



Reducing food wastage, improving food security?



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An inventory study on stakeholders' perspectives and the current state of knowledge on the relationship between reducing food wastage and improving food security.

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List of Abbreviations

AfDB	African Development Bank
APHLIS	African Postharvest Losses Information System
CBL	Centraal Bureau Levensmiddelenhandel (Central Bureau for Food Trade)
CFS-HLPE	Committee on World Food Security of the High Level Panel of Experts on Food Security and Nutrition
CHEETAH	Chains of Horticultural Intelligence: towards Efficiency and Equity in Agro-Food Trade along the Trans-Africa Highway
DADTCO	Dutch Agricultural Development and Trading Company
FAO	Food and Agriculture Organization of the United Nations
F&BKP	Food & Business Knowledge Platform
FEBA	European Federation of Food Banks
FME	Federatie voor de industrie (Dutch Umbrella Organization for the Metal and Electrical Industry)
FNLI	Federatie Nederlandse Levensmiddelen Industry (Dutch Food Industry Federation)
FUSIONS	Food Use for Social Innovation by Optimising Waste and Prevention Strategies
GKI	Global Knowledge Initiative (Rockefeller financed)
GMV	Groep Fabrieken van Machines voor de Voedings- en Genotmiddelenindustrie (Dutch Manufacturers of Machines for food Processing and Packaging)
ICRA	International Centre for development oriented Research in Agriculture
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Centre
ITC	International Trade Centre
KHN	Koninklijke Horeca Nederland (Royal Dutch Catering Organisation)
LTO	Land- en Tuinbouw Organisatie Nederland (Dutch Agricultural and Horticultural Organization)
MFA	Ministry of Foreign Affairs
MEA	Ministry of Economic Affairs
NAFTC	Netherlands Agro Food and Technology Centers
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
Veneca	Vereniging Nederlandse Cateringorganisaties (Dutch Association of Catering Organisations)
WBCSD	World Business Council for Sustainable Development
WFP	World Food Programme
WRAP	Waste and Resources Action Programme
WRI	World Resources Institute
WUR-FBR	Wageningen UR Food and Biobased Research

Preface by the Food & Business Knowledge Platform

The Food & Business Knowledge Platform (F&BKP) has been operational since September 2013 in order to attain a more focused Dutch knowledge agenda for food security. A first set of themes for this agenda has been identified in which The Netherlands is fairly active internationally, The Netherlands has the potential to be a relevant player, and stakeholders have knowledge questions.

Food waste and losses, together defined as food wastage in this study, was one of the identified themes. Increasing attention is being paid to this in recent years by many Dutch and related governmental, civil society, business and knowledge actors operating internationally. In various meetings and documents on the reduction of wastage, a direct link is claimed with reducing worldwide hunger, malnourishment and poverty.

Within the F&BKP was suggested that in general and over the long term this link may be true, but whether interventions on food wastage reduction enhance food security for all in all circumstances can be questioned. From a development perspective a relevant knowledge question could particularly be how to improve food security for poor livelihoods in low- and middle-income countries while reducing food wastage.

After a first round of talks with various experts held by the F&BKP-Office to explore this, the numerous statements on the relation between food wastage and food security often did not seem to be (well) supported by scientific evidence. As a result the F&BKP-Office team, together with experts in the field of wastage, decided not to immediately begin an extended knowledge program on improving wastage reduction interventions. Rather, the relevance of focussing on food wastage issues in order to improve food security would first be explored within the F&BKP.

Two professional experts did so by conducting the present research; Joris Tielens, science journalist specialized in the field of agriculture, development cooperation and food security issues, and Jeroen Candel, researcher at the Public Administration and Policy subdivision of the Wageningen University specialising in the discourse of EU food security governance.

These experts were asked to complete an inventory study based on two sub-questions:

1. Which international actors working from or with the Netherlands are active in the field of food wastage and what are their motives and assumptions?, and;
2. What is known in academic and grey literature about the effects of such (potential) reductions of wastage on food security, in particular on access to food in developing regions?

Answers to these questions had to result in recommendations on the relevance of future policy and research in the field of the reduction of food wastage for improving access to and availability of food.

Many relevant studies have been published recently and were included in this study. One of them - conducted and published at the same time as our study - with very valuable insights is the broad and important report of the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security titled *Food losses and waste in the context of sustainable food systems*. The study seeks insight into the reasons for food losses and waste, and the means to reduce them. Although it does consider how food losses and waste relate to the various dimensions of food and nutrition security it seems that it has not systematically reviewed the literature on impacts of food loss and waste interventions on food security, in particular for poorer target groups.

With an overview of Dutch actors and their motives, plus the systematic literature review that gives insight into what is actually known of the potential (short and long term) effects of wastage reduction on the availability of and access to food in this study we hope to deliver added value to the, in particular Dutch, debate on food wastage.

The F&BKP-Office positively welcomes the increasing activity of the many Dutch and related international actors in the field of the reduction of food loss and waste. In the end, reducing food wastage will strengthen general food security in general. However, this study shows that reducing food wastage to enhance food security (including access, stability and utilization) for specific groups in low- and middle income countries over the short term requires more consideration. Despite this, the study clearly shows that much is still uncertain about wastage statistics and relations between wastage reductions and food security. Consensus exists that context- specific and integrated approaches to improve value chains and food systems, including the wastage issue, are most appropriate.

With this study the FBKP-Office hopes to challenge involved actors to critically reflect on their motives and delve into the relation between their interventions and food security effects, in particular access for the poor.

The general lack of knowledge on the relation between wastage and food security does not have to be problematic for wastage interventions in local contexts per se. For actors active in the field of reducing wastage it is recommended to focus on what works locally for specific target groups in the perspective of the broader food chain and system context, preferably based on what is known on (side) effects elsewhere. Often this will mean targeting interventions to improve the efficiency of broader value chains and systems with an eye on the specific circumstances.

All readers are free to publicly share and discuss this study. As a follow up within the F&BKP, various stakeholders will look at relevant knowledge questions for policy and practice that could be taken up within the platform based on this study but also studies such as the mentioned CFS-HLPE on Food Security and Nutrition study, and the recent “Visie Internationale Agrologistiek” (that identifies post-harvest losses in upcoming countries and the possible contribution of the Dutch private sector to reduce them).

Last but not least, the Office would kindly like to thank Joris en Jeroen for their efforts in compiling this study. The same goes for all the professionals that were willing to share relevant and frank information with our researchers.

Summary

The study

This study is concerned with the relation between food wastage reduction and the improvement of food security. By food security we mean that all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. This food security has a global and long term element to it (9 billion people to feed in 2050) and can be targeted at national, local and even individual level.

In recent years, food waste and food loss (together called food wastage in this study) have become high on the agenda of policy makers, researchers, business and civil society organisations. Many of those actors claim a positive relation between the reduction of food wastage and eliminating hunger and malnutrition. However, what is known on the link between those two factors?

As a result, the central question of this inventory study is to what extent interventions to reduce food wastage are effective contributions for food security, in particular for local access in developing regions, but also the food system stability in general?

To investigate this, an overview of international actors working in the field of wastage has been made, with a European/Dutch focus. Their activities and motivations and their assumptions on the relation between reducing food wastage and increasing food security have been mapped. Following this, a synthesis of insights on this relation from scientific and grey literature was made. Finally, conclusions were drawn up.

Results

A first, large group of active global, European and Dutch actors make implicit statements on the relation between food wastage in Western and low- and middle-income countries and food security, suggesting a link, but without explicitly explaining how one issue affects the other.

A second group of actors tries to deliver a more direct impact on food security by contributing to reducing pre- and post-harvest food loss in value chains in developing countries, for example with technological solutions in agro-logistics.

Literature shows that some food wastage interventions can have a direct impact on short-term food security conditions, in particular availability of food, but this depends on the circumstances. Nevertheless, the more direct effect of reducing waste in Western countries on food supplies, livelihood and food prices, in particular in developing countries, is less clear.

A third group of actors focuses on reducing waste on the consumer side of the supply chain in developed countries. Their aim is to make an indirect and long term impact on food security by creating a more efficient food system in environmental or economic terms.

Indeed there seems to be plausible evidence in the literature that suggests reducing and reusing wastage may have a positive impact on long-term food security through the efficient use of resources and environmental impacts.

Here it should be noted that in spite of the popularity of food wastage interventions in policy circles, the number of studies and documents on the relationship between food wastage interventions and food security has been found to be relatively small. Also the evidence for the relation is rather implicit with often a lack of a sound empirical foundation. In particular, little evidence exists for pro-poor effects of reducing wastage.

However, consensus in the literature exists that possible positive outcomes for food security, in particular wider access to food, depend on the larger context in the value chain or food system. For example proper infrastructure, means of transport and market access are essential for wastage interventions to have more significant effects. Wastage interventions in themselves may not solve the underlying causes of food wastage, such as poor communication within value chains or poor marketing strategies.

Key messages

The main conclusion of this study is that reducing the wastage issue cannot be solved in a single stroke. Interventions, although important, often do not make a significant contribution on their own, but can do so when embedded in a broader and integrated value chain or food system approach with an eye on context specific circumstances.

