LOWINFOOD

Multi-actor design of low-waste food value chains through the demonstration of innovative solutions to reduce food loss and waste

GA No. 101000439

D1.1 METHODOLOGICAL FRAMEWORK

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Contact of the deliverable's lead beneficiary:

Silvia Scherhaufer, WP leader BOKU. Email: silvia.scherhaufer@boku.ac.at

Authors:

Scherhaufer S. (BOKU), Giordano C. (UNIBO), Koseoglu N. (JHI), Di Fiore G.N (UNIBO), Carloni E. (UNIBO), Piras S. (JHI), Gollnow S. (BOKU), MacLean L. (JHI), Somervail P. (JHI), Falasconi L. (UNIBO), Obersteiner G. (BOKU)

LIST OF PARTNERS THAT HAVE CONTRIBUTED TO PRODUCE AND REVISE THE DELIVERABLE

UNITUS, SLU, ISUN, TAU, HUA, AIE, ELH

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LOWINFOOD Consortium

N.	Full name of the organisation	Short name	Country
1	Università degli Studi della Tuscia	UNITUS	Italy
2	Alma Mater Studiorum Università di Bologna	UNIBO	Italy
3	Sveriges Lantbruksuniversitet	SLU	Sweden
4	FH Munster University of Applied Sciences	ISUN	Germany
5	The James Hutton Institute	JHI	United Kingdom
6	Universitaet Fuer Bodenkultur Wien	BOKU	Austria
7	Tampereen Korkeakoulusaatio SR	TAU	Finland
8	Charokopeio Panepistimio	HUA	Greece
9	Osterreichisches Okologieinstitut	AIE	Austria
10	Elhuyar Fundazioa	ELH	Spain
11	Matomatic AB	MATO	Sweden
12	Unverschwendet GmbH	UNV	Austria
13	Akademie Deutsches Baeckerhandwerknord GGmbH	ADB	Germany
14	Foresightee	FOR	Belgium
15	Leroma GmbH	LER	Germany
16	Mitakus Analytics UG	MITA	Germany
17	Kitro SA	KITRO	Switzerland
18	Regione Emilia Romagna	RER	Italy
19	Pianeta Cospea srl	PICO	Italy
20	Cogzum Bulgaria OOD	COZ	Bulgaria
21	Uppsala Kommun	UPP	Sweden
22	Recuperiamo srl	REG	Italy
23	Antegon GmbH	FT	Germany
24	Confederazione Nazionale dell'Artigianato e della piccola e media impresa Associazione di Viterbo e Civitavecchia	CNA	Italy
25	Assemblee des Regions Europeennes Fruitieres Legumieres et Horticoles	ARE	France
26	L.V.L Anonymi Emporiki Toyristiki Kksenodoxeiaki Kataskevastiki Etaireia	BLU	Greece
27	Iridanos-Inabelos Anonymi Etaireiatouristikes Ksenodoxeiakes Kai Agrotikes Epixeiriseis	THA	Greece

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Summary

The methodology for the evaluation of LOWINFOOD's innovations has been elaborated in a multi-actor approach. This deliverable explains the process of setting the methodology, the framework of the innovations (value chain maps, type of food waste) as well as the roadmap for data collection (type and source of data, collection method, identification of data facilitators and collectors).

A set of indicators has been identified focusing on the three dimensions for the evaluation: efficacy, socio-economic impacts, and environmental impacts.

This deliverable has been elaborated in close cooperation with the task leader teams of WP1: BOKU, UNIBO and JHI. The content of this deliverable has been shared and revised with the External Advisory Board as well as other research partners of LOWINFOOD.

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Introduction to the deliverable

LOWINFOOD is a project committed to co-design, together with actors of the food chain, low-waste value chains by supporting the demonstration of a portfolio of innovations in a set of value chains particularly concerned by food loss and waste (fruits & vegetables, bakery products and fish), as well as in at-home and out-of-home consumption. Each of these value chains corresponds to a single Work Package (WP) of the project.

The innovations are selected among promising solutions that have already been developed and tested by some partners of the consortium, with the aim to provide the necessary demonstration and upscale to allow market replication.

The LOWINFOOD consortium comprises 27 entities, located in 12 different countries, and ranging from universities and research institutes to start-ups, foundations, associations, and companies working in the food sector. During the 52 months of the project, the partners are committed to complete 30 tasks and to deliver 60 outputs (deliverables).

This deliverable 1.1 (D1.1) is dedicated to the methodological framework of the evaluation of innovations which is part of WP1 of the project. WP1 is dedicated to evaluating the efficacy of LOWINFOOD's innovations and, the socio-economic and environmental benefits and efforts when implementing the innovations. The tasks in the first year of the project were applied to design a common methodology for the evaluation including the selection of indicators, the identification of data needs and data sources as well as the creation of questionnaires and data collection protocols in a multi-actor approach. The results of the methodological discussions but also how the multi-actor approach was put into practice are reported in D1.1. For further information on the methodology and the evaluation approach for each innovation (in total 15), it is referred to complementing deliverables within WP1, which are dedicated to the specific dimensions of the evaluation: efficacy (D1.3), socio-economic (D1.4) and environmental evaluation (D1.2).

