

eip-agri  
AGRICULTURE & INNOVATION



# EIP-AGRI Focus Group

## Reducing food loss on the farm

FINAL REPORT  
APRIL 2020

## Table of contents

<b>TABLE OF CONTENTS</b> .....	<b>2</b>
<b>EXECUTIVE SUMMARY</b> .....	<b>3</b>
<b>INTRODUCTION</b> .....	<b>4</b>
<b>BRIEF DESCRIPTION OF THE PROCESS</b> .....	<b>5</b>
<b>STATE OF PLAY</b> .....	<b>6</b>
<b>Key Issues</b> .....	<b>6</b>
Measuring food loss .....	6
Definitions and Standards .....	7
Supply and demand; and trading practices .....	8
Unfair Trading practices.....	9
Good Practices.....	9
<b>Success and fail factors</b> .....	<b>11</b>
Overview.....	11
Market impact.....	12
How to predict and prevent market-based losses .....	12
Loss and Waste prevention vs. sale for valorisation .....	12
Jevons Hypothesis.....	12
Consumer.....	13
How to make better crop management decisions .....	13
The 'Impact Hierarchy' .....	14
<b>RECOMMENDATIONS</b> .....	<b>15</b>
<b>Overview</b> .....	<b>15</b>
<b>a. Ideas for Operational Groups (OGs)</b> .....	<b>15</b>
<b>b. Research needs from practice</b> .....	<b>16</b>
Multi-actor 'value chain approach'.....	16
Research programme on 'circular economy' and food loss.....	16
Quantifying On-Farm Loss and Waste .....	16
'Digital Agriculture' .....	17
<b>c. Other considerations</b> .....	<b>17</b>
Corporate Social Responsibility .....	17
Risk Assessment .....	18
Refrigeration (deep freeze) Supply-Demand Buffering .....	18
Educating the next generation.....	18
<b>REFERENCES</b> .....	<b>19</b>
<b>ANNEX 1: MEMBERS OF THE EIP AGRI FOCUS GROUP</b> .....	<b>22</b>
<b>ANNEX 2: EXAMPLES OF THE USE OF ICT IN ADDRESSING THE OVERALL OPERATIONAL EFFICIENCY OF FARMING SYSTEMS</b> .....	<b>23</b>
<b>ANNEX 3: INITIATIVES NEEDED</b> .....	<b>24</b>
<b>ANNEX 4: OUTLINE OF SOME CONSTRAINTS, ONGOING INITIATIVES AND COLLABORATION OPPORTUNITIES ACROSS EUROPE</b> .....	<b>26</b>
<b>ANNEX 5: LIST OF MINI-PAPERS FROM THE FOCUS GROUP EXPERTS</b> .....	<b>27</b>

## Executive Summary

This document presents the results of the EIP AGRI Focus Group (FG) 'Reducing food loss on the farm', identifying the principal on-farm practices and technologies that can minimise such losses. Addressing these losses is a major societal challenge and forms a key pillar of the UN's Strategic Development Goals (SDGs). While in Western societies, most of the documented food losses/wastes occur post-farm gate, relatively little attention has been paid to on-farm (pre-farm gate) losses. These can be far in excess of 10% of total production and in the opinion of this FG, arise for a range of reasons such as inefficient farming operations, difficulties with fulfilling production contracts and lack of awareness and consequently inadequate reporting (categorising) of such losses. There is a lack of information on the extent of these losses, as they are not readily measurable and some are 'virtual losses' arising from reduced yield due to inefficient operations. Consequently, the FG considers that there is a need to establish clear definitions of what constitute 'food losses' on the farm, and to devise and implement systems that measure and monitor these on an ongoing basis. The new 'digital agriculture' age has already started and offers new opportunities to;

- ▶ Quantify the extent of losses;
- ▶ Enhance on-farm operational efficiency;
- ▶ Provide detailed monitoring of operations and compliance.

Such capabilities provide a very effective tool to monitor and control losses and to reduce losses on the farm.

The FG considers that there is no single solution to resolve the on-farm losses problem, the solutions are multi-faceted and complex, at the interface between technology, economics, sociology, behavioural science and other considerations. However, this FG is of the opinion that highly efficient farming practices and suitable supply contracts between farmers and retail/processing sectors are required that are structured to minimise product discard. Poorly conceived contracts can force farmers into discarding edible produce due to, for example, products not reaching 'cosmetic' contract quality standards. While retailers are responding to consumer demand (market forces), nevertheless there is a strong case for reassessing such contracts in the context of their impacts on food losses.

Farming is a risk business, open to the vagaries of the weather and markets. This poses major challenges for the design of coherent systems that ensure loss and waste minimisation. The food chain is market-driven and as such the 'consumer is king' scenario applies. Retailers respond rapidly to fluctuating consumer demand and impose standards and prices that reflect such demand. However, there is a lack of awareness amongst the citizenry regarding how their food preferences and choices impact on-farm losses; hence the FG considers that there is a need to enhance the level of awareness in society by education and dissemination programmes aimed at all 'actors' and stakeholders along the chain, including the consumer and wider society. A number of topics for potential Operational Groups (OGs) and ideas for future research are proposed by the FG - There is a need to explore Unfair Trading Practices (UTPs) that place the farmer at the mercy of the markets and by default have negative impacts on the environment. The FG considers that farmer cooperatives are a mechanism to enhance the strength of the farmer in contract negotiation, while simultaneously placing emphasis on Corporate Social Responsibility (CSR) provides a framework within which such contracts can be framed.

The global arable land resource is limited, hence the need to optimise the use of such lands. For efficient agri-food chains, the loss generated can be classified as 'unavoidable loss' or, in effect, a by-product of the production system. Such by-products can be used as feedstocks for valorisation stages, where they are converted into a valuable product (e.g., new food products, bio-plastics, energy). Such valorisation steps add value to the chain but it is important that they do not generate their own market for by-products as this may trigger a 'Jevons Effect' where farmers ignore the production efficiency constraint because they now have a new market for their waste.

## Introduction

There has been much interest in food loss in the last decade following the publication of the FAO report in 2011 which estimated that one-third of food is wasted from farm to fork (FAO, 2011). In the EU, ca. 90 million tonnes of food waste are generated annually with associated costs estimated at €143 billion (**FUSIONS, 2016**). While in Western societies, most of the documented food losses and wastes occur post-farm gate, nevertheless there can be considerable food losses (>>10%) pre-farm gate arising from:

- ▶ Inefficient farming operations
- ▶ Difficulties with fulfilling production contracts
- ▶ A lack of awareness and consequently inadequate reporting (categorising) of food losses.

It is clear that there are major variations in the estimates of losses, and this is to be expected for two main reasons:

- (1) there is a relatively low level of appreciation of what constitutes losses, with broad variations in what's considered to be a loss;
- (2) farming practices and conditions vary considerably from one farm to the next, and from year to year, depending on market, weather and other factors. This variation will in itself lead to concomitant variations in on-farm losses.

Losses generated during primary (on-farm) production can be broadly categorised as 'practice-based' and 'market-based'. 'Practice-based' refers to direct loss generated during the operations of growing and harvesting the crops. 'Market-based', on the other hand, is loss that is generated as a result of external market events that influence production on the farm.

### *The management of food loss:*

The FG considers that the management of food loss is so complex that it must be viewed on a holistic basis, considering the different steps and stakeholders involved in the complete food supply chain. Every level of the supply chain provides its own challenges. Food loss is a poor use of resources and is socially, economically and environmentally detrimental. For some food products, significant environmental impact occurs before or during harvest on the farm. Having 100% harvesting efficiency, i.e. where no edible food is left on the fields after harvest, is considered not feasible. For the purposes of this report, food losses on the farm comprise those elements of the crop (food and inedible parts) that end up not being used in the food chain, including output foregone (i.e. reduced yield) due to inefficient on-farm operations. Further discussion on the definitions of food loss and food waste can be found in the mini-papers produced by the Focus Group experts, and ongoing FAO food loss measurements on farm were also developed while the FG was operating.

Addressing on-farm food losses is a multi-faceted challenge. There is no single solution and while a range of initiatives may be proposed, such initiatives must make commercial sense from the farmer's perspective, otherwise they will fail. Policy and ensuing regulation are very powerful tools but they will fail to have impact if they make the farming operations commercially unviable. This is a complex area at the interfaces between technology, economics and human behaviour.

## Brief description of the process

This FG comprises 20 members from different EU regions, with expertise and practical, advisory and research experience relating to reducing food loss on farms. The FG met twice, including a field trip during the first visit, and experts worked further electronically to produce the materials for the wider audience. Shane Ward (University College Dublin) was appointed as a coordinating expert to write a starting paper (available on the FG website) to form a basis for the discussions and to facilitate the technical discussions at the FG. The group draws from the experience and expertise of its members as well as examples of good practice or solutions from elsewhere. The focus is on delivering solutions that are practicable and have a good probability of success. The present report also presents key innovation practices, further needs for research, and ideas for Operational Groups at local level. The experts also produced 5 mini-papers, listed in [Annex 5](#), which provided inputs for this report.



