of the Sustainable Development Goals*. United Nations University Institute for Integrated Management of Material Fluxes and of Resources. Dresden, Germany, (UNU-FLORES).

World Bank. 2011. *Missing Food : The Case of postharvest Grain Losses in Sub-Saharan Africa*. Washington, DC, World Bank.

SAVE FOOD FOR A BETTER CLIMATE

CONVERTING THE FOOD LOSS AND WASTE CHALLENGE INTO CLIMATE ACTION

This paper aims to inform on the interrelationship between food loss and waste and climate change. In this context, the paper highlights the related impacts, and outlines the recent global frameworks adopted by the international community, and how they have been translated into national priorities and targets. Climate technology options are explored, along with the challenges and opportunities related to financing needs. Finally, this paper will identify ways and enabling factors to reduce food loss and waste as part of the collective effort to enhance ambition for climate action while simultaneously delivering the other objectives of the sustainable development agenda.

Food and Agriculture Organization of the United Nations (FAO)
Viale delle Terme di Caracalla
00153 Rome, Italy
www.fao.org

ISBN 978-92-5-109989-6
9 789251 099896
I8000EN/1/10.17