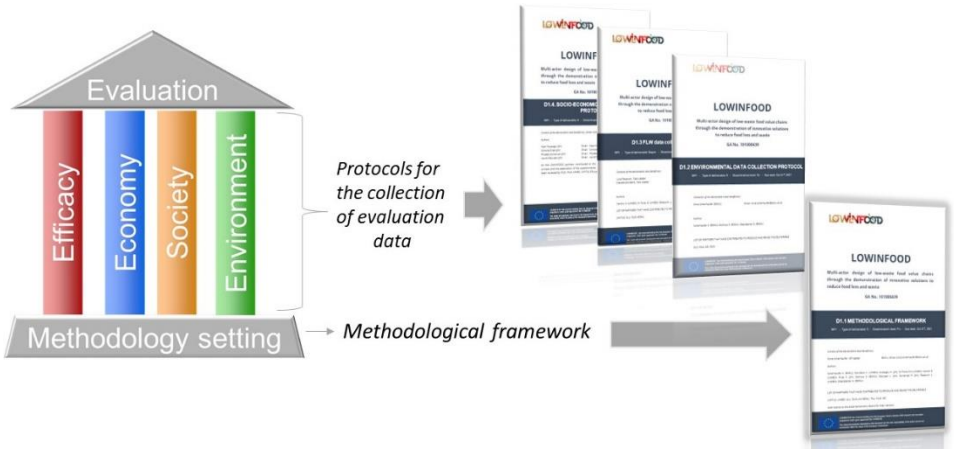

Figure 1: Dimensions of the evaluation of LOWINFOOD's innovations and dedicated deliverables within the first year of the project

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Abbreviations

C	Consumer
D	Deliverable
EAB	External Advisory Board
EF	Environmental Footprint
F & V	Fruits and vegetables
FLW	Food Loss and Waste
FP	Food Processing
FS	Food Service
FW	Food Waste
GWP	Global Warming Potential
ICT	Information and Communications Technology
JRC	Joint Research Center
KPIs	Key Performance Indicators
LCA	Life Cycle Assessment
M	Month
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PP	Primary Production
RD	Retail and Distribution

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1 Introduction

A solid evaluation is the basis for taking informed decisions. In LOWINFOOD we decided to define a robust and practical methodology for the evaluation in a multi-actor approach. We will look at the following pillars of sustainability: efficacy of innovations, socio-economic as well as environmental impacts of the innovations.

What we want is:

- Close the gap between science and practice for mutual benefit
- Identify feasible and practical methods to assess the benefits of innovation
- Enable harmonized and efficient data collection
- Present the results on aggregated level
- Handle data with care (awareness of confidential data)
- Exclude possible shift of burdens
- Assess the impact assessment of each innovation

What we don't want is:

- Judge the efficiency of single companies and publishing disaggregated data
- Compare innovations (they are too diverse to compare, however experiences from one innovation can be used for another, e.g. experiences in data collection, …)
- Overload companies with data collection (emails, inquiries, etc.)

How can we support each other in the LOWINFOOD consortium?

- Provide manpower/resources to actively support data collection/observations
- Identify synergies between data collection needs and production/processing activities
- Exchange views and experiences (think outside the box)

Objectives of the evaluation

The evaluation shall help to improve the performance of LOWINFOOD's innovations and shall trigger replication to move towards our common goal to generate low-waste food chains.

Actors involved in LOWINFOOD's innovations

LOWINFOOD's consortium consists of partners with complementary knowledge and competences: The more scientific part is covered by **researchers**, who are called to facilitate the demonstration of a set of innovative solutions proposed by the **innovators** (companies which provide and implement innovations to reduce food waste) in a number of settings provided by **food chain actors**. During these demonstrations, other actors and companies of the food chains, that are external to the consortium, are also included. They will be involved in the LOWINFOOD **Innovation Platform**.

The key actor is the **user of the innovation,** e.g. retailer, restaurants, schools, bakeries, households. As those are directly involved in the innovations, but not involved in the consortium, it is a delicate and challenging situation to win their trust and willingness to cooperate with the

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project and to share information as well as data. The user of the innovation can be furthermore grouped on the one hand into **food surplus provider (=seller, donor)**, e.g. farmers, producers, on the other hand the **food surplus receiver (=buyer, beneficiary)**, e.g. charities. These sub-groups of the user are applied for actions linked to food redistribution or transactions.