EIP-AGRI Focus Group experts

## State of Play

In many respects, food losses on the farm are not considered food losses *per se*, but rather losses associated with normal farming operations. There is a significant lack of data, general information and awareness of the extent and causes of food losses on the farm: the so-called 'pre-farm gate losses'. One specific challenge is reaching agreement on a definition of what these food losses are, as some farmers may view ploughing an unharvested crop back into the soil as an appropriate use, whereas citizen appreciation and Life Cycle Analysis evaluations may not. It is essential that these losses are clearly defined and mechanisms put in place to address them.

There are several national studies addressing food losses on farms (Belgium, Spain, Finland, Estonia, Sweden, Norway, Denmark, UK, US etc.) (Franke et al., 2016; Hartikainen et al., 2017, 2018) but there are no concerted efforts of systematic and continuous data collection on food losses on farms. The existing studies are limited to certain times and locations. Moreover, the methodologies employed and definitions vary between studies.

Food is lost through inefficiencies in the way we produce, process, store and transport food, which may spoil the food or cause a loss in its nutritional value – in addition to market failure and contractual obligations. Unlike downstream wastes/losses, primary production wastes/losses are highly influenced by external factors such as weather, diseases, market conditions, supplier contracts, etc., whereas in other parts of the food supply chain food waste is more dependent on internal factors, such as bad planning and variations in technology efficiencies.

There is a lack of peer-reviewed literature addressing on-farm food loss. However, the overarching indications from work to date highlight a number of key factors contributing to such waste:

- ▶ Market conditions and associated farmer-retailer/processor contracts;
- ▶ Quality standards dictated by both the market and regulation;
- ▶ Availability of labour to effect a more complete harvest or 'glean' such losses where it is feasible (Gentry, Edgar, Graham, & Kirkpatrick, 2017; Timmons, Wang, & Lass, 2008; Berkenkamp & Nennich, 2016; Gunders, 2012a, 2012b; ReFED, 2016).

## Key Issues

The Focus Group discussed the main issues and drivers related to food loss on the farm, starting from the framing elements described in the Starting Paper, available on [the EIP AGRI website](#). The key issues identified by the experts can be grouped under four categories:

- ▶ Measuring food loss
- ▶ Definitions and standards
- ▶ Supply, demand and trading practices
- ▶ Food loss and waste hierarchies

## Measuring food loss

Food loss on the farm has received less attention than other parts of the food supply chain, yet for many food products most of the environmental impact occurs before or during harvest on the farm.

Quantifying food loss at the farm level is important, as without a baseline set targets cannot be monitored. Food loss on the farm can be estimated using qualitative approaches such as surveys and interviews or using quantitative approaches such as in-field measurements. Qualitative approaches such as interviews generate a greater volume of evidence than field measurements; however under-reporting is a common problem when using estimates provided by growers, hence accuracy may be reduced (Johnson et al., 2018). Grower recruitment for studies is also a challenge. Furthermore, there is no 'typical season', so ideally on-farm food losses should be estimated over more than one growing season. Currently, holistic long-term studies quantifying on-farm food losses are not available.

The levels of waste vary considerably between food produce types, with highly perishable products, such as lettuce, being more susceptible to loss than relatively hardy produce such as potatoes (Berkenkamp, 2016a; Gunders, 2012a). It is common practice to plough such unharvested losses back into the soil and hence farmers do not perceive these as losses as they are enhancing soil quality (Berkenkamp, 2016a; Gunders, 2012b; ReFED, 2016; Sigler, 2009).

There have been numerous estimates of on-farm food losses, and these range from 3 - 47 %, across a range of crops and production scenarios (Hartikainen et al. (2018); Feedback (2018); Beretta et al. (2013); Redlingshöfer (2017); WRAP (2011), Beausang et al. (2017), Schneider et al. (2019), Ludwig-Ohm et al. (2019)). Estimates by FUSIONS (2016) show that pre-farm gate losses (i.e. in primary production) for the EU-28 account for ca. 10% of the total food loss and waste produced across the food chain.

Sector	Food waste (million tonnes) with 95% CI*	Food waste (kg per person) with 95% CI*
Primary production	9.1 ± 1.5	18 ± 3
Processing	16.9 ± 12.7	33 ± 25
Wholesale and retail	4.6 ± 1.2	9 ± 2
Food service	10.5 ± 1.5	21 ± 3
Households	46.5 ± 4.4	92 ± 9
<b>Total food waste</b>	<b>87.6 ± 13.7</b>	<b>173 ± 27</b>

\*Confidence interval

**Estimates of food waste across the various elements in the food chain for EU-28 in 2012, including food and inedible parts associated with food (source: FUSIONS, 2016).**

## Definitions and Standards

### Food loss versus food waste

The distinction between 'food loss' and 'food waste' is often not clear. Food that could be harvested, but that is not, is only included within some food waste and loss definitions.

The European Commission recently developed a **common EU methodology**<sup>1</sup> to measure food waste as part of the EU action plan for the circular economy.

According to the Focus Group, it is important to monitor all on-farm losses, including biomass used for animal feed, composting or biogas production on-site as well as material streams which are directed to external waste treatment facilities (e.g. composting, anaerobic digestion). A better understanding of the material flows can

<sup>1</sup> COMMISSION DELEGATED DECISION (EU) 2019/1597 of 3 May 2019 ([https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L\\_.2019.248.01.0077.01.ENG&toc=OJ:L:2019:248:TOC](https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.248.01.0077.01.ENG&toc=OJ:L:2019:248:TOC)).

lead to an reduction of losses on the farm as well as to economic, environmental and societal benefits for farmers and other stakeholders along the supply chain.

There is a strong case to use the term food waste for all stages of the food supply chain (including before farm gates) as food loss might imply that human agency is not a cause and the solutions needed are purely technical. However, food loss on farms can result from unfair trading practices (see next chapter), which are due to human agency.

Food loss and waste 'hierarchies' are useful in order to specify a preferred order in which solutions for avoiding or treating lost or wasted food on the farm are applied. Ideally destinations of food loss and waste on the farm should be monitored and reported separately according to the stages of the food waste hierarchy to monitor and incentivise progress towards moving produce further up the stages of the food hierarchy.

Preventing food loss and waste is the top priority as it means lower food production levels are required, reducing the environmental impacts of the food system. If food that is edible for humans is currently being used for livestock feed, local actors should be encouraged to move this food surplus up the hierarchy, preferably through waste prevention in the first instance, and if that is not possible, through novel high value valorisation pathways or, depending on market dynamics, redistribution for human consumption via e.g. product promotions, charities. Likewise, food that is not edible by livestock should be moved up the food waste hierarchy from disposal options such as incineration to higher value uses such as anaerobic digestion.

### **'Cosmetic standards'**

'Cosmetic standards' are significant contributors to food loss. An example of 'cosmetic standards' is where fruits and vegetables have to meet specific requirements with regard to colour, shape and size after preparation and packaging (Roels and Van Gijsegheem, 2017). In addition to legal requirements, retailers apply their own standards, which are generally stricter than the legal ones and are driven by perceptions of 'consumer demand'. Produce that is perfectly edible but does not look appealing enough may be rejected. Furthermore, the dominance of retailers in the supply chain has led to fewer outlets for growers with 'low grade' produce. Several campaigns have been carried out to bring 'ugly' fruits and vegetables onto the market. These campaigns are generally on a small scale and limited in time to avoid 'creation of demand for defect products' (Roels and Van Gijsegheem, 2017), however a limited number of retailers have begun marketing these products on a year-round basis.

A survey conducted among 300 growers in Flanders found that two-thirds were unable to sell part of their products in the intended sales channel because the required cosmetic standard was not met (Roels and Van Gijsegheem, 2017). On average, growers indicated a sales loss of 10% due to cosmetic standards. Only one-third of growers were able to valorise unmarketable produce for human consumption through processing, social initiatives and direct selling at the farm.

On farm food loss could be reduced by relaxing cosmetic standards further and promoting greater consumer awareness of the relationship between product appearance and quality. For example, emphasising that imperfect shape does not necessarily imply inferior product.

### **Supply and demand; and trading practices**

A lack of financial resources and/or return is often cited as a reason for food loss on the farm. If financial resources are limited, it may not be economically viable for producers to harvest and hence produce is left in the field. Sporadic changes in weather (e.g. a sudden hot dry period) and consumer preferences (e.g. sudden demand for salads arising from good weather) impact on supply-demand dynamics.