The Dutch government is very aware of this and has set up cooperation between the Ministry of Foreign Affairs and the Ministry of Economic Affairs to enable such an integrated approach for post-harvest losses interventions based on the extensive Dutch expertise. Ideally, actions would be tailored to match local or national needs and demands with the wide array of policy instruments that are available based on a careful assessment of the specific context.

In addition the assumption that interventions to reduce pre- and post-harvest loss automatically contribute to food security, in particular for poor consumers, has been found not evident per se. It is recommended to pay, on a case-by-case basis, explicit attention to context specific food wastage interventions (e.g. by downscaling) and their impact on local food security.

With respect to activities to reduce waste in the West that often claim a direct link to food security in developing countries, this study concludes that these suggestions often cannot be lived up to.

The reduction of wastage, be it post-harvest, in the distribution or processing stage of the food chain, or at the consumer level, is not a bad thing, and will often contribute to general food security through positive effects on the environment. However, if one aims to improve access to food, in particular for the poor and over the short term, a more context specific and holistic value chain and food system approach is needed.

It is recommended that future research and policy, aimed at increasing food security in low- and middle-income countries, should not focus specifically on the reduction of wastage only. It should rather focus on integral context specific programmes to improve the effectiveness of value chains or food systems of which reducing food wastage could be part.

What is this study about?

Method, approach and limitations of the study

In recent years, food waste and food loss have risen up high on the agenda of policy makers, researchers, business and civil society organizations, internationally and in particular in Europe and in the Netherlands. Many of these actors see a linkage between food waste or food loss on the one hand, and food security on the other. For example, when launching the Zero Hunger Challenge in Rio in June 2012, UN Secretary General Ban Ki-moon called for zero food loss and waste as part of the challenge of eliminating hunger. In October 2012, FAO Director-General José Graziano da Silva said achieving zero hunger would require, among other measures, moving to eliminate food loss and waste.

Such statements fit in with the increasing attention to world global food security. At the same time they remain rather implicit about the relationship between food waste/loss and food security. Using an example: if a school child in the Netherlands throws away the contents of his or her lunch box, this action does not directly result in another school child in South Sudan becoming more hungry. The link that does exist is often not made explicit.

In this study we investigate to what extent reducing food waste and food loss is an effective action to improve food security. To do so, we aim to generate a better understanding of the present state of knowledge, and perspectives of several stakeholders on the relationship between reducing food wastage and food security.

In the first part of this report, we give an overview of major international, European and Dutch actors active in the field of loss and/or waste. These actors are grouped according to their activities and associated motives to take action, particularly with respect to the effect on food security they hope to achieve.

In the second part of this report, we set out a synthesis of the current state of knowledge about the relationship between reducing food waste/loss and food security in the scientific and grey literature

In the third part, we combine these two previous parts into conclusions and recommendations on policy and on the question of whether or not further research on food security should also include research on food waste and loss.

Extent and definitions of food loss and waste

The FAO estimates that roughly one-third of the edible portions of food produced for human consumption gets lost or is wasted globally, which is about 1.3 billion tons per year.¹ The value of food lost or wasted annually at the global level is estimated at US\$1 trillion.² Yet reliable numbers on specific numbers of wastage are absent.

Food is lost or wasted throughout various stages of the food supply chain. During agricultural production, crops and harvest can become damaged or spilled, animals may die due to diseases, fish may be discarded during fishing and milk could be lost due to cattle diseases. Crops, animals, fish or milk may be lost during post-harvest handling, storage and in transportation. During processing, food may be lost or degraded during washing, peeling, slicing, canning, packaging etc.; or during slaughtering, smoking, freezing or pasteurising. During distribution, food may be lost or wasted during transport, at wholesale markets, supermarkets, retailers, etc. Finally, consumers may waste food by throwing it away.

Food loss refers to food that is lost at production, post-harvest and processing stages in the food supply chain. Food waste generally refers to food discarded at the end of the supply chain, by retailers or consumers. Food wastage refers to the combination of both food loss and food waste.

In medium- and high-income countries, food is wasted to a great extent at the end of the supply chain by consumers. In low-income countries food is mainly lost during the early and middle stages of the food supply chain and much less food is wasted at the consumer level.¹

According to the UN, food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996).³ This includes the availability of food, access to food, utilization of food and stability of all these three elements in the future. In this study we approach food security from a food systems

perspective, implying that we also include broader environmental, economic, and social factors that interact with food security in the narrow sense.

Methodological approach

The overview of actors is based on a literature review, internet search and interviews with key stakeholders. An overview of organizations and websites used is provided in Annex 1. It is impossible to provide a complete overview of the actors, but we have tried to include all major actors, branches and networks.

The literature review was performed by applying systematic review methods. Academic and grey literature was searched by using predefined search terms and the eligibility of articles, documents, and other materials for the purposes of this study were judged on the basis of clear inclusion criteria. The final body of literature consisted of 52 articles, which were read and their relevant sections were put in data extraction matrixes, which formed the basis for writing the synthesis of insights from the literature. A more detailed explanation of the review methods can be found in Annex 2.

1 Overview of relevant actors

Many businesses, governments, civil society organizations and multi-stakeholder initiatives are in some way involved - on a global, European or Dutch level - in reducing food waste and loss. Their motive to do so differs according to their aim and the eventual linkage they observe between reducing wastage and food security. Here we categorize actors according to the interventions or activities they employ, the motives these activities stem from, and to the extent that they claim that these relate to food security. In other words, what they do and what they hope to achieve in terms of food security.

The relationship between food wastage and food security is a complex one. We distinguish between economic, environmental and social perspectives on this relationship. Effects can also be distinguished at a micro-, meso-, and macro-level. The linkage between reducing wastage and food security can be direct and short term, or indirect and long term. Additionally, actions may have an effect on different aspects of food security such as availability, accessibility, utilization and stability of food. Like many others we adopt a broader food systems approach, including actors who claim reducing food wastage may have indirect effects on food security, via effects on the economy or on natural resources.

Actors may have varying perspectives and assumptions aiming at reducing wastage, which can broadly be classified in the following three points:

1. The economic perspective: production costs of food products could fall by reducing or reusing wastage. Wastage represents a wasted investment that can reduce farmers' and businesses' incomes and increase consumers' expenses.
2. Natural resources/Environmental perspective: reducing wastage can reduce the claim on natural resources (land, water, energy) that were used in producing the food. This perspective can also be focussed on the reduced emission of greenhouse gasses as a result of reduced wastage of food.
3. Ethical and social perspective: reducing wastage can increase food security of people in need of food.

Within these perspectives, different types of motives for reducing wastage can be distinguished. Improving food security is an important one. However, the economic or environmental perspective can also be motivated by the desire to prevent climate change, or to reduce conflicting claims on land. Many actors, however, suggest a relationship between food wastage and food security without specifying the relationship. Some actors act based on a short term, direct link between reducing loss in developing countries and food security, mainly from a value chain perspective. Another motivation is to make an impact through a long term, indirect link between food wastage and food security, for example through an impact on natural resources or the economy, or through developing and making information and knowledge available. We will discuss all these motives in more detail below.

Many larger organizations combine several goals and are not easily categorized under one particular motive. This is especially applicable to the UN and governments. However, we will include the various motives these organisations have.

1.1 Implicit relation: Less wastage improves food security

The most widely mentioned linkage between food wastage and food security is an implicit link between food wastage and food insecurity. This is especially seen in campaigns to raise awareness against waste in the Western world, in media reports, press releases and on front pages of websites. The amount of food wasted globally is stated, followed by the amount of people that go hungry in the world. The exact relationship between the two is often not specified. This statement is usually accompanied by an ethical appeal to change this situation.

At the global level, such an implicit linkage was made for example by World Bank president, Jim Yong Kim, based on the World Bank Food Price Watch report of February 2014. He stated 'The amount of food wasted and lost globally is shameful. Millions of people around the world go to bed hungry every night and yet millions of tons of food end up in trash cans or spoiled on the way to market. We have to tackle this problem in every country in order to improve food security and to end poverty.'

The same applies to the UN Zero Hunger Challenge. This is a global campaign to raise awareness and eliminate hunger. As part of this, 13 UN organizations held a meeting in September 2013 on food loss and waste reduction in support of the 'zero loss or waste of food' element of the Challenge. Though many UN organizations have specific perspectives on the relation between food wastage and food security, in a statement from the meeting the relation was not specified. It was concluded that 'food loss and waste reduction is one of the most effective ways of improving global food supply, thus contributing to enhanced food and nutrition security', without further specification of the relationship itself.⁴

The FAO campaign Think.Eat.Save⁵, aimed at increasing awareness, uses a non-specified claim: 'About one third of all food production world-wide gets lost or wasted, amounting to 1.3 billion tonnes. In industrialized nations, retailers and consumers discard around 300 million tonnes that is fit for consumption. This is more than the total net food production of Sub-Saharan Africa and would be sufficient to feed the estimated 900 million people hungry in the world.'

On a European level, the Agricultural Committee of the European Parliament suggests a link without specifying it, in a press release: 'Up to 50% of edible and healthy food gets wasted in EU households, supermarkets, restaurants and along the food supply chain each year, while 79 million EU citizens live beneath the poverty line and 16 million depend on food aid from charitable institutions.'⁶

Civil society organizations like Feeding the 5000, Damn Food Waste and Kromkommer, also mention a non-specified direct link. They assume that reducing waste by Western consumers and retailers, will affect food security. However, these organizations mainly want to achieve more resource efficiency (Please see page 18).