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2 Multi-actor approach

Projects under the Horizon 2020 are required to apply the "multi-actor approach". This means that projects must focus on real problems or opportunities that different actors of the supply chain are facing and that partners with complementary knowledge – scientific, practical and other – must join forces in the project activities from beginning to end (EIP- AGRI, 2017).
In LOWINFOOD, the implementation of the multi-actor approach was horizontally and vertically integrated with the structure of the project. The structure of the project foresees that every demonstration of innovation against food loss and waste (FLW) makes up a task of WP2, WP3, WP4 and WP5 of the project; in each of these tasks, at least one research partner is involved, together with innovators and companies hosting the demonstration. During the multi-actor discussion of the methodological framework, WP1 task leaders established a continuous discussion both horizontally, with the research partners involved in the demonstration tasks across different WPs and food chains, and vertically, within each task, with the actors involved in the demonstration of single innovations. Such a process assured the involvement of all the components of the project in the establishment of a common methodological framework.
The strategy for setting the methodology of WP1 in a multi-actor approach is illustrated in Fig. 2. The steps of this process are explained below. Impacts of innovations shall be measured for two systems, which are set in comparison:

- Conventional Food Supply Chain (**baseline);** the system before implementation of innovation and
- Low-waste Food Supply Chain (**innovation**); the system after the implementation of innovation

Methods for the impact assessment need to be both practical and robust. Therefore, several feedback loops have been necessary between data collectors and data providers. The process of defining the goal and scope for evaluation including the selection of indicators is an iterative process. Hence, the evaluation approach is continuously adapted during the elaboration of a common methodology.
In the process for setting the methodology it is furthermore relevant to generate a common understanding of terms and definitions used within the evaluation, as well as the specific scope and boundaries (what is included, what is excluded from the assessment). For this, **a value chain map** is created for each innovation illustrating processes and actors involved in the innovation, as shown in **factsheets** for each innovation in the ANNEX I.

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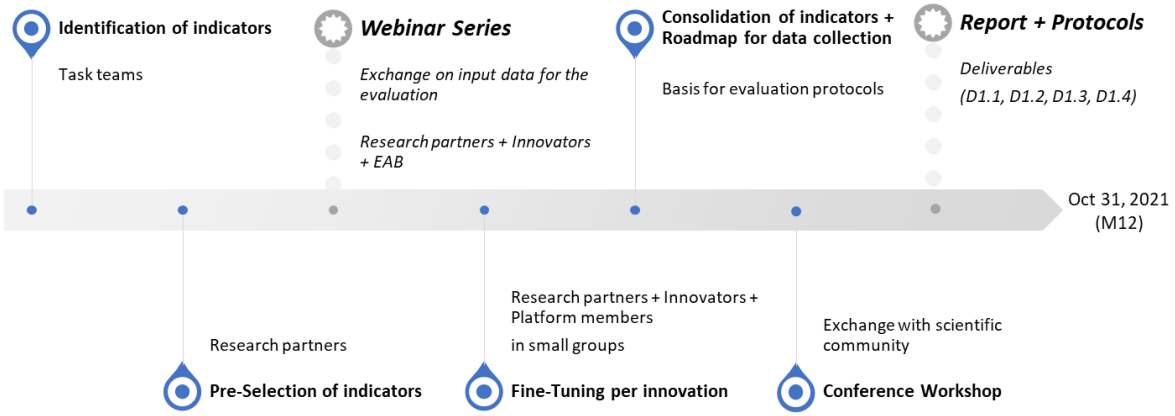

Figure 2: Timeline for the methodology setting in a multi-actor approach (M1-M12)

Identification of indicators

A range of indicators is available for assessing sustainability (e.g. profitability, utility, competitiveness, global warming potential, consumer behaviour). However, not all indicators are appropriate for assessing the sustainability impacts identified here and not all of the appropriate indicators are applicable to the innovations demonstrated within the scope of LOWINFOOD. In addition to concerns around data collection and disclosure, there are also concerns about some indicators that could lead to a potentially and lower quality of responses as a result (e.g. awareness of own food wastage).

So, a careful selection of indicators is the prerequisite of a successful evaluation. At first, a range of indicators relevant for LOWINFOOD's innovations were identified by the core team of research partners, which were then further reduced in the course of discussions (or by applying the Delphi method in case of efficacy) among the research partners and only later (to reduce burdens for the companies) with the innovators.

Pre-Selection of indicators

Drawing on the FUSIONS Policy Evaluation Framework (Burgos et al., 2016), indicators were pre-selected according to the following principles:

- **Attainable**: The measurement of the indicators should be achievable by the stakeholders/partners involved and should be sensitive to the improvements the innovation wishes to achieve.
- **Clear (transparent)**: Indicators should effectively target the factor they are measuring and should avoid ambiguity and arbitrariness in the measurement.
- **Comparable**: The indicator measurement should enable comparison over the different implementation phases of the innovation if required, as well as between different innovations.

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- **Comprehensible**: The definition and expression of the indicator should be intuitively and easily comprehensible to users.
- **Cost-effective**: The cost (and time) of collecting and processing the data needed for the indicators should be reasonable and affordable.
- **Up to date**: Indicator information should be as up to date as possible, to reflect current or recent circumstances. The impact of delays between collection and use (refinement) should be considered.
- **Measurable**: Indicators should be defined so that their measurement and interpretation are unambiguous, preferably using data that is readily available, relevant, reliable, and meaningful.
- **Redundant**: While each input variable should measure a discrete phenomenon, separate indicators that measure the same phenomenon may be necessary and desirable.
- **Relevant**: Indicators should be directly relevant to the issue being monitored or assessed and should be based on clearly understood linkages between the indicator and the phenomenon considered.
- **Reliable**: The results from an indicator should be replicable by different researchers using standard methods. The methods should be stable over time, and valid in as wide a circum-stance as possible.
- **Sensitive**: Indicators should reflect small changes in those aspects that the actions intend to change.