Previously, supermarket promotions were planned around the seasonal availability of produce. However, now promotions are planned weeks or months in advance, providing little flexibility for growers.

Fast-changing consumption patterns present major challenges for retailers. It is only possible to predict demand within certain limits because weather is unpredictable and is a major driver of food produce preferences and hence demand at any given time. As a result, producers have little time to adjust their production to meet demand from retailers, which can be somewhat unpredictable.



## Unfair Trading practices

The European Directive on Unfair Trading Practices in the food supply chain was agreed in December 2018. They are broadly defined as practices that grossly deviate from good commercial conduct within trading relations between two parties, often as a result of an unequal balance of power in that relationship (Refresh, 2018). These practices can cause food loss and waste in the supply chain due to poor demand forecasting, quality rejects, last minute order cancellations and overly strict 'minimum life on receipt' criteria as a reason to reject produce that the buyer deems unsaleable because of falling demand or inaccurate forecasting (Refresh, 2018).

Any approach to reduce food loss on farms needs to be phrased and framed in a context that is relevant to farmers, for example, in terms of economic losses. Improving relations between farmers and retailers will be crucial to reduce on-farm losses of edible produce. Measures facilitating co-operation between these two groups can effectively contribute to address food waste on the farm.

## Good Practices

### (i) Examples of initiatives to address food loss

The following are examples of initiatives focusing on addressing aspects of the food loss challenge. Most are in effect stand-alone initiatives as there is no national, international or global framework to enable a holistic approach. The Focus Group experts considered that they all have merit, but would benefit from a more concerted approach at national or EU level. Also, examples of initiatives required to address this overall challenge are presented in [Annex 3](#) and further examples are presented in [Annex 4](#) and in the Mini Papers.

### LEAF Guide

LEAF (Linking Environment and Farming) in conjunction with WRAP in the UK have produced a short guide for fresh produce growers entitled 'Food Waste Matters', which indicates that crop utilisation and profitability can be increased through measuring food waste (WRAP & LEAF, 2018). The guide highlights that by quantifying the scale and cause of loss at different stages on the farm, yield can be optimised, and where loss cannot be reduced, the best destination can be selected.

### Espigoladors

Espigoladors is a social enterprise that is based in Barcelona, Spain. Espigolador means 'gleaner' in Catalan. Gleaners are volunteers who 'glean', i.e. collect fruit and vegetables that are leftover in fields once main harvesting has finished. Produce may be left in the field due to a decline in sales, for aesthetic reasons, or arising from surplus production. Over 90% of the produce collected is redistributed to community kitchens and not-for-profit organisations involved in food provision for vulnerable people.

Espigoladors guarantees that with 24-48 hours of prior notice, a team of volunteers will be ready to pick up what is left in the field. Volunteers include individuals and companies. Espigoladors also provides work opportunities for people who are at risk of social exclusion. The remaining 10% of produce that is collected is processed into artisanal preserves (jams, creams, sauces and pâtés) under the brand name 'es Im-perfect'. This provides revenue to economically sustain the rest of the operations. Espigoladors saves about 50,000 kg of fruit and vegetables annually.

### **AgroCycle Marketplace**

A H2020 international team of researchers, led by University College Dublin (UCD), has developed AgroCycle Marketplace (see: [www.agrocycle-platform.com](http://www.agrocycle-platform.com)) a new free, web-based platform (branded as **GreenPlace**) for trading agri-food waste to add value within the circular economy. AgroCycle Marketplace can connect producers of agri-food by-products with potential users. Potential customers for agri-waste include organisations with anaerobic digesters to convert waste into biogas energy; livestock feed producers; and start-up companies developing new products, which add value to such residues.

### **Fruta Feia**

Fruta Feia is co-op in Lisbon, Portugal that connects smallholder growers with consumers. Customers can choose between 2 box sizes, which are delivered on a weekly basis in recyclable carton boxes. The initiative connects 235 producers with 5557 consumers through 11 delivery points to save 2026t of food otherwise deemed as 'waste'.

### **Dörrwerk**

The German company Dörrwerk produces dried fruit products from misshaped produce, which cannot be marketed. They buy the apples, which are the main ingredient, from selected partner farms at a fair price level, mainly from Germany but also from other European countries. In addition, other fruits are used such as mango, strawberries, pineapples which do not meet the common market specifications. The company is interested in long-term partnership with their suppliers and a fair trading policy. The main product is so-called "fruit paper" which is a filmy, crispy snack made from 100% fruit. The product is packed in small plastic bags that ensures durability for 4-6 months from time of production. Founded in 2014, the products are marketed online and through cooperating retailers.

### **Inglorious Fruit & Veg – by Intermarché**

To fight against food waste, Intermarché, the 3rd largest supermarkets chain in France, decided to sell (30% cheaper) 'non-calibrated' and imperfect fruits and vegetables: "the inglorious fruits and vegetables". The stores were rebranded 'inglorious' and Intermarché developed and distributed 'inglorious vegetables soups' and 'inglorious fruit juices'. There has been a high level of interest by the consumer as they get similar quality products cheaper, while the growers get money for products that are usually thrown away and Intermarché increase its business by selling a brand new line of products.

### **AgroCycle Kids**

AgroCycle Kids is a spinout from the Horizon 2020 AgroCycle project. It is a novel initiative by Maynooth University, Ireland aimed at educating the youth of Europe in regard to the 'circular economy' and how their lifestyles impact on the environment, food loss and humanity. The concept is to start young thereby influencing the next generation - the future of mankind. Pilot programmes have been introduced in schools in Ireland and China with excellent outputs.

(<https://www.maynoothuniversity.ie/froebel-department-primary-and-early-childhood-education>)

## SOLAAL

SOLAAL is a French initiative, which plays the role of a facilitator between farmers and food associations. SOLAAL organises the donation and takes into consideration the constraints of both farmers and charities in terms of packaging, logistics and product preservation. SOLAAL has also created a national farmer donation day to mobilise all the growers. They are given the option of donation either to a charity or a national authorised food association.

## Valorisation: nutrient recovery

WiSErg is a company in the United States that transforms food scraps and food surpluses into organic fertilisers. WiSErg 'Harvesters' are placed at food service facilities where the Harvester processes food scraps in a self-contained system. During the transformation process, valuable nutrients are captured and stabilised. The resulting material is transported to a nearby facility where it is processed into liquid fertiliser. Similarly, Re-Nuble, which is also based in the United States, creates an organic liquid nutrient that is derived from vegetative waste for hydroponic growers and traditional gardeners.



## Mis-shapen produce

If the market demands certain 'cosmetic standards', then the retail trade will respond and deliver as required. However, where produce falls below such standards, it is best to use such produce in the food chain, where possible. One solution is the development of a new market for such produce, provided it's nutritious and perfectly safe to eat.

The use of special discount rates for so called 'ugly food' is practised quite widely. This ensures that product that is of a high quality but mis-shapen (or other such 'cosmetic' defect) enters the food chain. The consumer gains from obtaining a perfectly nutritious product at a reduced price, and the environmental impacts are minimised.

## Success and fail factors

### Overview

Pre-farm gate losses are particularly challenging to address for several reasons:

- ▶ Definition of a 'loss' or 'waste' is very subjective and actor dependent;
- ▶ Many losses are hidden i.e. not considered as losses or operators are unaware of these;
- ▶ Many of the losses generated on farm are caused by actions outside the control of the farmer;
- ▶ Policy confusion: a key challenge is the incentives in place to manage losses in the most sustainable manner;
- ▶ Information availability: practice-based losses and wastes can be generated due to inefficiencies in production and actors not having sufficient information to manage appropriately the primary production risks.

Many stakeholders involved in primary production do not use the term 'food waste', because the material is often not 'wasted' but used as some other valuable input, even if this means that it is ploughed back into the field. This represents a key challenge to primary producers, as the question is not about 'waste' prevention, but optimally utilising all the resources on the farm, from economic and environmental perspectives.

### Market impact

Reducing on-farm losses increases the market supply of the produce, and so less additional input resources (fertilisers, labour, etc.) are needed to produce such additional output. This has major environmental and logistical benefits. However, it does have direct market implications. The increased amount of produce available has to be absorbed into the food supply chain (market), and may necessitate a change in consumer and processor/retailer acceptance of produce that does not meet traditional cosmetic specifications.

Furthermore, an increase in supply will reduce the market price, which may have a negative economic impact for the farmer. This emphasises the point that a simplistic approach of reducing losses alone will not solve the problem. Nevertheless, one fundamental principle is that on-farm operational efficiency must be as high as possible, with minimal losses.