Last in this category, a non-specified motive to reduce waste is mentioned on the website⁷ of a conference in London, organised by the Dutch embassy in London and the Ministry of Economic Affairs (MEA): 'There are nearly one billion malnourished people in the world. These people could be lifted out of malnourishment on less than a quarter of the food that is wasted in the US, UK and Europe'. These actors have other motives as well, which will be examined later in this report.

1.2 Direct and shorter term links: Food bank and value chain perspective

At the consumer end of the supply chain, some actors work on the direct link between food waste prevention and food security by collecting food that consumers or retailers would otherwise throw away and donate it to those in need. An example of this is the European Federation of Food Banks (FEBA), a federation of food banks in several countries. The motive to act is an ethical one. In the Netherlands and elsewhere, retailers such as Albert Heijn cooperate with food banks. The Centraal Bureau Levensmiddelen (CBL) supports this and there is discussion on changing liability law to prevent retailers being liable for donated foods.

At the other end of the supply chain, many actors see another direct and relatively short term link between reducing wastage and food security. It is assumed that reduction of post-harvest losses through interventions aiming at a more efficient supply chain in developing countries has a direct impact on food security as it increases the amount of food available for poor smallholder food producers and increases the general availability of food at community or regional level. This motive is mentioned by many actors. We will discuss several of them, from the global to national level.

International organizations

At UN level, the work of several UN organizations is driven by this perspective, for example the African Development Bank (AfDB), International Fund for Agricultural Development (IFAD), International Trade Centre (ITC), United Nations Industrial Development Organization (UNIDO), and World Food Programme (WFP).⁴

Increasing the efficiency of value chains as an action to reduce post-harvest losses and increase food security is an important motivation for the FAO as well. The FAO has been a major actor in this field for decades. The FAO Action Programme for the Prevention of Food Loss⁸ from 1978 to 1990, aimed at assisting developing countries in implementing over 250 projects on the reduction of food loss.

In a broad study that the FAO commissioned on food wastage, the authors mention direct effects of reducing loss on the food security of both smallholder farmers and poor consumers. Improving the efficiency of the food supply chain could help to bring down the cost of food to the consumer and thus increase access. A reduction in food loss could have an immediate and significant impact on the livelihoods of many smallholders that live on the margins of food insecurity. However, it is also noted that food insecurity is often more a question of access, i.e. purchasing power and prices of food, than a supply problem. Given the magnitude of food loss, making profitable investments in reducing loss could be one way of reducing the cost of food. That would, of course, require that financial gains from reduced loss are not outweighed by their costs.¹

A major actor in more efficient value chains in Africa is IFDC (The International Fertilizer Development Centre)⁹, a US-based organization implementing business-oriented programs on input and supply chain improvement for smallholders. IFDC includes post-harvest losses as a problem and links that to its activities to connect farmers to partners that improve processing, storage and transportation infrastructure.

IFDC is one of the implementing partners in the 2Scale programme, a large programme funded by the Dutch Ministry of Foreign Affairs (MFA). ICRA (International Centre for development oriented Research in Agriculture) and BoPinc (Base of the Pyramid innovation centre) are other partners. 2Scale aims to include 1.15 million smallholder farmers in viable agribusiness clusters that will target local, mostly BoP markets. An example of a 2Scale project that relates to reducing post-harvest losses is DADTCO.

Example: Company - DADTCO¹⁰

The demand for cassava, for example in the production of beer, is increasing. The transport of cassava roots to processing plants often involves high loss and costs. A social enterprise, the Dutch Agricultural Development and Trading Company (DADTCO), developed mobile processing units that process the tubers into cassava cake, which can then be transported to a processing plant to produce high quality cassava flour. The company claims that this reduces loss and makes growing cassava a more viable option for many smallholders.

Dutch government

Increasing the efficiency of value chains through reducing post-harvest losses is an important motivation in the policy of the Dutch government. The Ministries of Economic Affairs and Foreign Affairs have worked together extensively on this issue. An interdepartmental team on agro-logistics and regional trade in Africa has been installed since January 2014 to formalize this cooperation.

The Ministry of Economic Affairs (MEA) aims at reducing waste in its policy and activities in the Netherlands, based on an economic as well as natural resources perspective. It focuses on reducing post-harvest losses early on in the value chain of developing countries in its international perspective, aiming to contribute to food security. Causes of food loss that are identified are suboptimal harvesting, underdeveloped cold chains, bad storage facilities, deficient transport and market information. The policy letter 'Toekomst agrologistiek' (2014) states: 'The Dutch expertise in agro-logistics is of great value and there are possibilities for application on a global level. Agro-logistics offer solutions for the world food problem.'. The ministry will organize an international conference on food wastage in December 2014, together with the European Commission. Projects related to improving efficient value chains, as part of the economic 'top sector' policy are, for example, on dairy chain development in Indonesia and Vietnam with the Dutch dairy industry, horticulture chains in Vietnam, an agro-logistics platform for fresh chains in Egypt, and reducing loss in potato, vegetable, fruit and sesame chains in Ethiopia.

The MEA further initiated several activities to bring actors together. For example it founded the No Waste Network, which gives information via a website on news, research and initiatives to reduce food wastage in the Netherlands (see below). MEA also founded the Network of Excellence on post-harvest losses. MEA asked Wageningen UR Food and Bio based Research (WUR-FBR), partners in the network, to assess the feasibility of establishing a network of excellence on agro-logistics based solutions for the reduction of post-harvest food losses in developing and emerging countries. The feasibility study makes an inventory of the activities and possibilities of stakeholders, including companies and other organizations involved in the fruit and vegetable supply chain in developing countries. The study concludes that Dutch companies can provide solutions for post-harvest food losses and that civil society organizations and intermediary organizations have a role in linking them with local chain actors and their questions. It is concluded that setting up a Network of Excellence, bringing together the private sector, governments, NGOs and intermediate organizations, within a holistic and demand

driven approach is a more effective way of dealing with the complexity of post-harvest losses than the activities of single parties. The study states that reducing post-harvest losses has a direct and positive effect on food security.¹¹

Plans have been developed to establish Centres of Excellence in the future based on the Network of Excellence. These would be physical centres located in production regions in developing countries focussing on specific commodities. The aim would be to build up local knowledge and capacity with local agribusiness, governments and institutes, through training, R&D and extension.

In addition, in late 2013 the MEA organized workshops, together with Buck consultants, which brought together Dutch businesses in the vegetable and fruit chain. The ministry stated that food security is an important issue for the government and that chain efficiency offers great opportunities to improve food security. The aim of the meeting was to identify new business cases. Opportunities were identified relating to reducing loss such as cold chain development in India and a master plan for agro-logistics and the fruit chain in Ethiopia. A similar workshop was held with companies in the dairy chain. In this case the need for more investment in local capacity and knowledge on the benefits of investment in technology in value chains was highlighted, as well as a general need for an overview of current issues and more cooperation with NGOs.

In spring 2014, the MEA commissioned an inventory study by Wageningen UR on post-harvest losses, improved food security and possible contributions of the Dutch private sector. This 'Visie Internationale Agrologistiek'¹² concluded that many Dutch SME companies in agro-logistics have the potential to contribute to reducing food loss but are too small to start business in emerging markets with their specific limitations. Support would be needed, such as information on local stakeholders, targeted trade missions, a selection of promising regions and finance structures. This study also reported from agricultural attachés at embassies, which identified loss in fruit and vegetables – potatoes, dairy, meat and fish being most significant. They listed necessary interventions as an improved cold chain, processing, packaging and infrastructure (hardware); combined with better entrepreneurship, investment climate and chain cooperation (orgware); and training, education and certification (software).

The Ministry of Foreign Affairs, in particular views efficient value chains as key in improving food security.¹³ Here the Ministry sees a role for the Dutch agricultural, logistics and food processing sector.

The issue of food loss is being explored by the ministry. However, apart from being part of a broader trade and value chain approach, the Ministry of Foreign Affairs does not target policy specifically at reducing loss yet. The reason they give for this is that there is not enough knowledge yet on the relation between reducing food waste and loss with food security. The commitment of the MFA is instead on the broader value chain and trade facilitation. From an inventory study done by Agri-ProFocus on the issue of reducing food loss in Ethiopia, Kenya and Uganda¹⁴, it emerged that although projects of embassies of the Netherlands may be relevant to help reduce food loss, they are seen as part of a broader approach of improving efficiency in value chains and do not have the specific aim of reducing food loss. The emphasis of the MFA is also on trade facilitation in improving value chains and reducing losses. For example, truckloads with food that are stuck at inefficient border posts result in losses. Specific actions to promote trade facilitation are for example, the support for Trademark East Africa, an organization that facilitates regional trade through streamlined and simplified border regulations. Also the project CLIENT, on e-certification of phytosanitary standards in trade, aims to facilitate trade.

Private sector

The Netherlands has a large private sector in agro-logistics (storing, transport, cooling, packaging) and processing industries (machinery, technology) aimed at the agro-food sector, that has the potential of contributing to better functioning value chains by exporting its expertise and technical solutions.