Webinar series

The first LOWINFOOD's webinar series took place in May 2021. The objectives of the webinars were:

- to inform participants about indicators to evaluate efficacy, impacts on society and economy and on the environment.
- to discuss the compilation and quantification of input data for the evaluation.

The webinar was targeted to both the innovators and the food chain companies which are members of the LOWINFOOD consortium and that are hosting the demonstration of the innovations. The webinars were classified by the type of food and step of the Food Supply Chain (FSC): Fish waste (May 10), Food waste at food service, (May 12), Food waste at households, (May 20), Bread waste (May 26), Fruits & Vegetable waste (May 27).

A first set of indicators was presented by task leaders for each evaluation dimension (efficacy, socio-economic, environment) to the companies and organisations introducing the innovations. The methods, as well as the input data, which were necessary for calculating the indicators were shortly introduced and included in a supporting document. The value chain map for each innovation was discussed to ensure that both research partners as well as innovators have the same understanding of the process to evaluate.

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Input data for the evaluation

For each indicator, a list of input data needed for its assessment was compiled by the research partners in charge of the evaluation. These data are the 'bricks' that are needed to build the evaluation for each innovation. The compilation and quantification of these bricks requires careful elaboration. Firstly, **type and unit of input data** was clarified and further elaborated in bilateral discussions between the WP1 task leaders and the leaders of the innovation tasks. Furthermore, the **source for the input data** as well as the frequency and the quantification method (survey, records, etc.) were defined in common. The expectations around the allocation of responsibilities in data collection, and agreement of its frequency and timeline; both for indicators drawing from financial accounts, and for the implementation of surveys had to be clarified in several feedback loops.

A data matrix giving an overview of evaluation needs served as a basis for a consultation process between research partners and practitioners within each of the 15 innovation tasks (belonging to WP2, WP3, WP4 and WP5). The data matrix presents the maximum data requirements for the evaluation. Adaptations were expected for each innovation as each demonstration task is different; furthermore, some actors are more accessible than others and the efforts for quantifying input data are different (sometimes data is available from records; sometimes data needs to be directly measured).

Fine-tuning per innovation

The data matrix served as a basis for the fine-tuning process for each innovation. Data facilitators (staff members of research partners involved in the innovation, see also definition in chapter 7) were selected to organise and lead **discussions with companies** implementing the innovations within LOWINFOOD. The feasibility of data needs as well as possible data sources were discussed. This process required several meetings in small groups.

Following discussions, data facilitators were asked to compile **first drafts of questionnaires** addressing stakeholders for requesting data and information which need to be obtained for the evaluation. Guiding questions were provided from the corresponding partners for each evaluation dimension.

Consolidation process and roadmap for data collection

The questionnaire drafts were checked for **completeness** as regards the data needs for the evaluation and **consistency** among each other. For this, the type of questions (open or closed-ended), their structure (e.g. Likert scale), the answering possibilities (in case of multiple answers), and the order and the manner of the questions were consolidated as much as possible. However, it needed to be considered, that each respondent may need a different style of questionnaire. So, the intention was not to provide one questionnaire with a strict set of questions which fits to all stakeholders and all innovations, but rather to provide questionnaires which are adapted to the needs and availabilities of respondents. The needs and availabilities of respondents were estimated by actors within the LOWINFOOD consortium which are mostly experienced working with respondents and so, can estimate the time and willingness to contribute to a survey. This is the strength of the multi-actor approach.
We will include a gender perspective and ensure **gender equality** throughout the evaluation, disaggregating data by sex, accounting for multiple inequalities and for women's needs. Data will

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be collected disaggregated by sex using the categories female, male, other and prefer not to say. In this way different gender identities will have visibility. The age of the participants will be another indicator to be taken into account. Both vertical and horizontal segregation will also be analysed by asking participants about the position and sector to which they belong to, and the satisfaction of each person with the questionnaire will be taken into account. In the case of the innovation to be carried out at household level, the types of families will be analysed according to the age and sex of each member and an attempt will be made to ensure the participation of different types of families.
The current status of questionnaire drafts is displayed in the ANNEX of D1.2, D1.3 and D1.4. So, the discourse on the elaboration of questionnaires has already been started. However, a final set of questionnaires still need to be produced before distribution to stakeholders.