### How to predict and prevent market-based losses

Farmers do not have direct control over many factors involved in primary production (e.g. weather, markets, etc.). 'Market based' wastes in particular, present a great challenge to primary producers. Many of the causes of food losses as identified by farmers are due to factors further along the food supply chain. Supermarkets, responding to consumer demand, or in some cases influencing consumer demand, order fresh produce that must fit exacting size, shape and colour specifications, regardless of the nutrition, taste and value of the food. Farmers have also indicated that a concentration of power among large retailers has resulted in fewer outlets for lower grade and surplus produce.

Farmers may deliberately over produce as a form of risk management for meeting retailers' demands. According to WRAP, fear of losing business is the major concern. Since retail forecasting and crop production are not exactly aligned, the expectation of high in-stock levels of fresh produce is chiefly met by growers producing more than the anticipated demand (Lillywhite et al., 2016). The key problem being that it is more 'economically advantageous' to waste food rather than under-deliver to a customer (Lillywhite et al., 2016).

### Loss and Waste prevention vs. sale for valorisation

A key challenge facing primary producers is assessing how to manage effectively primary production food losses. This starts with categorising losses and wastes that are generated to help identify the most sustainable and economically viable options for their management.

In the agri-food chain, and particularly at the primary production stage, many material flows may be considered valuable resources. A prime example is that of crop and other vegetable residues which can either be viewed as a material to be exported from the farm as a feedstock for valorisation or as a vital resource to be kept within the agricultural system to provide necessary 'ecosystem services'. The challenge for farmers is determining if resources should be kept on farm or sold for high value valorisation purposes.

The removal of by-products from the farm for off-farm 'valorisation' may have negative impacts on soil health and the longer-term sustainability of farming systems, as traditionally they may have provided soil organic matter and nutrients through incorporation into the soil. This has to be accounted for in a holistic assessment of the off-farm use of such material. There is a lack of verified data on the sustainable removal rates for by-products arising from crop production.

### Jevons Hypothesis

Many solutions proffered to reduce waste do not consider their holistic impacts. For example, the '3 for 2' marketing of produce that is approaching its best-before-date tends to shift the loss from the supermarket to the kitchen bin, as generally consumers tend to purchase excess produce to avail of such offers but end up not consuming the items. Furthermore, this may also have the effect of reducing pressure on supermarkets to reduce losses, hence running the risk of an increase in overall system losses.

The agri-food chain is a continuum and it is not possible to simply 'close the farm gate' and ignore the dynamic impacts of the other stages in the chain, beyond the farm gate. For example, the contracts between the retailer and the farmer are reflective of the final demand by the consumer to whom the retailer sells produce. If the consumer is under the impression that there is no loss or waste along the chain, then it's the 'business as usual' scenario that will persist, where there is no incentive or pressure on the consumer to consider behavioural change.

One common thread of the general discussion on how to reduce the impact of food waste is the use of such wastes as a feedstock for other purposes, such as anaerobic digestion. This approach can be implemented at any stage along the chain to valorise: on-farm food losses such as un-marketed vegetables; consumer generated waste; etc.

However, providing such valorisation options may increase on-farm production inefficiency, by removing pressure to ensure optimum efficiency on the farm. This is the classic 'Jevons Effect' where, for example, the retailer can state that any produce that doesn't meet its contractual standards can be diverted to e.g. anaerobic digestion. This completely overlooks the fact that the farmer has invested resources (fertiliser, energy, agro-chemicals) to produce this food with an environmental and economic burden. This may reduce the pressure on both the retailer and farmer to enhance operational efficiency, and on the consumer to change their habits towards minimisation of food waste.

## Consumer

Food is a basic human need and each citizen has an expectation and right to adequate food of a nutritious and safe standard, at an affordable price. Demand in the food chain is consumer driven, hence educating the consumer (citizen) is a key pathway to avoiding the 'Jevons Effect'.

## How to make better crop management decisions

The key on-farm operational challenges consist of weather, crop diseases and poor storage of crops, among others. Effective decision making on-farm remains one of the greatest challenges facing primary producers. Practice-based losses on the farm occur from poor decision-making as a result of insufficient information. Examples include not having high quality environmental data in order to best manage the crop production throughout the growing cycle.

Inefficient crop production operations, arising from technical, weather and market variables, is the key 'driver' of on-farm losses, hence the goal is optimisation of crop production operations while achieving minimal environmental impacts. Overcoming this challenge requires the generation of more farm and plant specific information that can enable farmers to make better decisions to increase the efficiency of production and subsequently reduce losses.

## The 'Impact Hierarchy'

### Outline of the top 5 items in the 'Impact Hierarchy' regarding the pathways to minimise food losses on the farm.

1. **Market** - contracts between farmers and retailers or processors
2. **Education** of the consumer and other stakeholders/actors regarding the dynamics of the agri-food chain and how lifestyle and expectations affect food losses
3. Producer **cooperatives** and negotiating strength with retailers
4. **Quantifying** the extent of food losses on the farm
5. **Socio-political and behavioural science** considerations and the attendant policy to support efficient and sustainable systems

These top 5 types of solutions to minimise food loss on the farm are based on a range of issues affecting food losses on the farm which were identified by the Focus group experts. This range of issues is presented below.

### The range of issues affecting food losses on the farm identified by the Focus Group experts

- Quantification of losses - provide data on the extent of these losses
- Trust between the 'actors' - particularly between farmers and both retail and processing (i.e. their main customers)
- Cooperatives providing collaboration on addressing market pricing and the specific conditions associated with such contracts
- Technology adoption, such as 'Digital Agriculture'
- Consumer habits and preferences
- Price of agricultural produce - farmers require an economically viable market price for their produce, and the market should be structured to incentivise the consumer to minimise food waste and loss
- Awareness of the issue amongst farmers and the consumer
- Knowledge sharing through e.g. EC 'Operational Groups' (OGs)
- Education of farmers regarding operational efficiency and implementation of best practice
- Measure the impact of implementation strategies
- Valorisation of (preferably) unavoidable losses and wastes
- Incentives for farmers to reduce losses
- Multiplier effect within the local economy arising from economically viable and profitable farming
- Awareness of the contribution that reduced on-farm loss and waste make to the UN's SDGs
- The role of CAP in modifying markets, and providing incentives to farmers for both enhancing on-farm efficiency and profitability (sustainability) of farming
- Resource use efficiency such as optimisation of fertiliser use efficiency
- The societal importance of ensuring national, EU and global food security
- The need for research on optimum system performance
- The need for a pan-EU repository of data on food loss and waste

## Recommendations

### Overview

Any sector which wastes up to 30% of its products along the supply chain is not only inefficient and polluting, but it also means that it is ripe for disruption and innovation. The agri-food sector is in this category. The level of wastage in the agri-food chain has prompted the development of a range of new technologies which seek to make the agri-food chain more efficient and less wasteful, particularly when it comes to primary production.

Significant value creation opportunities exist in capturing lost value on the farm, in the form of reducing 'avoidable' loss and waste and valorising those unavoidable loss, waste and by-products of the production systems. Given that the level of loss and waste is driven, *inter alia*, by market dynamics, it is essential that the role of the market be addressed in the quest for a holistic solution.

The solutions offered must be commercially viable. In particular, they should be compatible with the UN Strategic Development Goals (SDGs) as these underpin a sustainable approach to the management of the biosphere. This includes the delivery of secure and wholesome food supplies for mankind while maintaining biodiversity, soil health and the wider environment. 'Digital agriculture' has a key role to play in the delivery of efficient on-farm operations that can also be verified to the satisfaction of regulatory authorities and the citizen (consumer).

The Focus Group experts identified a set of ideas for Operational Groups and other innovative projects, as well as questions requiring further research to develop holistic solutions together with farmers, advisers, retail, consumers and research. These are presented below and further developed in the Mini Papers.

### a. Ideas for Operational Groups (OGs)

Based on the dynamics of the agri-food chain and the list of impact factors presented previously in this report, the following is a list of subject areas that would benefit from the establishment of **Operational Groups** or other local innovative projects.

Title	Description	Who to involve
Defining losses and sustainable 'wastes' removal rates from the farm	Defining food losses on the farm, and quantifying the extent of such losses (down to individual farm level) and in particular the relationship between removal rates and recirculation of nutrients and organic matter in the context of soil health and sustainable production systems.	Farmers, advisers, soil scientists, life cycle analysis experts, systems dynamics modellers
Enhancing on-farm operational efficiency	Testing new digital technologies to improve farming efficiency and meet citizens' requirements for monitoring and verification of on-farm operations (also see the FGs mini-paper on ICT approaches to on-farm food loss reduction).	Farmers, farm advisers with knowledge on precision farming and other useful digital technologies, consumers, IT specialists
Enhancing consumer awareness	Initiating cooperation between local schoolchildren (or schools?) and farmers to raise awareness of the availability of 'ugly vegetables' and the environmental benefits of utilising this resource.	Farmers, schoolchildren, teachers?, advisers, retailers?