The technological industry is united in umbrella organization, FME, which has an Agro Food cluster. 90% of the turnover of the agro-logistical and technological industry is from export, including to emerging and developing countries. From the perspective of this sector, technology, though not the only thing needed, forms a key contribution to feeding the 9 billion people that will live on earth in 2050. It should increase the efficiency of value chains and reduce losses in developing countries. This branch aims to contribute to reducing food loss by 15%, by delivering suitable technologies, for example in cooling, distribution, processing and packaging. The main motives are the business opportunities that companies find in developing countries, but in interviews with stakeholders, the corporate social responsibility of the sector is mentioned as well. Websites of individual companies, as far as could be searched, do not mention a specific contribution to food security.

Initiated by the umbrella organization of producers of food processing machinery (GMV), centres were set up in China, India and South Africa - the so called Netherlands Agro Food and Technology Centres (NAFTC). The aim of these centres is to represent the Dutch agro-food business in emerging markets and facilitate business development. As an example of an activity, the Netherlands is a partner of the India Cold Chain Expo 2014 in Mumbai, India.

GMV also initiated the platform for Metropolitan Food Security, an initiative of Dutch agro-food businesses aiming at improving the supply and production of food in metropolitan areas worldwide. The platform brings together companies, knowledge institutes and the government for the joint creation of solutions and is supported by the MEA.

Example of cold storage: Solar powered cooling units for milk

Mueller, a company that develops cooling systems, used research of LEI-Wageningen UR in a pilot with BoPInc, SNV and an Ethiopian entrepreneur to develop a small milk cooling unit that is solar powered. The units enable small scale dairy farmers, mainly women, to sell fresh milk. As fresh milk is priced higher, the women earn more income and as such the cooling units support food security. Fresh milk also has a higher nutritional quality than milk that is not fresh. Milk, however, is usually not wasted as sour milk is processed to butter or cheese.

Finally, several civil society organizations, such as ICCO, Oxfam, Cordaid, Solidaridad and SNV, are involved in programmes to improve the livelihood of smallholders, to improve farmers' organizations, to increase market access and value chain efficiency, and to improve enabling institutions such as credit facilities. Agriterra and Agri-ProFocus are involved in supporting farmers' organizations and entrepreneurial skills of smallholders to improve value chains. All of these activities could have a positive effect on reducing post-harvest losses, yet the organizations do not specifically claim contributions to food security as a result of their activities to reduce post-harvest losses.

1.3 Long term, indirect environmental and economic effects on food security

Apart from a direct effect on food security, reducing food waste and loss could have an impact on other aspects of the food system and in doing so have an indirect impact on food security. These long term, macro scale effects are claimed in various ways by different actors, which we will discuss below.

Decrease pressure on natural resources

A motive is mentioned based on *natural resources* linked to food production and food security. If food wastage is reduced, less land, water, inputs and energy are needed, and less greenhouse gas emitted. These natural resources could be used to increase food production, or affect the food system in other ways. Linked to this motive, is a specific one based on the *future need* for food, and increasing global food supply.

On a global level, the World Resources Institute (WRI), a global research organization, for example states from a natural resources perspective that reducing food loss and waste is part of creating a sustainable food future. From a recent study, it concluded that reducing wastage could contribute to future food availability: 'The world will need about 60 percent more calories per year by 2050 in order to adequately feed the projected population of more than 9 billion people. Cutting current rates of food loss and waste in half would reduce the size of this food gap by about 22 percent.'¹⁵

WRI partnered with the World Business Council for Sustainable Development (WBCSD) in Action 2020, a global business platform¹⁶. WBCSD mentions economic and environmental motives to reduce waste and loss. Its plan is to involve businesses in reducing waste and loss. Together with WRI and UNEP, WBCSD is developing a Food Waste Measurement Protocol to encourage business to measure waste.

For the FAO, the long term link is important as well. It claims that food loss represent a waste of resources used in production such as land, water, energy and inputs. Producing food that will not be consumed leads to unnecessary CO₂ emissions in addition to loss of economic value of the food produced¹. This is the main opinion

of the Think.Eat.Save campaign, part of the Save Food initiative, a global network of actors involved in reduction of food waste and loss, from governments, business, knowledge institutes, NGOs, including several Dutch actors. The FAO has specifically reported on the effect of wastage on natural resources.¹⁷

UN special rapporteur on the right to food, De Schutter, reasons from a natural resources perspective as well but views the relation between food wastage and food security differently than most actors. Often an equal responsibility is suggested by stating that roughly half of the food is wasted or lost in developing countries and the other half in developed countries. In his concluding report¹⁸ published in April 2014 De Schutter points out that per capita food waste is about ten times higher (95 to 115 kg per year) in rich countries than in developing countries (6 to 11 kg per year). De Schutter claims that these inefficiencies result in food production exerting a much higher pressure on natural resources than would otherwise occur. He views globalized supply chains and widely diverging purchasing powers as part of the problem, as these allow 'the luxury tastes [such as waste] of the richest parts of the world to compete against the satisfaction of the basic needs of the poor'. In fact, De Schutter views food wastage as a symptom of a malfunctioning food system.

On the European level, the European Commission plays a major role in facilitating research, advocacy and policy making in the field of reducing waste and loss. To increase resource efficiency, the EC aims for 50% less food wastage in 2020.¹⁹ Future policy will, amongst others, be based on the EU financed research project FUSIONS (Food Use for Social Innovation by Optimising Waste Prevention Strategies), which also has as its main purpose a more resource efficient Europe through significantly reducing food waste. The project unites universities, knowledge institutes, consumer organizations and businesses, while aiming to understand the extent that social innovation can reduce food waste.

Several national governments in Europe have developed policies, interdepartmental teams or regulation on reducing food waste (UK, Germany, Denmark, Netherlands, Belgium, France, Spain). France has new legislation on best-before product labelling. The main motivation, as far as could be established in this inventory study, is resource efficiency. There is an abundance of information on how to reduce food waste and loss, but relatively little on why this should be done (see Annex 1 for websites of initiatives).

A more sustainable resource use and a circular economy is the goal of WRAP, a UK-based non-profit company aiming at helping consumers and industry to minimize food waste through informing the public and creating public-private partnerships. It does not have a focus on food security as such. A similar initiative in the Netherlands is Voedselmarkt.nl, a social enterprise that works to find new destinations for waste streams by publishing advertisements of traders of food that is beyond the expiry date. It is driven by an economic desire for greater efficiency.

Civil society organizations are mostly driven by an environmental motive, like Feeding the 5000, initiated by British activist Tristram Stuart. Feeding the 5000²⁰ aims to reduce food waste in western markets and does not focus on food security. A similar initiative in the Netherlands, Damn Food Waste is also driven by the need for greater resource efficiency. Damn Food Waste is campaigning against food waste in the Netherlands, by cooking meals from food that would be otherwise wasted. The goal is ethical, revaluing the value and fun of food. Damn Food Waste²¹ is a multi-stakeholder coalition of the Youth Food Movement, OneWorld, Voedingscentrum, Wageningen UR, Feeding the 5000 and the EU Fusions project. Another Dutch civil society organization driven by resource efficiency is Kromkommer, that seeks to raise awareness specifically on the food that is discarded because it does not have the standard 'looks' that retailers want. Kromkommer²² also has its own products made from vegetables that would be thrown away otherwise. This initiative is also driven by an ethical appeal, and does not specify a link between food waste and food security.

Economic efficiency

Another long term incentive is an *economic purpose*, based on the idea that investments in the production of food are wasted when food is wasted or lost. A more specific variant of this incentive, is a claim based on *world market prices*. If less food is wasted, world prices will drop and a greater number of poor people will have access to food.

For the Dutch government, the long-term and indirect impact of food waste is also important. Food waste is high on the agenda of the national government and is mentioned in various policy papers. While in the international perspective the focus is on efficient value chains, in the Netherlands the goal of the Ministry of Economic Affairs is greater economic efficiency. Reducing food waste is one of the priorities in the 2013 policy paper Sustainable

Food Production.²³ The aim is to reduce food waste by 20% in 2015 compared to 2009. The MEA supports the 'Alliantie Verduurzaming Voedsel' and has commissioned research such as the Monitor on Food Waste.²⁴

The MEA also initiated the stakeholder platform No Waste Network²⁵, which has an efficiency motivation as well. The network's mission is to reduce food waste and increase the value of food residues. It strives for this in cooperation with the Alliantie and Wageningen UR, and gathers information from the private sector (retail, food industry, agriculture, catering and hospitality industry) while calling on the public to get involved.

Private sector actors involved in reducing waste in the Netherlands or other western markets are mainly driven by an economic goal for greater efficiency, and by a natural resources motivation. The 'Alliantie Verduurzaming Voedsel' aims to make the food chain more sustainable and reducing waste is one of the nine themes focussed on by branches and companies within the Alliantie. The Alliantie is a cooperation between Centraal Bureau Levensmiddelenhandel (retail, CBL), the Federatie Nederlandse Levensmiddelen Industrie (food industry, manufacturers in food, FNLI), the Land- en Tuinbouw Organisatie Nederland (farmers' organization LTO), the Vereniging Nederlandse Cateringorganisaties (catering, Veneca) en the Koninklijke Horeca Nederland (hospitality industry, KHN). These branch organizations state cost reduction and reduced use of energy, raw materials and water and reduced pressure on the environment as incentives to reduce waste. Also mentioned is that reducing waste is close to the heart of consumers and is a popular issue, it can improve brand image and it is in line with the sustainability agenda of the government. Only occasionally, note is made of an effect on food security.