Conference workshop

Although methodological approaches for the different evaluation dimensions are largely developed (e.g. Caldeira et al., 2019) and guidelines or standards exist (e.g. ISO standards for life cycle assessment), there are still open questions when implementing the methods in practice. The intention within LOWINFOOD is to apply both a robust but feasible methodology for the evaluation. For this, various questions arise when implementing the method in practice. Questions such as the data quality, the disaggregation level of food waste amounts, the influence of internal and external factors to the evaluation results, the identification of a meaningful baseline, the sample size when food waste amounts are directly quantified, and the handling of confidential data. Consequently, a conference workshop was organised to discuss some of the critical issues when it comes to evaluation in practice.
The workshop was conducted in the framework of the Symposium on Waste Management and Sustainable Landfilling (Oct 11th to Oct 15th, 2021) in Cagliari, Sardinia (IT). The Symposium takes place every second year, and the topic "Food Waste" has become an important session topic for more than 10 years at the Symposium. The structure of the workshop, including five introductory lectures of LOWINFOOD partners, is shown in the ANNEX II.

Development of report and protocols

This report about the methodological framework (D1.1) and the dedicated protocols for the data collection (D1.2 for environmental data, D1.3 for data to evaluate the efficacy and D1.4 for socio-economic data) including the draft questionnaires has been compiled with the support of the whole consortium, since all partners were involved in the discussion and development processes. The multi-actor approach was fully adopted. Its strength to define a feasible but robust methodology out-weighed its weakness of being a long and complex approach involving a lot of efforts by each partner.

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3 Framework of the innovations

Innovation types and groups

LOWINFOOD's innovations aim to reduce food waste by prevention (e.g. prevention of surplus food at source), redistribution (e.g. by food donations) and reprocessing (e.g. reprocessing of surplus food for human consumption), and are therefore situated in the upper halve of the waste hierarchy (European Commission, 2008) or the food use hierarchy (Papargyropoulou et al., 2014; Wunder et al., 2018). Innovations make use of technological (e.g. forecast software, waste tracker, app), organisational (e.g. cooperation, dialogues) and educational measures to achieve this goal. LOWINFOOD's innovations can be grouped into the following types of actions according to Caldeira, De Laurentiis, and Sala (2019):

A. Actions of the type 'Food redistribution'

R1 RER Software for F&V (T2.1)
R2 UNV cooperation system for F&V (T2.2)
R3 Leroma B2B digital marketplace for F&V (T2.3)
R4 Leroma B2B digital marketplace for fish (T4.2)

B. Actions of the type 'Consumer behaviour change'

B1 CozZo Mobile app (T5.5)
B2 REGUSTO Mobile app (T5.6)
B3 MATOMATIC Plate waste tracker (T5.3)
B4 SLU/AIE Holistic educational approach (T5.4)

C. Actions of the type 'Supply chain efficiency'

S1 FORESIGHTEE software for packed F&V (T2.4)
S2 FT Software for bakeries (T3.3)
S3 KITRO Innovative bin (T5.1)
S4 MITAKUS Forecasting software for restaurants (5.2)

D. Actions of the type 'Food waste prevention governance'

G1 Supplier-retailer agreements (T3.1)
G2 Stakeholder dialogue in the bread value chain (T3.2)
G3 Stakeholder dialogue in the fish value chain (T4.1)

E. Actions of the type 'Food valorisation'

V1 (T2.3) Leroma B2B digital marketplace for F&V by-products (T2.3)
V2 (T4.2) Leroma B2B digital marketplace for fish by-products (T4.2)

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Food Waste categories

LOWINFOOD uses the term 'food loss and waste' (FLW), which refers to "any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)" (Östergren et al., 2014). This term reflects the EU definition of 'food waste' but also the definitions by the FAO of 'food losses' and 'food waste' (FAO, 2021). However, differently from the EU regulation (Commission Delegated Decision (EU) 2019/1597), which does not include in the definition the crops which are not harvested because they are not considered 'food' (regulation 178/2000), LOWINFOOD also includes losses at primary production since some of the LOWINFOOD innovations might aim at recovering them too.

LOWINFOOD's innovations cover specific parts of FLW, whereby the general focus is on the avoidable part that is by definition of Quested and Johnson (2009) "food and drink thrown away that was, at some point prior to disposal, edible (e.g. slice of bread, apples, meat)." or by definition of Lebersorger and Schneider (2011) "which are still unrestrictedly edible at the time of their disposal or which would have been edible if used in time". However, also unavoidable FLW can be covered in some innovations that is "waste arising from food or drink preparation that is not, and has not been, edible in normal circumstances (e.g. meat bones, egg shells, pineapple skin, tea bags)." (Quested & Johnson, 2009).

In the description of LOWINFOOD's innovations a further classification of FLW is necessary:

Surplus food (avoidable food waste): is arising in food production and distribution chain for a variety of reasons and is by definition of European Commission (2017) "consisting of finished food products (including fresh meat, fruit and vegetables), partly formulated products or food ingredients". "Foods which do not meet manufacturer and/or customer specifications (e.g. variations in product colour, size, shape, etc.) as well as production and labelling errors can generate surplus in the agricultural and manufacturing sectors for instance. Difficulties in managing supply and demand can lead to over-ordering and/or cancelled orders." This applies to surplus fruits & vegetables (T2.1, T2.2, T2.3, T2.4), surplus bread (T3.1, 3.2, 3.3) and surplus fish (T4.1, T4.2) in LOWINFOOD.