Waste Valorisation	Testing ways to maximise value for 'unavoidable' wastes, co-products and by-products (such as animal manures), by utilising these resources for high value applications, within the context of ensuring sufficient return of resources back to the land (soil).	Farmers, startups, advisers, different types of enterprises using food 'waste' as inputs, such as producers of animal feed or biogas, or builders, or?
Developing and testing new business models and fair trading practices	Develop and test new business models that will enable farmers to plan better and avoid (minimise) the need to over-produce to meet retail demands. NB Policy support such as the European Commission's proposal to ban unfair trading practices in the food supply chain <a href="http://europa.eu/rapid/press-release_IP-18-2702_en.htm">http://europa.eu/rapid/press-release_IP-18-2702_en.htm</a> may be helpful here	Farmers, consumers, advisers, retailers, logistics experts

## b. Research needs from practice

### Multi-actor 'value chain approach'

A number of key research themes were identified to address mechanisms to reduce food loss and waste on the farm. Central to these is the need to take a multi-actor 'value chain approach' to research on this subject, with an integrated mix of researchers, businesses (large and SME) and the citizen (consumer). The suite of solutions required is multi-faceted and includes both technical and policy as a key driver of change in society. It is clear that a full-chain approach must be undertaken as on-farm losses are impacted by market 'draw' arising from the consumer and other post-consumer commercial valorisation businesses. The danger is that the waste becomes a product in its own right and 'feeds' a growing waste valorisation market (manifestation of the Jevons Effect).

### Research programme on 'circular economy' and food loss

The Focus group experts considered that it is essential that the EU is a world leader in research and innovation in this domain. A multi-disciplinary and multi-actor approach is essential, where the research community work hand-in-glove with key industry stakeholders, from farmers right through to the consumer (citizen) and beyond into a sustainable bio-economy based on unavoidable agri-food waste as a feedstock.

### Quantifying On-Farm Loss and Waste

A key initial step is knowing and quantifying the extent of on-farm losses. These are quite difficult to quantify as some fall in the interspace between actual waste and recirculated nutrients and organic matter that maintain soil health (e.g. unmarketable vegetables that are ploughed back into the soil to improve soil health). Furthermore, virtual losses can also be considered as an 'opportunity loss' where inefficient operations lead to lower yield than is feasible, using the same (or lower) level of input resources.

There is a need to develop a clear understanding of what we categorise as on-farm losses. Furthermore, even if we establish clear definitions of such losses, there are practical difficulties in accurately measuring these. Nevertheless, it is important that reasonably accurate assessments are made as we need to benchmark the impacts of reduction systems on overall levels of loss and waste.



## 'Digital Agriculture'

ICT applied to agricultural production systems and full agri-food chain monitoring and control offers a new frontier in systems operation and control. Agriculture 4.0, the new 'Digital Agriculture' era, is dawning and holds out the prospect of enhanced control over on-farm operations and mainstream food chain, from farm to table. This is an area that requires rapid increase in research and innovation, with a high level of engagement with the industry. Given that the technology offers optimisation of resource use efficiency and a concomitant level of monitoring of actual on-farm operations (for compliance purposes), this is a very valuable tool that significantly contributes to meeting the needs of the industry and regulators. It also provides a high level of assurance to the consumer that their food is produced to the highest standards and this is verified through the records provided by the technology.

**Annex 2** presents a non-exhaustive list highlighting examples of on-going European ICT projects that are utilising digital agriculture to minimise food loss and waste that potential Operational Groups could collaborate with to further develop methods of minimising food loss and waste pre-farm gate.

### On-Farm Food Losses Priority Areas for Research

1. Understanding the **dynamics** of the multi-actor 'value chain approach' addressing, inter alia, the **market dynamics** of contractual agreements between producer (farmer) and consumer (retail, processing) and how policy and regulation impact on market dynamics and sustainability;
2. Definition, measurement and ongoing **monitoring** of actual losses on the farm in the context of sustainable farming systems;
3. **Risk** modelling of on-farm production systems, taking account of the full-chain and wider societal factors impacting on risk;
4. **Technologies** (particularly '**digital agriculture**') that offer enhanced operational efficiency based on best practice and monitoring of operations for management and compliance purposes;
5. **Valorisation** pathways - that offer new opportunities for utilising 'unavoidable' wastes arising from highly efficient on-farm operations;
6. **Education** of the stakeholders, enhancing awareness of the extent and impact of the issue and solutions- with a particular focus on youth;
7. Understanding the influence of **Corporate Social Responsibility (CSR)** on reducing losses and waste along the agri-food chain;
8. **Environmental impact** assessment, including holistic **LCA modelling**;
9. **Digital Platform** to provide stakeholders with an effective communications pipeline, disseminating state-of-the-art in near real-time;
10. **Socio-economics and behavioural studies - understanding the consumer**: addressing such aspects as household purchasing practices and, for example, the role of 'Refrigeration (deep freeze) Supply-Demand Buffering' as a tool to reduce supply-demand fluctuations and associated food losses.

## c. Other considerations

### Corporate Social Responsibility

The agri-food chain is a multi-actor chain, stretching from the farmer right through to the consumer and beyond (bio-economy). Most of the chain post-farm gate is operated by large corporate entities, including processors, retailers, logistics providers and financiers. Given that food supply is a basic human need and right, it is essential that all 'actors' along this chain operate to the highest standards (efficiency, environmental, economic and societal). Indeed, there is increasing concern amongst the consumer (citizen) regarding discarded food by supermarkets (Spring, 2018) and this is placing moral pressure on corporate entities to address the issue. There is an international movement towards initiatives attempting to prevent unsold food being wasted (Davies & Evans, 2019). The Mistral Urban Futures project (SAFE - Self organised Action for Food Equity) aims to generate

knowledge regarding store-level possibilities and challenges of dealing with unsold food in a sustainable and accountable manner, using UK and Swedish examples - see:

[www.mistraurbanfutures.org/en/project/safe-self-organising-networks-food-justice](http://www.mistraurbanfutures.org/en/project/safe-self-organising-networks-food-justice).

These can assist in informing supermarkets on best initiatives to minimise such surplus. It is evident that Corporate Social Responsibility (CSR) has a key role to play in this domain. There is an onus on such entities (most large multi-nationals) to operate to the highest CSR standards, and support initiatives that meet societal needs. Very often, such initiatives come with a price tag, nevertheless the societal and market benefits accruing to good CSR operators tend to outweigh any short-term economic costs. The existing literature in this area is quite sparse, but studies show that there is a significant premium attached to companies practising high levels of CSR including concomitant societal and environmental benefits (Gruber et al., 2016; Kulikovskaja & Aschemann-Witzel, 2017). A research initiative into the role of CSR in this domain is required as this has the potential to make really significant inroads into addressing this major societal challenge.

### Risk Assessment

Agricultural production operations are at the vagaries of the weather and associated disease and performance impacts, as well as market forces. European agriculture can be considered as a medium risk business, with occasional very poor annual performance arising mainly from weather and market induced impacts. Risk levels impact on system planning and operations and ultimately on food losses on the farm. There is a need to research risk with a view to implementing strategies that minimise exposure to such risk. This is particularly important in the context of some key drivers of risk that are becoming more pronounced: climate change and impact on local weather; global trade disputes and impacts on product prices and markets; environmental constraints on production practices.

### Refrigeration (deep freeze) Supply-Demand Buffering

Farming is a market driven business, where the farmer produces in response to demand and associated market price. However, seasonal demand can vary considerably for many reasons, mainly weather driven. The dynamics of the market operations are a key driver of on-farm losses, and anything that buffers against glut and scarcity helps reduce such losses. One aspect that is insufficiently researched is the socio-economic and behavioural (convenience) use of in-home deep freezers. If used properly (economic incentives), these can act as buffers in times of low demand (e.g. consumer stocks up with cheaper produce that would otherwise be discarded) and uses these as required. This is an area somewhat akin to the distributed energy storage capacity of electric cars where they can act as electricity grid buffers, smoothing out supply and demand issues. This is an area that has had little research and is an interesting aspect that deserves a concerted research effort. For example, the project Drawdown (2017) recognises that 'refrigeration (deep freeze) buffering' can contribute to reducing waste of precious food and has addressed its potential as a method to reduce global climate impact. While this is shifting some of the refrigeration capacity from the supermarket to the home, nevertheless this provides the consumer with better control over product supply and pricing. Such technologies and systems come at a financial and energy cost, and hence warrant examination in the context of their role in reducing food loss along the chain, right back to the primary producer. This is further testament to the need to address all solution in the context of the full chain and wider societal impacts.