The alliance's activities include a helpdesk for the private sector on residue streams and how to reduce waste, communication towards consumers, and research on new uses of waste streams and reducing decay of fresh produce. The Alliantie initiated several Innovation pilots, mostly on valorising residual streams, thereby reducing food waste, for example in catering. Another pilot is on higher value use of residue streams (fibres) from the potato starch industry. There is also a pilot on reusing bread that is past its expiration date, but can be processed into ingredients for new bread.

Retailers are driven to increase economic and resource efficiency. For example Albert Heijn cuts prices near the end of product's shelf life and reduces waste through a combination of smart procurement and supply chain management. Albert Heijn also developed with the Voedingscentrum an 'eetmaatje', a cup to measure the amount of pasta or rice to cook per person. The retailer collects food waste separately, which is used for the production of biogas and green electricity. Like other retailers, Albert Heijn also cooperates with the Voedselbank.

Multinationals like Unilever have a resource efficiency goal as well. Unilever has a programme, Food Solutions, aimed at reducing food waste in (professional) kitchens and the catering industry. DSM has several products aimed at extending shelf life and reducing waste.

Information, knowledge and expertise

Worth mentioning as a separate indirect, long term link between food wastage and food security that a number of actors embrace, is the claim that information, knowledge and expertise can help to deal with food waste and loss. This perspective is closely linked to other perspectives that involve social and technological innovation. However, from this perspective, the focus is specifically on research, education, extension and training. On reducing waste in the European market, a research project like FUSIONS fits in this perspective. In developing countries, the Rockefeller financed Global Knowledge Initiative (GKI), fits in this perspective, working to identify opportunities, stakeholders and approaches to reducing food loss in Africa²⁶. Aimed more at information-sharing, the EC financed African Postharvest Losses Information System (APHLIS)²⁷ is a network of cereal grain experts in East and Southern Africa that facilitate the estimation of annual post-harvest loss for the cereal grains of the countries of East and Southern Africa.

This perspective is also important for the Network of Excellence and plans for Centres of Excellence, in which the research institute Food and Bio based Research of Wageningen UR is the main stakeholder. Apart from the contribution that Dutch knowledge and expertise of private sector and knowledge institutes can make in a global supply chain perspective, these initiatives also aim specifically to improve research, education and training in production regions in developing countries. The assumption behind this is that knowledge of postharvest losses is lacking, and improving this would contribute to food security. It is also suggested that focus in current research on food security is on breeding, production, pests and water use, while reducing post-harvest losses is a neglected field of study (presentation FBR).

Example: The Pasteur tag

An example of a high tech solution to prevent food waste is the pasteur tag, developed by NXP Semiconductors and WUR-FBR, winner of the Food Valley Award 2013. The tag indicates where the product comes from, how it is transported and keeps a dynamic record of its shelf life.

A sector that, through facilitating information sharing in the value chain, could contribute to efficient value chains and reduced loss, is the ICT industry. Few actors in this field mention a direct link between food wastage or post-harvest losses, and food security, but work on improving markets or value chain efficiency in general. The Netherlands based NGO International Institute for Communication and Development (IICD) has several projects in this field, for example in Kenya, aiming at improving farmers' access to market information. An example of a company in ICT and agriculture is FIT Uganda, that has set up a text message based information service for farmers. FIT Uganda has links with Cordaid, Agri-ProFocus and the Dutch embassy in Uganda. The Dutch Ministry of Economic Affairs signals the issue as promising and is preparing a policy document on how to contribute.

Example: CHEETAH

CHEETAH (Chains of Horticultural Intelligence; towards Efficiency and Equity in Agro-Food Trade along the Trans-Africa Highway) is a mobile app developed by a spinoff company of Twente University, called Ujuizi. The app allows users to share value chain shortcomings, such as delays at borders, bribes or bad road quality. Data gathered through such crowd sourcing is combined with remote sensing and can improve information for growers and transporters, as well as for policy makers.

2 Synthesis of insights from the literature:

The impacts of food waste interventions on food security

The previous section made clear that actors have various motives for reducing waste. Many of them claim a relation between food waste interventions and food security. In this section we report the findings of a review of the existing literature regarding this relationship: What do we already know about the impacts of food waste actions on food security?

Linkage between food waste interventions and food security often not explicit

In spite of the popularity of food waste interventions in policy circles, the number of studies and documents on the relationship between food waste actions and food security is relatively small. In this review, 52 studies were found and discussed. Although the claim that food waste interventions contribute to food security is quite pervasive in both the academic and grey literature, the relationship between both variables is rather implicit. There are few documents or studies on a possible causal relationship between reducing, reusing, or recycling food waste on the one hand and food security, including environmental conditions and necessary natural resources for food security, on the other. Those that do, often lack a sound empirical foundation or an evaluation after the intervention has finished, a so-called *ex post* evaluation.²⁸ This void is reinforced by a lack of available data concerning the number of actions in general, and their effects in particular, which makes it difficult to measure any form of progress.^{11 29}

In addition, the relationship is difficult to determine due to the vagueness of the concepts of food and waste. There is no agreement about what counts as food, and about when food is wasted or not. For example, bio fuels and livestock feed are considered as food by some, but as a waste of products that are potentially fit for human consumption by others.²⁸ Some consider overconsumption as a form of waste, but most of the literature does not reflect on it.³⁰ Even if both variables would be well defined, the impact one observes or measures depends on the perspective through which one approaches the relationship between food waste interventions and food security. Actions may have a positive impact from an environmental perspective, but not from an economic perspective, and vice-versa. The interactions between waste reduction and the various aspects of food security are highly complex and involve many trade-offs, which are often overseen and not taken into account by scholars or practitioners who make claims about possible contributions to food security. Furthermore, some believe that a focus on food waste is not effective at all. Professor of Food Policy at City University London, Tim Lang, argues that food waste is a symptom of underlying causes that result from an entire food culture that is factored around waste, and which should therefore be addressed in the first place.³¹

In spite of these complexities and shortcomings, the literature does provide some useful and relatively unambiguous insights. These will be further elaborated on in the following sections. We make a distinction between types of interventions that could have an impact on short-term food security and those that could contribute to long-term food security.

2.1 Short-term impacts of food waste interventions

It is generally agreed in the literature, that some food waste interventions can have a direct impact on short-term food security conditions. This is particularly true for pre- and post-harvest loss reduction actions in developing countries, particularly interventions at a local level in smallholder agriculture. Not only can these actions positively affect national food supplies, they also contribute to enhanced household food security by increasing farmers' incomes and ensuring year-round food availability.^{32 33 34 35 36} Pre- and post-harvest loss reduction can help smallholders to adapt to climate variability.³⁷ Various options have been argued to work in this respect:

- Metal silos and granaries: bridge the gap between harvests and as such improve household and community food stocks and diversity of diets, and farmer incomes.^{37 38 39 40 41} Their impact is supported by a sound empirical basis. A positive spin-off is the employment it may create for local producers.⁴⁰
- Protection against invasive species and pest management measures.^{42 43} There is no empirical support from quantitative research.
- (Ecological) rodent management helps prevent the loss of entire harvests and rodent-borne diseases.⁴⁴
⁴⁵ According to Meerburg⁴⁵, ecological rodent management could reduce food loss by 5% in countries

that experience widespread undernourishment. However, it should be noted that harvesting rodents provides a source of food intake and income to some people, albeit an inefficient one.⁴⁴ Empirical support is based on scenario analysis and review.

Another type of intervention that can have a direct effect on food security is the donation of residues to people in need. Reusing food for human consumption is generally considered the ethically most desirable as well as the environmentally most sustainable option^{17 29 46}, which can have several additional positive spin-offs. Schneider²⁹, for example, points at the possibility of employing long-term unemployed people for the redistribution of food, which helps them to reintegrate in society. Also, she points out that it can create opportunities for people to eat together, which helps them to break out of their social isolation. However, to fully employ the potential of food donation, various barriers have to be addressed such as stigmatization of recipients, the gap between acquisition and demand, legal requirements regarding liability, and market saturation.

2.2 Middle- and long-term impacts of food wastage interventions

In this section, two categories of more indirect impacts of food wastage interventions on middle- and long-term food security are synthesized. The first group of impacts concerns those that have an effect on food security in a narrow sense, i.e. on the direct availability, affordability, stability of and access to food. The second group is related to impacts on the broader food system factors that interact with these food security dimensions, notably environmental conditions and natural resources.