Kitchen waste (avoidable and unavoidable food waste): is typically arising in restaurants and food service as well as households, but also in retail and other distribution sectors. According to the waste code included in the European list of waste for types of waste which typically includes food waste, this fraction is covered in "20 01 08 - biodegradable kitchen and canteen waste".

Plate waste (avoidable food waste): is a sub-category of kitchen and canteen waste. Generally, food waste in restaurants and canteens can be categorized by its receiving point (e.g. storage, preparation, dishwasher sieve, serving and plate) (C. Caldeira, Sara, & Serenella, 2017).

By-products (unavoidable food waste): are defined as circular flows of food removed from the FSC to be used to produce other products such as animal feed or biomaterials (Carla Caldeira, De Laurentiis, Corrado, van Holsteijn, & Sala, 2019). Although by-products are according to the EU definition not included in food waste, it is often classed and reported as waste in industrial

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context (Corrado et al., 2019). Therefore, it is also included in LOWINFOOD's innovations (T2.3, T4.1, T4.2).

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4 Method for the evaluation of efficacy

Goal and method

Measuring the efficacy of innovations is of primary relevance to assess success of the innovation actions and to enable their replicability. By efficacy, the innovation's actual capacity to reduce food waste (in mass, volume, or number of items) is meant. Such reduction may be achieved by means of avoiding the generation of FLW (prevention at source) or by changing the destination of the food discarded, thus avoiding its disposal as waste. Apart from the reduction in the quantity of FLW achieved through the implementation of the innovations, these indicators also cover other issues, e.g. the possibility of creating food side streams within FLW along the entire value chain, replicability potential, user-friendliness and utility. The identification of Key Performance Indicators (KPIs) is intended to evaluate the innovation's feasibility, but also to guide the stepwise and systematic implementation, and validate the overall project success. Ultimately, the indicators are used to confirm the achievement of the project's objectives, i.e. the project's overall impact on the reduction of FLW at all stages of the supply chain and on the development and implementation of more sustainable and profitable business models.

Data resulting from the implementation of innovations in the food value chains through quantification and evaluation of selected performance indicators, will be used to estimate the potential impact on FLW reduction at a larger scale. For each innovation, FLW is quantified before the innovation demonstration and during the demonstration. Quantification methods lie on the Delegated Decision of May 3, 2019, of the European Commission on a common methodology and minimum quality requirements for the uniform measurement of levels of FLW (e.g. waste composition analysis, surveys, records) and the UNEP's food waste index. Last, special attention has been given to practicality in the implementation.

Pre-selected indicators

The efficacy

Following our primary goal of FLW prevention and reduction, the major indicator for evaluating the efficacy is

- The amount of Food Loss and Waste (FLW) prevented thanks to the LOWINFOOD's innovations

An 'absolute' indicator will address the amount of FLW avoided thanks to the innovation by looking at FLW before and during the innovation. Furthermore, each innovation will be evaluated according to 'relative' indicators aiming at assessing the FLW rate over the amount of food processed (see Fig. 1).

A further list of indicators will then address the innovation performance in terms of:

- Replicability: to what extent can the innovation be applied to other contexts?

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- User-friendliness: is the innovation easy to use? Does it require technical expertise to be performed?
- Utility: is the innovation useful and profitable?

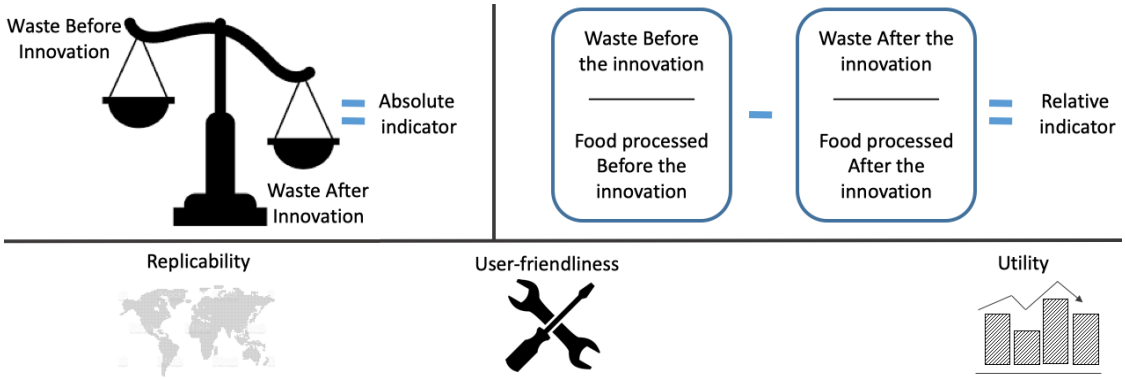

Figure 3: Illustration of measuring efficacy in LOWINFOOD's innovations

The utility, replicability, and user-friendliness

During the WP1 meeting held on 01/03/2021, the necessity to move the evaluation of utility, replicability and user-friendliness indicators in charge to Task 1.3 on the socio-economic evaluation to the efficacy task emerged. Therefore, a second task meeting was organized on 30/03/2021, devoted to a thorough discussion of KPIs on utility, replicability and user-friendliness.