### Educating the next generation

The citizen (consumer) is the principal driver of the agri-food chain through demand for food in the marketplace. Consumers are largely poorly informed regarding the nexus between their market demands for food and ensuing losses along the chain. Societal behaviour is a key driver of the demand for food, hence enhancing awareness of the issues is a very effective pathway to ensuring lasting impact, particularly if the education is focused on the youth, the next generation. A society-wide education and dissemination programme is essential to achieving a lasting impact across society, right into the heart of the family unit. Children are the future and should be empowered to have the last say in this major existential challenge.

## References

- ▶ AgroCycle ([www.agrocycle.eu](http://www.agrocycle.eu)) Accessed 12-12-2019
- ▶ Beausang, C., Hall, C. L. (2017) TomaFood waste and losses in primary production: qualitative insights from horticulture Resource Conservation and Recycling, Vol 126, pp. 177-185
- ▶ Beretta, C., Stoessel, F., Baier, U., Hellweg, S. (2013) Quantifying food losses and the potential for reduction in Switzerland Waste Manage., Vol 33, pp. 764-773
- ▶ Berkenkamp, J. (2016a). *Beyond beauty: The opportunities and challenges of cosmetically imperfect produce. Report no. 2: Survey results from Minnesota Produce Growers*. Retrieved from [http://misadocuments.info/Beyond\\_Beauty\\_Grower\\_Survey\\_Results\\_052615.pdf](http://misadocuments.info/Beyond_Beauty_Grower_Survey_Results_052615.pdf)
- ▶ Berkenkamp, J. (2016b). *Beyond beauty: The opportunities and challenges of cosmetically imperfect produce. Report no. 3: Fresh cut processing and foodservice distribution*. Retrieved from <http://ngfn.org/resources/ngfn-database/Beyond%20Beauty%20-%20Distribution%20Report%203%20FINAL%204-1-16.pdf>
- ▶ Berkenkamp, J., & Nennich, T. (2016). *Beyond beauty: The opportunities and challenges of cosmetically imperfect produce. Summary of findings*. Retrieved from <http://ngfn.org/resources/ngfn-database/Beyond%20Beauty%20-%20Final%20Summary%20of%20Findings%20-%20July%202016.pdf>
- ▶ Breewood, H. (2019). What is food loss and food waste? Foodsource: building blocks. Food Climate Research Network, University of Oxford.
- ▶ Davies, A., & Evans, D. (2019). Urban food sharing: Emerging geographies of production, consumption and exchange. *Geoforum*, 99, 154-159.
- ▶ Drawdown (2017) The most comprehensive plan ever produced to reverse global warming. Editor: Paul Hawken. See: <https://drawdown.org/references>
- ▶ European Commission, (2018). See: [https://ec.europa.eu/commission/news/tackling-unfair-trading-practices-food-supply-chain-2018-apr-12-0\\_en](https://ec.europa.eu/commission/news/tackling-unfair-trading-practices-food-supply-chain-2018-apr-12-0_en) Accessed 12-12-2019
- ▶ FAO (2011) Global food losses and food waste – extent, causes and prevention. Rome. <http://www.fao.org/docrep/014/mb060e/mb060e00.pdf> Accessed 12-12-2019
- ▶ FAO (2013) Food wastage footprint. Impacts on natural resources. Summary Report. Rome. [www.fao.org/docrep/018/i3347e/i3347e.pdf](http://www.fao.org/docrep/018/i3347e/i3347e.pdf) Accessed 12-12-2019
- ▶ FAO (2014) Building a common vision for sustainable food and agriculture. Principles and Approaches.
- ▶ FAO (2018). Gender and food loss in sustainable food value chains. A guiding note. Rome. <http://www.fao.org/3/i8620en/I8620EN.pdf> Accessed 12-12-2019
- ▶ Feedback (2019). *Consultation Response to European Commission on EU Food Waste Methodology*. [online] Available at: <https://feedbackglobal.org/wp-content/uploads/2019/03/Feedback-and-SAFE-policy-brief-EU-food-waste-methodology.pdf> Accessed 12-12-2019
- ▶ FLW Standard, <http://flwprotocol.org/flw-standard/> Accessed 12-12-2019

- ▶ Franke U., Hartikainen H., Mogensen L., Svanes E., (2016). Food losses and waste in primary production: Data collection in the Nordic countries, Nordic Council of Ministers, Nordic Council of Ministers Secretariat, Nordisk Ministerråd, 90p.
- ▶ Fusion (2016). Estimates of European food waste levels. European Commission, Stockholm 31 March 2016. ISBN 978-91-88319-01-2
- ▶ Gentry, M., Edgar, L. D., Graham, D. L., & Kirkpatrick, T. (2017). Assessing Extension agents' nematology knowledge needs and related resource preferences: Implications for trainings on complex agricultural topics. *Journal of Extension*, 55(1), Article 1RIB7. Available at: <https://www.joe.org/joe/2017february/rb7.php>
- ▶ Gruber, V., Holweg, C., & Teller, C. (2016). What a waste! Exploring the human reality of food waste from the store manager's perspective. *Journal of Public Policy & Marketing*, 35(1), 3-25.
- ▶ Gunders, D. (2012a). *Left-out—An investigation of the causes and quantities of crop shrink*. Retrieved from: [https://www.nrdc.org/sites/default/files/hea\\_12121201a.pdf](https://www.nrdc.org/sites/default/files/hea_12121201a.pdf)
- ▶ Gunders, D. (2012b). *Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill*. Retrieved from: <https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf>
- ▶ Gustavsson, J., Cederberg, C., Sonesson, U., Emanuelsson, A., (2013) The methodology of the FAO study: "Global Food Losses and Food Waste—extent, causes and prevention" – FAO, 2011. SIK, Göteborg
- ▶ Hartikainen, H., Svanes, E., Franke, U., Mogensen, L., Sørensen, J., Andersson, S., Bond, R., Burman, C., Eklöf, P., Joensuu, K., Räikkönen, R., Sinkko, T., Stubhaug, E., Olsson, M.E., Rosell, A., Sundin, S., (2017) Case studies – food losses and waste in primary production, Technical report, Nordic Council of Ministers Secretariat, Nordisk Ministerråd.
- ▶ Hartikainen, H., Mogensen, L., Svanes, E., Franke, U. (2018), Food waste quantification in primary production - The Nordic countries as a case study. *Waste Management*, 71, pp502-511.
- ▶ Johnson, L., Dunning, R., Bloom, J., Gunter, C., Boyette, M. and Creamer, N. (2018). Estimating on-farm food loss at the field level: A methodology and applied case study on a North Carolina farm. *Resources, Conservation and Recycling*, 137, pp.243-250.
- ▶ Kulikovskaja, V., & Aschemann-Witzel, J. (2017). Food Waste Avoidance Actions in Food Retailing: The Case of Denmark. *Journal of International Food & Agribusiness Marketing*, 29(4), 328-345.
- ▶ Lillywhite, R.D., McCosker, C., Sheane, R. (2016) The embedded resource and environmental burden of deliberately wasted lettuce. 10th International Conference on Life Cycle Assessment of Food 2016
- ▶ Klockgether K. (2019) Approaches to Reduce Food Losses in German Fruit and Vegetable Production. *Sustainability* 2019, 11(23), 6576; <https://doi.org/10.3390/su11236576>.
- ▶ Redlingshöfer B, Coudurier, B., Georget, M. (2017) Quantifying food loss during primary production and processing in France, *Journal of Cleaner Production*, Vol 164 pp. 703-714
- ▶ ReFED. (2016). *A roadmap to reduce U.S. food waste by 20 percent*. Retrieved from <http://www.refed.com/download>
- ▶ Refresh (2018). *Regulating the role of Unfair Trading Practices in food waste generation*. Refresh Policy Brief. [online] Available at: <https://eu-refresh.org/regulating-role-unfair-trading-practices-food-waste-generation> [Accessed 12-12-2019].
- ▶ Roels K. & Van Gijseghe D. (2017). The impact of cosmetic quality standards on food losses in the Flemish fruit and vegetable sector, summary report, Department of Agriculture and Fisheries, Brussels.