On food security and food prices

The positive impacts of wastage interventions that are targeted at the processing, retailing and consumption stages of food chains are less clear than those for actions in the production, storage and transport stages of value chains. The arguments that food waste reductions are a relatively efficient way of increasing global food supplies to meet increasing demand and that a more efficient supply chain could result in lower food prices are widespread.^{1 47 48 49 50} However, these claims are not backed-up by a lot of evidence. Even though a reduction of waste would theoretically result in an increased overall availability of nutrients to individuals, it remains unclear how and to what extent such reductions in the developed world would increase the availability of and access to those nutrients for those in need. Studies that examine these effects are simply lacking, with the exception of a study performed by Martine Rutten.²⁸ She identified various potential trade-offs from an economic perspective regarding the relationship between wastage interventions and food security and welfare, on both the supply and demand side. First, some producers will come out as winners and others as losers, depending on whether consumers would spend the money they save from spending on previously wasted foods on other products, and if so, on what kind of products. Second, producers that cut losses may face significant short-term costs associated with the action, while long-term income could, but not necessarily, increase. Rutten argues that overall impacts would depend on a broad range of factors that are currently hardly taken into account, including the extent of wastage relative to the size of the market, the extent to which they are avoidable, the underlying causes that cause wastage to arise in the first place, the costs of reduction interventions, and interactions in the supply chain with other markets and actors. Therefore, although a reduction of food wastage certainly has the potential of positively affecting world food prices, the extent to and ways in which this would occur needs to be determined by future research, both before implementing actions, and afterwards. In this research special attention should be paid to those groups that would benefit from wastage interventions and those that might experience a loss of purchasing power and access to food. In a first analysis, Rutten, together with Yuca Waarts, modelled that a 40% reduction of waste during retail and consumption in the EU, would lead to a very small, but positive, increase of food consumption (0,04%) and a decrease of food prices (0,2%) in Sub-Saharan Africa, particularly for fruit and vegetables.⁵¹

On the environment

Another argument that is widely resonated throughout the literature is that a reduction or a better use of wastage throughout the food chain would contribute to a more efficient use of natural resources and nutrients, and through this would decrease the environmental and climate impact of food production and consumption.^{17 48 32 47 52 53 54 36 55 30 46} As the environmental costs of waste that occur in the processing, retailing, and consumption stages of the food chain are relatively higher than losses that occur during and immediately after the production phase, effective food waste interventions may have a particularly significant positive impact on environmental costs.

The claim that the reduction of waste and loss results in the use of fewer resources and consequentially in a more environmentally sustainable food system, is generally understudied. Apart from a number of life-cycle

assessments, these studies lack a sound empirical understanding. The FAO even comments on possible counter effects: 'The short term solutions for reducing losses often lead to increased use of energy, especially for the preservation of food products'². Following the line of reasoning of Rutten²⁸, the effect of wastage reducing actions would partly depend on interactions in the supply chain and with other markets and actors, which have currently only sparsely been taken into account. Though some positive environmental effects, in particular on the longer term, may be expected, wastage interventions are never a silver-bullet solution and should be part of a broader approach. We will come back to this. An example of the relative use of waste reduction is on Germany. The Germans use a larger area of land than their own country, to produce the goods they consume. Meier et al. found in a scenario analysis, that a reduction of avoidable food waste would not be sufficient to level out this negative land balance without also promoting the domestic production of leguminous protein plants and a change towards more plant-based diets.⁵⁶

In spite of these limitations, reducing wastage seems a more efficient and sustainable way of meeting increasing world food demand than a dominant focus on increasing production^{1 43 33 35 57 55 58 36 32} or than establishing national food stocks.⁴¹ It could, for example, contribute to a smaller expansion of land used for agricultural production⁵², but also to reduced pressures on water and energy. Pearson et al. add that out of various people-oriented strategies to more sustainable diets, consumer waste reduction seems to be one of the most feasible and successful, because a relatively high number (70%) of consumers indicated that they are willing to cut waste.³⁰ However, it is important to note that the environmental benefits of wastage interventions should be bigger than their costs. Particularly in the case of private investments, they should also pay off economically.¹⁷ The Bio Intelligence Service in this respect calculated that the British 'Love Food, Hate Waste' campaign spent 15 million euros over five years, of which every euro spent enabled 500 euros of food waste to be avoided.⁵⁹

Some types of actions may be preferable above others in terms of their environmental impact. FAO¹⁷ developed a four-step approach towards addressing food waste, whereby each step is preferable above the following:

- Reducing food waste.
- Reuse waste, preferably by redistributing food to people in need, but alternatively by using it as feed for animals. A reservation here is that the sustainability of the manufacturing of feed from food depends on whether any by-products are properly used.⁶⁰
- Recycling/recovering food waste. Anaerobic digestion^{17 61} and the use of waste streams for ethanol production⁶² are the most preferred options throughout the literature in this respect, followed by anaerobic composting.^{61 60 17} Regarding the latter, home composting may be a preferable option over centralized composting due to the environmental costs of the logistics needed for the latter.⁶³ A consideration for all forms of recycling or recovering food waste is that new challenges are also created, such as the set-up of a waste separation system.⁶⁴
- Landfills: by all agreed to be the least favourable option.

Another action that may be effective in reducing waste and decreasing the negative environmental impacts of food production and consumption is the use of smart packaging, as is propagated by a range of studies. Smart packaging may reduce food loss, and as such decrease environmental impacts.^{65 66 67 68 69 70 71} Additionally, packaging could contribute to food quality and safety⁶⁵, to year-round availability of food in developing countries⁶⁷, and in the case of small portion packaging, to a reduction of obesity⁶⁸. Although the production and processing of packaging itself also has a negative impact on the environment, this impact is arguably smaller than that of the food it helps to preserve if it would go wasted.^{69 71} Consumers' negative attitudes toward packaging would be a challenge to overcome in this respect.⁶⁸ An important note to the potential benefits of smart packaging is that a number of these studies were financed or commissioned by the packaging industry itself.

Success of interventions depends on circumstances

Apart from technological possibilities and conditions, the success of interventions for reducing food waste and food loss, as well as for enhancing food security, depends on various other factors. For that reason, the same type of action can vary in its success in different contexts, depending on the circumstances. An example given by The World Bank is that the aforementioned metal silos have been a notable success in Central America, but have not been to the same extent in Africa (although various studies mentioned above do report positive impacts in Africa).³³ In general, the following conditions need to be taken into account when deciding about a food wastage intervention approach:

- Economic, environmental, and/or food security pay-offs from investments.^{1 72} Food wastage interventions will only be initiated by most supply chain actors if there proves to be a viable business case, meaning that the benefits pay off against any costs. In addition, the environmental and food security benefits should outweigh any negative impacts of an intervention.⁷²
- Expertise and education of the users of reduction tools or methods. Investments should be accompanied by training and advice.⁷² Examples given by Nyambo³⁸ are demonstrations of the use of new methods or techniques to smallholders and on-farm advice.
- The degree of cooperation and information exchange in the supply chain. Capacity building in the supply chain can contribute to a better understanding of factors that affect the safety, quality and value of products.⁷²
- An enabling political and institutional environment.⁷²
- The cultural acceptability of intervention methods.³³ Genetic transformation of crops could for example reduce loss but may not be acceptable in many Sub-Saharan African countries. Similarly, farmers in Malawi prefer to store harvests in their houses to protect it from theft. This is a consideration to take into account when initiating improved storage capacities.

These conditions underline the need for approaches that go beyond the food wastage interventions as such. This will be further elaborated in the next section, which synthesizes the calls in the literature for value chain and food system approaches.

Wastage interventions should be part of a broader approach

A widely shared argument in the literature is that food wastage interventions should be part of a broader, more holistic approach, if one wants to address wastage and enhance food security effectively. Some scholars go even further by arguing that a fixation on wastage reduction is not the right way forward, because they see wastage as a symptom of the underlying causes rather than a problem that stands on its own. Interventions should therefore be targeted at these underlying causes.^{31 28}

Especially in developing countries, most interventions are not effective on their own, with the notable exception of some small scale actions that aim to improve the household food security of smallholders. For example, investing in metal silos could enhance local food storage in developing countries, but this does not result in improved national food security without additional investments in infrastructure and local markets. Therefore, (global) food security cannot be ensured by wastage interventions alone.⁵²

Calls for a more holistic approach are theoretically embedded in the notions of value chain and food system approaches.^{1 53 28 33 72} Both schools of thought argue that various activities in the food chain and between food chains and their broader environment are interdependent. Therefore, it is essential to invest in several of these activities, considering the way they interact, depending on the specific situation and context. Examples of such complementary investments are improving market access or investment climates in specific regions.⁵¹ Not only does this prevent a situation in which improvements in one part of the chain are undone by failures in other parts of the chain, also engaging with all value chain actors provides a better understanding of where and why wastage occurs and what could be done to address it most effectively.²⁸ A value chain approach also helps identifying opportunities for farmers, even in Sub-Saharan Africa, where urbanizing populations and a changing demand lead to more efficient and quality-oriented chains to some extent.³³

Apart from chain activities, wastage interventions can benefit from investments in the socio-economic environment, including education, entrepreneurship, and gender equality. The World Bank argues that these socio-economic components should be the key elements of post-harvest projects.³³

The Network of Excellence, as described in the previous section, fits into this approach. Such a network could be used to support and exchange knowledge on post-harvest loss strategies, suggests van Gogh et al. in a study commissioned by the Dutch Ministry of Economic Affairs.¹¹

In the design of such food wastage approaches based on value chains or food systems, various new factors need to be taken into account, including the increasing influence of private sector actors, further global integration of markets and lengthening of supply chains, urbanization in developing and emerging countries, and growing South-South trade volumes.⁷²

3 Conclusions and recommendations

In the first part of this report, we gave an overview of actors that have initiated activities or implemented interventions to reduce wastage, their motives, and how they view the food wastage's relationship with food security. In this section we link this with the results from the literature review of the second part of this report, and draw up conclusions.