The result of the discussion led to the creation of a second table reporting the KPIs for utility, user-friendliness and replicability. The table was sent out in the latest draft of the methodology.

The following definitions were employed:

Replicability: also defined as transferability and scalability, described as the potential of the innovation or pilot test to be replicated, scaled up, expanded, or adapted. It aims to understand the innovation features that enable or constrain replicability.

Questions identified that the indicator should be able to address:

- Is it easy to assess the results (monitoring, evaluating processes)?
- Does it generate direct or indirect economic resources and benefits itself or is it sustainable only through external funding? If yes, how long does it take after the adoption of the innovation to see the results?
- Is it easy to access and start the innovation? - Does the innovation require many resources in order to be adopted? (Partly adapted from Chapter 3.2. Guidance on assessing the replicability of IFES, FAO 2014 Link).

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User-friendliness: consists of usability + satisfaction, both from the innovator and final user perspective (innovators and final user to be defined for each innovation). (Based on what has been discussed in T 1.3).

The indicator should address the following questions:

- Is the application of the innovation easy to perform?
- Can all relevant staff members operate the innovation easily?
- Are innovations easy to maintain (i.e. check-ups) or does it require the help of the innovation providers?
- Does the innovation require specific training or know-how to be implemented?
- Does the innovation require many resources in order to keep performing it?

Utility: usefulness - the state of being useful, profitable, or beneficial.

The process of pre-selection – the Delphi method

As the consortium's academic partners have been already engaged in FLW reduction activities in the past but they all have a different background, a consultation was value-added. Considering that this task was the first to be accomplished all together with the academic partners of the project, we decided to set up a Delphi consultation (Okoli & Pawlowski, 2004). The Delphi shows many advantages compared to other consultation methods: it avoids direct confrontation of the experts, thus leaving every single expert free to provide its contribution without being influenced by group dynamics. A certain degree of anonymity for the individual responses is guaranteed (see box 1 in ANNEX III).

The selection of the most appropriate methods and KPIs relies upon a dialogue between the stakeholders involved, in a two-step process. The first step involves the academic partners in a theoretical exercise to define a quantification method for each innovation; to achieve the output, a Delphi has been run among the academic partners, until the consensus has been reached. The second step involves the stakeholders, thus the innovators and the beneficiaries of the innovation, in a consultation phase to refine the methodologies proposed and assess their feasibility.

The first round involved all the academic partners of the WP1 and started on 28 January 2021. Academic partners were asked to fill out one table, providing their view for some or all the innovations with reference to:

1. Indicators and unit of measure
2. KPIs and final target
3. Actors involved
4. Scope (boundaries)
5. Method (baseline and monitoring)
6. Indicators for replicability, user-friendliness and utility

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The second round was sent out on 24/02/2021, and the contributions were expected by 08/03/2021. The second round structure can be found in box 2. In the second round, some additional information was asked:

1. FSC and scope (based on REFRESH): PP: Primary Production, FP: Food Processing, RD: Retail and Distribution, FS: Food Service, C: Consumer/Household
2. Indicators of efficacy
3. Method: who is performing the data collection (innovator or researchers)
4. Duration of measurements
5. Open questions to innovations
6. Actors involved

Especially with reference to the indicators, some different points of view were recorded, thus a dedicated file to address them was necessary. This additional file aimed at extrapolating the issues where no consensus was reached and at leaving space for comments and suggestions. All the comments on the additional file were collected in complete experts' autonomy and anonymously.

The open issues mainly concerned the way the absolute indicators and relative indicators of efficacy should be collected. The experts were asked to choose the formulation they like the most, merge the formulations, suggest a further formulation and/or comment on the right side of the table.

Emerging contrasting issues could not be solved in two rounds only. Therefore, Task leaders decided to organize a Task meeting (22/03/2021) to be able to discuss each of the open issues more in-depth. During this meeting, attention was focused on the absolute and relative indicators, method, duration of measurement, actors involved.

From the meeting, most of the issues that were still open from the additional file reached a consensus. Although only two rounds of Delphi were initially foreseen to set up the efficacy methodology, a final round became necessary after the two task meetings to find a common solution to the open issues and consolidate the final draft of the efficacy part. To make the process faster, the third Delphi round was organized as a questionnaire where experts had to express their agreement about specific aspects.

The contrasting issues addressed in the final round can be summarized as follows:

- Whether or not to group comparable innovations (i.e., Producers-oriented innovations, Forecasting-oriented innovations, Stakeholders-oriented innovations, Plate waste-oriented innovations, Household-oriented innovations) and to add a common indicator for each group of innovations.
- Whether or not to adopt a common terminology across projects and to use the definition of Food side-flows when referring to products.
- Whether or not to conduct additional measurement by means of interviews to address potential further sources of FLW of the food traded through innovation
- Further discussion on the duration of measurement and reference unit for some innovations.

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- Discussion on the proposal of a new absolute indicator for innovations 5.1, 5.2, 5.3, 5.4, 5.5.