- ▶ Schneider F., Part F., Göbel C., Langen N, Gerhards C., Kraus G.F., Ritter G. (2019) A methodological approach for the on-site quantification of food losses in primary production: Austrian and German case studies using the example of potato harvest. *Waste Management* 86 (2019) 106–113. <https://doi.org/10.1016/j.wasman.2019.01.020>
- ▶ Sigler, S. (2009). *Utilizing new methods of crop harvesting to introduce nutrient-dense specialty crops to low income consumers*. Retrieved from <http://www.cafoodbanks.org/sites/default/files/utilizing-new-methods-of-crop-harvesting.pdf>
- ▶ Spring, C. (2018). *Eating waste: a critical evaluation of surplus food redistribution as solution to food waste and food insecurity*. (PhD), University of Salford, Manchester, UK.
- ▶ Strid, I., Eriksson, M., Andersson, S., Olsson, M., (2014) *Losses of Iceberg Lettuce During Primary Production and Whole Sale in Sweden (in Swedish)*, Report 146. Swedish Board of Agriculture, Jönköping, Sweden.
- ▶ Timmons, D., Wang, Q., & Lass, D. (2008). Local foods: Estimating capacity. *Journal of Extension*, 46(5), Article 5FEA7. Available at: <https://joe.org/joe/2008october/a7.php>
- ▶ WRAP (2011). *Fruit and vegetable resource maps, final report*, Waste & Resources Action Programme, Banbury.
- ▶ WRAP (2019) *Food Waste in primary production in the UK. Final report*, prepared by Bojana Bajzelj, William McManus and Andrew Parry, Banbury, July 2019, available at [http://www.wrap.org.uk/sites/files/wrap/Food\\_waste\\_in\\_primary\\_production\\_in\\_the\\_UK\\_0.pdf](http://www.wrap.org.uk/sites/files/wrap/Food_waste_in_primary_production_in_the_UK_0.pdf).
- ▶ WRAP & LEAF (2018). *Food Waste Matters*. Available at: <https://s3-eu-west-1.amazonaws.com/leaf-website/Food-Waste-Matters-18.pdf> [Accessed 12-12-2019].

## Annex 1: Members of the EIP AGRI Focus Group

<b>Name of the expert</b>	<b>Profession</b>	<b>Country</b>
<a href="#"><u>Argyropoulos Dimitrios</u></a>	Researcher	Germany
<a href="#"><u>Bernaert, Nathalie</u></a>	Researcher	Belgium
<a href="#"><u>Briaumont, Dorothée</u></a>	Working at an NGO	France
<a href="#"><u>Chavier, Nathalie</u></a>	Adviser	Spain
Elorrieta, María Antonia	Adviser	Spain
<a href="#"><u>Feret, Samuel</u></a>	Other	France
<a href="#"><u>Halbert, Catherine</u></a>	Expert from agricultural organisation, industry or manufacturing	Ireland
<a href="#"><u>Hartikainen, Hanna</u></a>	Researcher	Finland
<a href="#"><u>Jaakkola, Mari</u></a>	Researcher	Finland
<a href="#"><u>Jiménez Pérez, Sonsoles</u></a>	Expert from agricultural organisation, industry or manufacturing	Spain
<a href="#"><u>Krol, Marjon</u></a>	Adviser	Netherlands
<a href="#"><u>Power, Colman</u></a>	Farmer	Ireland
<a href="#"><u>Rivereau, Adélaïde</u></a>	Adviser	France
<a href="#"><u>Roels, Jana</u></a>	Adviser	Belgium
Rätsep, Reelika	Researcher	Estonia
<a href="#"><u>Schneider, Felicitas</u></a>	Researcher; Adviser	Germany
<a href="#"><u>Sermuksnyte-Alesiuniene, Kristina</u></a>	Industry	Lithuania
<a href="#"><u>Williams, David</u></a>	Adviser	United Kingdom
<a href="#"><u>Vittuari, Matteo</u></a>	Researcher	Italy
Vooijs, Jacco	Farmer	Netherlands
<b>Facilitation team</b>		
<a href="#"><u>Ward Shane</u></a>	Coordinating expert	Ireland
<a href="#"><u>Morin Alexandre</u></a>	Task manager	France
<a href="#"><u>Lepmets Eike</u></a>	Back-up Task manager	Estonia

You can contact Focus Group members through the online **EIP-AGRI Network**. Only registered users can access this area. If you already have an account, [you can log in here](#). If you want to become part of the **EIP-AGRI Network**, [please register to the website through this link](#)

## Annex 2 – Examples of the use of ICT in addressing the overall operational efficiency of farming systems

Project Name	Description	Link
Precision Farming Sweden (POS)	Testing precision agriculture techniques for crop management	<a href="http://www.agrovast.se/precision">http://www.agrovast.se/precision</a>
GPS-EGNOS based precision agriculture using unmanned aerial vehicles	Using unmanned aerial vehicles for real time monitoring of crop deficiencies and diseases	<a href="http://fieldcopter.eu/">http://fieldcopter.eu/</a>
Targeting Precision	Determining optimum management strategies during the growing season	N/a
CONSUS	Utilising machine learning techniques to increase yield and reduce inputs of crops	<a href="http://www.ucd.ie/consus">http://www.ucd.ie/consus</a>
SavingFood	Encompassing ICT techniques to create a social movement for reducing food waste	<a href="http://savingfood.eu">http://savingfood.eu</a>
EIP Agri Focus group "Precision Farming"	Addresses current opportunities, limitations and innovative solutions on the topic of precision agriculture	<a href="http://ec.europa.eu/eip/agriculture/en/focus-groups/mainstreaming-precision-farming">http://ec.europa.eu/eip/agriculture/en/focus-groups/mainstreaming-precision-farming</a>

## Annex 3: Initiatives needed

Some aspects that need to be addressed in order to reduce food losses along the agri-food chain, supported by examples of ongoing initiatives.

Strategy	Theory of Change and Ongoing Initiative
<b>Define and understand why losses are occurring</b>	<p>All actors in the supply chain must be first be aware of the key drivers, both on and off farm that are contributing to losses. Educating actors is the first key strategy to provide the needed information to combat the problem</p> <p>The Food Loss and Waste (FLW) Protocol, which includes representatives from the FAO, FUSIONS, WRAP, and the World Resources Institute (WRI) launched the Food Loss and Waste Accounting and Reporting Standard (the FLW Standard) in 2016 to help stakeholders quantify and report food waste. A clear, consistent approach to defining losses on the farm therefore still remains a research priority.</p>
<b>Develop new crop varieties</b>	<p>Development of new varieties that are less susceptible to disease, can reduce crop losses. Given the inevitable variability in crop quality, having a diversity of customers with different needs may reduce risk to the farmer and enhance overall productivity. There is a constant evolution of new crop varieties and cultivars, mainly emerging for the large multi-national crop breeding companies.</p>
<b>More precision agriculture techniques</b>	<p>'Data harvesting' and the embedding of effective sensor technology can help farmers better manage crops by providing real time, plant level data to optimise inputs and plant care. There are major challenges regarding data 'harvesting' and analytics. There are several commercial offerings available. One of particular significance is <a href="https://www.rhizadigital.co.uk/">https://www.rhizadigital.co.uk/</a> where the farmer is offered a suite of 'digital agriculture' offerings that deliver bespoke solutions for a given farm, enhancing operational efficiency. Europe's largest university-based 'digital agriculture' research programme on field-scale crop production, CONSUS, is undertaking pioneering work on the delivery of bespoke DA solutions for the farmer that will enhance operational efficiency on the farm (see: <a href="http://www.consus.ie">www.consus.ie</a>).</p>
<b>Improved storage and preservation methods</b>	<p>Ensuring adequate and appropriate storage facilities (e.g. ventilated, cold, etc.) can drastically cut food losses, helping farmers avoid losses due to spoilage and pests. The technology and systems are available but the commercial investment costs are often excessive and unrealistic at individual farm level.</p>
<b>Demand forecasting and sharing information</b>	<p>Retailers can be more forthcoming in sharing forecast data for specific food items to help farmers with their production planning and prevention of over-production. There are several academic institutions developing forecasting models aimed at matching supply and demand in the marketplace.</p>
<b>Further collaboration efforts within the supply chain</b>	<p>Yield reporting to make more accurate decisions earlier in the season that reduce the risk of both gluts and shortages, at farm and retail level. UK supermarket Asda's sourcing arm IPL is helping its growers use a new yield forecasting tool. Growers now use smart phones to upload photos of their crop throughout the season, and intelligent software uses these images to assess the crop's potential in relation to data from local weather stations, and historical data.</p>
<b>Better supply chain and</b>	<p>Prevent large retailers engaging in unfair trading practices, which often force primary producers to over produce, meet ever stricter cosmetic standards, both directly</p>