A first comment is that data are limited and figures on food wastage are generally estimates. A general lack of accurate data limits the possibility for assessing the direct and indirect impacts of food wastage interventions. This lack of data results from the absence of evaluations of realized actions (ex post) and from the complexity of causal links within the food system. The latter is clearly illustrated by the prevalence of models that estimate future events (ex-ante) and lifecycle assessments in the academic literature, which are hardly compared with real impacts.

Among actors, three major groups of motives could be distinguished. The first is a large group of statements with an implicit linkage between food wastage and food security. A relationship between the two is suggested, but not made explicit. This makes it difficult to draw conclusions on the approach to food security, if any, of the actors behind such statements. However, these type of statements are quite dominant in campaigns, media and on the front pages of websites and leaves the general impression that reducing food wastage is very relevant to improve food security. Given that food security is high on the international agenda, the urgency of the issue of food wastage can to some degree be justified by a claim on a relation with food security.

The second group of actors deploy activities aimed at reducing waste in developed countries on the consumer side of the supply chain. The claim is that by reducing waste, a contribution is made to food security in a long-term, indirect way through more efficient resource use, a more efficient economy, or enhanced knowledge of stakeholders.

An important category in this group are actors that campaign and raise public awareness to reduce waste in developed countries, such as the global Think.Eat.Save campaign of FAO, or campaigns and activities of civil society organizations such as Feeding the 5000 or Damn Food Waste in the Netherlands. Also national governments, the European Parliament, and organizations like the World Resources Institute promote this message, aiming to reduce consumer waste.

This motive is also popular among the private sector in developed markets, especially in the food industry and retailers, mostly with a focus on resource efficiency and economic efficiency. Activities in this case include reducing and reusing waste, and preventing landfills.

The literature suggests that there is ample reason to believe that reducing and reusing wastage may indeed have a positive impact on resource-efficiency, environmental impacts and, consequentially, on long-term food security. Not only would a reduction of waste lead to decreased pressures on natural resources, which could be reallocated to other forms of sustainable production, it would also contribute to mitigating environmental and climate hazards that undermine future food production. From a study in the UK, it can be concluded that investing in a campaign to reduce waste was effective in economic terms.

However, a couple of comments should be made in this respect. First, the degree to which more resource-efficiency can have a positive environmental impact depends on what the resources that are saved will be used for instead. The action, and its outcomes, should thus pay off in terms of emissions, footprints, etc. Second, reducing food wastage is not sufficient when one aims to achieve more sustainable food chains. Food wastage is often a symptom of underlying causes such as marketing strategies or poor communication within chains. These causes need to be addressed simultaneously. If this is neglected, one runs the risk of replacing wastage problems from the one phase in the value chain to the other (e.g. from supermarkets to consumers). Third, some types of interventions have a more positive impact than others. The four-step approach that was proposed in the FAO toolkit¹⁷ may offer guidance when deciding about reduction or reuse strategies.

When the aim is a positive impact on the sustainability and long-term viability of food systems, reducing waste in developed countries is a logical option. This is because environmental impacts of wastage are highest at the consumer end of the supply chain and per capita food waste is approximately ten times higher in developed countries than in developing countries.

The third group of actors is involved in, or could contribute to, reducing pre- and post-harvest losses in developing countries. Among these, supply chain programmes of organizations such as IFDC, FAO, civil society organizations and Dutch embassies tend to focus not specifically on reducing food loss, but rather on improving the efficiency of supply chains in general through a more holistic approach. Reducing pre- and post-harvest losses are seen as an outcome, rather than a goal in many programmes. The Dutch private sector in agrolistics and food processing is large and export oriented. The private sector could contribute to reducing food loss by exporting technical solutions and tends to have a more technological view on reducing pre- and post-harvest losses.

The Dutch Ministry of Economic Affairs is a firm believer in a win-win scenario in which the Dutch private sector contributes to food security by reducing pre- and post-harvest losses while at the same time increasing business opportunities. MEA has already set up various activities to facilitate this win-win scenario. For example, it organized workshops with the private sector on this issue, it initiated the Network of Excellence to bring together Dutch expertise and it commissioned research on this issue, for example the 'Visie Agrologistiek'.

It is important to note that activities to reduce pre- and post-harvest losses mainly have an effect on the availability of food, as reducing loss increases the amount of food available. Reducing food loss also, to a lesser extent, delivers an impact on other aspects of food security such as access, utilization and stability of the food system. However, this point is rarely made explicit by actors.

When the goal is to have a more direct impact on food supplies in developing countries, evidence from the literature is clearer for pre- and post-harvest wastage interventions than for waste reduction. Reducing harvest losses in developing countries can have a direct positive impact on the year-round availability of nutritious food for households and communities. In addition, it helps smallholders to increase their incomes and as such increases access to food for the poor. However, when the goal is to have a more regional or national impact, the success of food wastage interventions for enhancing food security depends on the degree to which these are embedded within a broader value chain approach. This suggests storage facilities, infrastructure, means of transport and market access are all taken into account. Investments and actions will have to be tailored to local situations and contexts. There is little specific research on the effect on food security of interventions that actors in the private sector assume to be effective, such as improvement of the cold chain and agrolistics.

The effect of reducing waste in developed countries on food supplies, livelihoods, and prices is less clear. A notable exception is food donation, which can make a direct contribution to food and nutrition security by distributing food that would otherwise go wasted to those in need. For other types of actions, the impact depends on many factors, such as the interactions with other markets. Rutten gave some initial examples of trade-offs and spill-over effects that should be taken into account, but the fact remains that at present we do not yet clearly understand how a reduction of waste in developed countries would affect food markets.²⁸

In conclusion, do food wastage interventions hold the potential of making an effective contribution to food security? The answer to that question depends on one's view of food security. It can, provided that requirements and conditions mentioned above are met, have a positive impact on the sustainability and long-term viability of food systems. Also, wastage reduction actions may have a direct and short-term impact on micro-scale food security situations, particularly in developing countries.

However, most food wastage interventions are not silver bullet solutions. They often do not make a significant contribution on their own, but can do so when embedded in a broader value chain or food system approach. Investing in metal silos, for example, may have a direct impact on community level but will only contribute to regional or national food security when proper infrastructure, means of transport and market access are in place. Wastage may also be a key reason for food insecurity in some contexts while not in others, whereas the global impact still remains to be seen. Additionally, the literature pointed out that technical innovations should go together with social innovations in order to transform the ways in which food is produced, used and consumed in order to reach more sustainable practices.

Also reducing food wastage in general, on its own, could not be simply solved by a single solution. Wastage reduction can play a role in the goal to improve food security, particularly in increasing food supply in a relatively efficient way, but complementary measures will be needed. This is also particularly the case because food wastage reduction tends to focus primarily on one dimension of food security, food availability. The dimensions of access, utilization, and stability are relatively overlooked in wastage interventions and the associated literature.

One can ask whether these types of efforts would be the most optimal way of addressing these other dimensions of food security.

Like many actors, the Dutch government agrees on the need for a holistic and integrated approach, embedding food wastage interventions in a broader value chain or food system approach. This is underlined by the cooperation between the Ministry of Foreign Affairs and the Ministry of Economic Affairs explicitly focussing on using Dutch private sector expertise. Here, although it is true that Dutch companies have a lot to offer in terms of know-how and expertise, it is important to stay aware of the risk that an overly strong focus on the private sector could eventually overlook other effective options of addressing food insecurity. Ideally, actions would be tailored to match local or national needs and demands with the wide array of policy instruments that are available based on a careful assessment of the specific context.

There is also a risk in assuming that interventions to reduce pre- and post-harvest losses automatically contribute to food security. This is not necessarily the case, as effects may be limited to a certain group of rich farmers or to a certain group of consumers. Actions may have effect on availability, but not on access and other aspects of food security. The risk of assuming a positive effect is that these other effects may be overlooked. The recommendation is, case-by-case, to pay explicit attention to local and context specific effects of interventions on food security.

Knowledge gaps and future research

Based on the above we give some suggestions for topics that would need further study.

In the first place, there is a general lack of empirical investigations into the relationship between wastage interventions and food security and the sustainability of food systems, particularly evaluations on actual policies or actions. However, it is recommended that eventual further research on this relation places the wastage issue in a more integrated value chain-efficiency or food system context.

Second, research could focus on (economic) studies that provide a greater understanding of impacts of wastage reductions on food prices and supply and demand side dynamics, and their interaction in the world food market.

Third, research is recommended on the possible synergies between food wastage interventions and other type of value chain or food system interventions. This would enable readers to see what type of action fits best in the broader context of the supply chain or food system to improve (local and international) food security.

Resources for research are limited. The main conclusion from this inventory study, that food wastage interventions should be seen in a broader context of value chains and food systems, has consequences for decisions on further research. Research specifically aimed at contributing to food security could probably be better aimed at the impact of integral programmes to improve the effectiveness of value chains or food systems, of which food wastage could be part, rather than focus specifically on the reduction of wastage only.