<b>trading policies to increase power of primary producers</b>	<p>related to built-in losses. New legislation which has been proposed by the European Commission will ban unfair trading practices, including late payments for perishable food products, last minute order cancellations, unilateral or retroactive changes to contracts and forcing the supplier to pay for wasted products (European Commission, 2018).</p>
<b>Redistribute surplus crop for animal/human feed</b>	<p>Identifying suitable distribution chains for surplus crop is essential to determine the effectiveness of this strategy. However, it is essential to avoid the development of a new market for waste streams that obviates the need to minimize waste. Redistribution specialist like <i>Food cloud</i> and apps such as <b>SpoilerAlert. Gleaning Network</b> are actively working with farmers across Europe to salvage surplus crops for redistribution. Emphasis must be on the use of <u>unavoidable</u> wastes.</p>
<b>Work with retailers to have more flexible quality specifications</b>	<p>Explore market niches by marketing 'ugly' (i.e. misshapen and non-spec) vegetables directly to customers. New app delivery services like <b>Imperfect Produce, wonky veg</b> boxes, and the <b>Fruta Feia</b> cooperative.</p>
<b>Consumer education and campaigns on 'ugly' produce</b>	<p>Get consumers to understand that ugly produce is safe, nutritious and desirable. Promoting the sale of these products can have a sizable upstream impact as more crops can be sold to retailers, leading to lower losses on the farm. These initiatives can be deemed win-win-win: consumers get the same quality products for cheaper, the growers get money for products that are usually wasted, and the retailers increase their business by selling a brand new line of products. France's third largest retailer, <b>Intermarche</b> launched a viral 'inglorious fruits and vegetables' campaign to get consumers to see the beauty of ugly produce in order to combat food waste. UK supermarket <b>Asda</b> sells a wonky vegetable box at a price that is 30% cheaper than standard lines. <i>AgroCycle Kids</i>, aimed at primary schools – the future generation (see: <a href="http://www.agrocycle-platform.com/">http://www.agrocycle-platform.com/</a>)</p>
<b>Opportunities for the retail sector (supermarkets) to deal with unsold food</b>	<p>By offering additional outlets for unsold food, supermarkets can help reduce the waste level in their supply chain. However, this has to be done without transferring the waste either upstream or downstream, which is a real problem with many such initiatives. The Mistra Urban Futures project, SAFE (Self-organised Action for Food Equity), is an action research project that aims to generate knowledge about retail-level opportunities and challenges in addressing the unsold food problem in an accountable and sustainable manner - see: <a href="https://www.mistraurbanfutures.org/en/project/safe-self-organising-networks-food-justice">https://www.mistraurbanfutures.org/en/project/safe-self-organising-networks-food-justice</a></p>

## Annex 4: Outline of some constraints, ongoing initiatives and collaboration opportunities across Europe

### Examples of synergies and collaboration opportunities

As a Knowledge and Innovation Community (KIC) of the European Institute of Innovation and Technology (EIT), EIT Food connects partners from leading businesses, universities, research centres and institutes across 13 countries in Europe and from the entire food value chain. <https://eit.europa.eu/newsroom/eit-food-launches-foodwastehero-challenge>

EU code of conduct by COPA-COGECA [https://copa-cogeca.eu/img/user/files/EU%20CODE/EU\\_Code\\_2018\\_web\\_version.pdf](https://copa-cogeca.eu/img/user/files/EU%20CODE/EU_Code_2018_web_version.pdf)

**Agroknow** is a company working on data availability in the agri-food sector [www.agroknow.com](http://www.agroknow.com) and presents examples of EIT Food projects on Education of Farmers

### Examples of projects

- ▶ **FUSIONS** [www.eu-fusions.org](http://www.eu-fusions.org) [Project ID: 311972. Funded under: FP7-KBBE]
- ▶ **Savingfood** <https://savingfood.eu/> [Project ID: 688221. Funded under: H2020-EU.2.1.1]
- ▶ **REFRESH** <https://eu-refresh.org/> [Project ID: 641933. Funded under: H2020-EU.3.5.4]
- ▶ **APLIS** African Postharvest Loss Information System [www.aphlis.net](http://www.aphlis.net)
- ▶ **Circular Food Generator Track** [www.eitfood.eu/programmes/circular-food-generator-track](http://www.eitfood.eu/programmes/circular-food-generator-track)
- ▶ **Educating for Technology Take-off** [www.eitfood.eu/programmes/educating-for-technology-take-off](http://www.eitfood.eu/programmes/educating-for-technology-take-off)
- ▶ **Focus on Farmers** [www.eitfood.eu/programmes/focus-on-farmers](http://www.eitfood.eu/programmes/focus-on-farmers)
- ▶ **Hodges, R.J., Buzby, J.C. and Bennett, B. (2011)** Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use **The Journal of Agricultural Science**, Volume 149 Issue s1
- ▶ **Explore how farmers produce sustainably** [www.eitfood.eu/programmes/Explore-how-farmers-produce-food-sustainably](http://www.eitfood.eu/programmes/Explore-how-farmers-produce-food-sustainably)
- ▶ **AgroCycle**: A H2020 research & innovation project addressing the application of the 'circular economy' across the agri-food chain, with particular emphasis on system efficiency and how to minimize losses at each stage. See: [www.agrocycle.eu](http://www.agrocycle.eu)
- ▶ **NoAW**: A H2020 'circular economy' research and innovation project addressing, *inter alia*, minimisation of losses along the agri-food chain. See: <https://noaw2020.eu>
- ▶ **GLOPACK**: H2020 project addressing the development and use of food packaging with no environmental footprint and the ability to extend the shelf life of food products. See: <https://glopack2020.eu/>

## Annex 5: List of mini-papers from the Focus Group experts

All mini-papers can soon be downloaded from the [‘Reducing food loss on the farm’ Focus Group page](#) on the EIP-AGRI website.

Title	Authors
From by-product to a new product: R&D, process, market, communication	Jacco Vooijs (coordinator), Mari Jaakkola, Colman Power, Felicitas Schneider, Jana Roels, Dimitrios Argyropoulos
New business models and relationships between farmers, retail and consumers	Sonsoles Jiménez Pérez (coordinator), Dimitrios Argyropoulos, Dorothée Briamont, Nathalie Chavier, Samuel Feret, Marjon Krol, Jana Roels, Felicitas Schneider
Pre- and Post Harvest Factors affecting fruits and vegetables	David Williams (coordinator), Antonia Elorrieta Jove, Kristina Sermuksnyte-Alesiuniene, Felicitas Schneider, Nathalie Bernaert, Sonsoles Jiménez, Augustas Alešiūnas, Jana Roels
Knowledge and Access to Information on food losses on the farm	Hanna Hartikainen, Reelika Rätsep, Adélaïde Rivereau, Felicitas Schneider, Catherine Halbert, Dimitrios Argyropoulos
<i>Mini Paper 5 – Title To Be Confirmed</i>	Kristina Sermuksnyte-Alesiuniene (coordinator) Antonia Elorrieta Jove, David Williams, Felicitas Schneider, Nathalie Bernaert, Sonsoles Jiménez, Augustas Alešiūnas, Jana Roels



**The European Innovation Partnership 'Agricultural Productivity and Sustainability'** (EIP-AGRI) is one of five EIPs launched by the European Commission to promote rapid modernisation by stepping up innovation efforts.

The **EIP-AGRI** aims to catalyse the innovation process in the **agricultural and forestry sectors** by bringing **research and practice closer together** – in research and innovation projects as well as through the EIP-AGRI network.

**EIPs aim** to streamline, simplify and better coordinate existing instruments and initiatives and complement them with actions where necessary. Two specific funding sources are particularly important for the EIP-AGRI:

- ✓ the EU Research and Innovation framework, Horizon 2020,
- ✓ the EU Rural Development Policy.

**An EIP AGRI Focus Group\*** is one of several different building blocks of the EIP-AGRI network, which is funded under the EU Rural Development policy. Working on a narrowly defined issue, Focus Groups temporarily bring together around 20 experts (such as farmers, advisers, researchers, up- and downstream businesses and NGOs) to map and develop solutions within their field.

**The concrete objectives of a Focus Group** are:

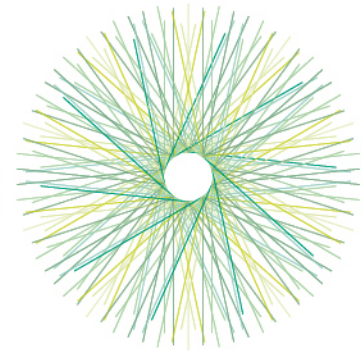
- ✓ to take stock of the state of play of practice and research in its field, listing problems and opportunities;
- ✓ to identify needs from practice and propose directions for further research;
- ✓ to propose priorities for innovative actions by suggesting potential projects for Operational Groups working under Rural Development or other project formats to test solutions and opportunities, including ways to disseminate the practical knowledge gathered.

**Results** are normally published in a report within 12-18 months of the launch of a given Focus Group.

**Experts** are selected based on an open call for interest. Each expert is appointed based on his or her personal knowledge and experience in the particular field and therefore does not represent an organisation or a Member State.

\*More details on EIP-AGRI Focus Group aims and process are given in its charter on:

[http://ec.europa.eu/agriculture/eip/focus-groups/charter\\_en.pdf](http://ec.europa.eu/agriculture/eip/focus-groups/charter_en.pdf)



eip-agri  
AGRICULTURE & INNOVATION



funded by  European Commission

Join the EIP-AGRI network &  
register via [www.eip-agri.eu](http://www.eip-agri.eu)