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Annexes

Annex 1- Overview of websites of actors

International – Policy

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<http://www.worldbank.org/en/topic/poverty/publication/food-price-watch-february-2014>
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International – Civil Society

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International – Business

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- Unilever *Food Solutions bestrijdt voedselverspilling in de horeca* (2014)
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- Global Green Growth Forum *Reducing Food Loss and Waste* (2014)
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International – Multi-stakeholder

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European – Policy

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European – Civil Society

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European – Multi-stakeholder

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Dutch – Policy

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Dutch – Science

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http://www.wageningenur.nl/upload_mm/2/7/e/6c08972f-1c91-49c6-8d65-f6c4e3a5ad33_FBR%20Inspiration%20day%202014%20global%20PH%20losses.pdf
- Network of Excellence postharvest losses *Feasibility of a network of excellence postharvest food losses* (2014)
<http://www.wageningenur.nl/en/Publication-details.htm?publicationId=publication-way-343338383538>

Dutch – Civil society

- Kromkommer *Voedselverspilling*
<http://www.kromkommer.com>
- Voedselmarkt *Online marktplaats tegen verspilling*
<http://www.voedselmarkt.nl/>
- Damn Food Waste
<http://damnfoodwaste.com/>

Dutch – Business

- Centraal Bureau Levensmiddelen *Voedselverspilling*
<http://www.cbl.nl/activiteiten/duurzaamheid-en-gezondheid/cbl-duurzaamheidsagenda/voedselverspilling/>
- Alliantie Verduurzaming Voedsel *Platform voor versnelling van verduurzaming grote voedselketens*
<http://www.verduurzamingvoedsel.nl/home>
- Federatie Nederlandse Levensmiddelen Industrie *Voedselverspilling*
<http://www.fnli.nl/werkgebieden/duurzaamheid/thema/voedselverspilling.html>
- LTO *Voedselverspilling serieus vraagstuk* (2013)
<http://www.lto.nl/actueel/Nieuws/10827539/Voedselverspilling-serieus-vraagstuk>
- Albert Heijn *Voedselverspilling*
<http://www.ah.nl/meerdoen/voedselverspilling>
- BoP Innovation Center *Small scale cold storage for dairy products in Ethiopia*
<http://www.bopinc.org/projects-initiatives-79/cross-cutting-themes/small-scale-storage>
- BoP Innovation Center *Flexible cold chains for fresh vegetables*
<http://www.bopinc.org/projects-initiatives-79/cross-cutting-themes/develop-flexible-cold-chains-for-fresh-vegetables>
- Dutch Agricultural Development & Trading Company *Mobile cassava processing unit*
<http://www.dadtco.nl/ampu>

- Ujuizi ICT company *Cheetah*
<http://cheetah.ujuizi.com/>

Dutch – Multi-stakeholder

- No waste network
<http://www.nowastenetwork.nl/>
- Voedselverspilling Verspilling van voedsel voorkomen
<http://www.voedselverspilling.com/StartPage.aspx>
- Wereldvoedseldag 2010 *Thema voedselverspilling*
<http://2010.wereldvoedseldag.nl/>

Annex 2- Methodology literature review

Literature review: methods of data collection and analysis

The literature review was performed by using systematic review methods. The advantage of systematic review methods over other types of literature reviews is that they enable researcher biases to be limited and make these visible (Petticrew and Roberts, 2006; Gough et al., 2012). Systematic reviews require the use of clear inclusion and exclusion criteria for selecting eligible literature and a positive attitude towards transparency in both performing the analysis and reporting the results of the study.

The review was performed by using a food system perspective, meaning that apart from the effects of food wastage interventions on food security in a narrow sense (the availability, access and utilization of food, and its stability over the long term), we also considered potential impacts on factors that can influence food security indirectly, such as income, the environment, and natural resources.

The data collection process is schematically depicted in Figure 1.

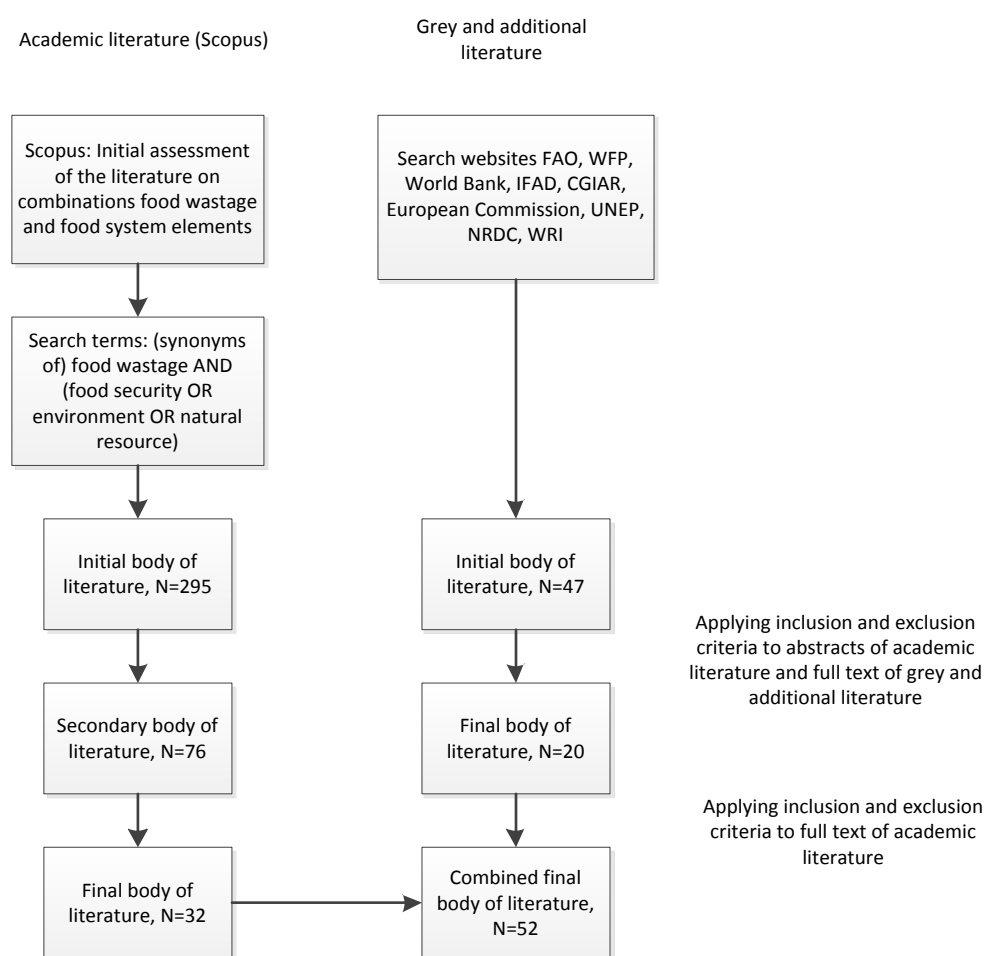


Figure 1 - Data collection process

Two different types of literature were searched: i) academic literature, and ii) grey and additional literature that was retrieved by searching the websites of various NGOs and international organizations (see Fig. 1).

The search for useful academic articles was performed by first scanning the literature using various queries in the online database Scopus. The query that was finally adopted was:

TITLE-ABS-KEY(("food waste*" OR "food loss*" OR "**harvest loss*") AND ("food *security" OR ((impact OR effect) W/3 environment*) OR "natural resource*"))

The titles, abstracts and keywords of the literature were thus searched for combinations of food wastage, food waste, food loss, and pre-/post-harvest loss on the one hand, and food security, environment(al) impacts/ effects, and natural resources on the other. This search resulted in an initial body of literature of 295 documents.¹ The titles, abstracts and keywords of all these articles were read and judged using the following inclusion criteria:

4. The document is in English or Dutch
5. The document is finalized, therefore excluding work in progress.
6. The document, or part of the document, is about food wastage interventions
7. The document, or part of the document, is about food security (in a broad sense)
8. The document lays an elaborated link between food wastage interventions and food security.

This selection led to a secondary body of literature of 76 articles. The full versions of these articles were read and judged again by using the inclusion criteria, resulting in a final body of academic literature of 32 articles.

Grey and additional literature was collected by searching the websites of several NGOs, think tanks, international organizations and Google for any documents on food wastage, food waste, and food loss (in case of Google in combination with food security), and through input of the Knowledge Platform, which consisted of academic articles and reports. This resulted in an initial body of literature of 47 articles. The summaries and/or full texts of these articles were read and judged on the basis of the inclusion criteria, resulting in a final body of grey and additional literature of 20 articles.

Together with the academic literature this resulted in a final body of literature of 52 articles.

The data analysis was performed by reading all articles again and extracting relevant parts of the texts in a data-extraction matrix, which consisted of various categories (see Table 1).

Author(s) + year	Type of document	Targeted at food waste, food loss, or both	Specific intervention	Locus of intervention	Impact of intervention on food security	Empirical evidence	Other thoughts/ comments (e.g. evidence gaps identified)

Table 1 - Data extraction table (empty)

These matrixes were analyzed by searching and coding for common themes, debates, and recommendations, on the basis of which the synthesis was written.

¹ Performed on 14 March 2014, no restrictions to time of publication.



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