The structure of the third Delphi round is shown in Box 4 in the ANNEX III.

The final Delphi round was also submitted in a different way compared to the first two rounds, a shared folder on Google Drive was sent out to all task partners on 09/04/2021. The folder contained the latest draft of the methodology, the "Additional file" and a file containing the illustration of Value Chains for each innovation to clearly identify the "Innovator" and "Final user" of each innovation and to illustrate the process underlying each innovation.

Conclusions

The Delphi method has been an essential tool to reach a consensus among individuals. The potentials of this approach derive from its adaptability to several needs, like theoretical formulation, as well as the search for practical solutions (Jones et al., 2015). It also allows thinking individually, according to each one's time and focus needs (Linstone & Turoff, 1975). Finally, participants do not influence each other, and we avoid social desirability bias (ibidem).

On the other hand, the Delphi approach shows some weaknesses as it relies too much on the role of the moderators. Thus, errors from the moderators could lead to participants' misjudgements regarding the type of request and information they are expected to provide. Another aspect to be considered is the time and the effort that this approach requires, especially from the point of view of the moderators (Vázquez-Ramos, Leahy, & Estrada Hernández, 2007).

Employing a Delphi method as a strategy for methodology setting had many advantages, including:

- The anonymity of participants, as the identity of the person filling in the questionnaire is not revealed.
- The possibility to think individually according to each one's time and focus needs.
- Avoiding influencing each other and social desirability bias, that is the tendency to underreport ideas that might be considered as socially undesirable.
- The possibility to get inputs from experts in the re-definition of the structure of the methodology.

At the same time, our experience showed that adopting a Delphi method requires a continuous commitment from both the facilitator and the experts and it was not possible to reach a consensus without face-to-face discussions (held online) to elaborate participant's views.

Key aspects for a successful adoption of the Delphi method have been identified based on the activities carried out in Task 1.2, as follows:

- We experienced the importance of having a partner acting as facilitator both in terms of trying to find a compromise when contrasting ideas emerged and having a key role in elaborating all contributions received and reconciling all different points of view.
- The importance of foreseeing a tool to converge participant responses.

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- The need of alternating between rounds of anonymous individually filled questionnaires with face-to-face meetings.

The final step of the creation of a methodology consisted of a joint effort with Task leaders from Task 1.3 and Task 1.4, who oversaw the socio-economic evaluation and of the environmental evaluation respectively to develop the protocols for evaluation.

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5 Method for the evaluation of economic and social impacts

Goal and method

This analysis aims to assess the socio-economic outcomes of implementing different innovations against food loss and waste (FLW) in different types of supply chains across different locations in Europe.

The assessment will be carried out through calculating a set of indicators. For indicators that could be captured quantitatively, integer and decimal numbers as well as percentages will be collected; ; for more qualitative indicators, appropriate data formats (e.g. rankings, free text entries) will be used. The results and their implications will be interpreted considering the local and policy context and supply chain conditions. The final list of socio-economic indicators is in Table 1.

The data facilitators will collect the primary data at the level of participating organisations (e.g. shops, bakeries, farms, school canteens, restaurants, and households). There are two scales at which we plan to assess the data collected (at the baseline and after implementation):

1. At the company level (or household) where data relating to the economic and social indicators will be measured.
2. At community or supply chain levels.

The assessment of the first level will rely on primary data collected through the surveys, and some indicators will not be relevant for all innovations, given the wide range of data providers (e.g. households, farms, supermarkets, restaurants etc.). Depending on the indicator, the unit of measurement will be either the currency (e.g. what the savings are in terms of local currency and the equivalent amount in Euros), full time equivalent of jobs created (e.g. to manage an app) or lost (e.g., due to reduced waste management needs or, upstream, due to lower input needs), or the number of people involved (e.g. number of jobs created, number of female staff and household members involved in the innovation and surveys). For some indicators (e.g. new partnerships upstream and horizontally, or downstream diversification), we will measure and discuss the changes qualitatively. When relevant (i.e. for changes in employment or for the roles in managing the innovations, where a gender dimension is present), we will also assess the process and allocation of resulting outcomes from a gender equality perspective (e.g. comparative impact on women and other genders). Thus, indicators to account for the gender aspect were incorporated.

System boundaries

An important aspect in terms of system boundaries is the geographical location (country, region) where the demonstration takes place. In this regard, the outcomes of each innovation will be assessed for each location separately as well as for all the locations jointly, and compared across the different locations where these are implemented. Also, innovations targeting similar stakeholders or types of waste in different supply chains will be discussed comparatively. The

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cumulative socio-economic outcome of the innovations demonstrated in the LOWINFOOD project will be compared to similar examples of innovation assessment in the literature (Caldeira et al., 2019). Some of the innovations demonstrated in LOWINFOOD focus on specific actors and supply chain levels; for these innovations, and for the resulting data constraints, it is not possible to quantitatively assess the trade-offs and impacts on other supply chain levels upstream and downstream in the framework of the Lowinfood evaluation process. Thus, our system is represented by the company, although spill-over effects on the region and on other companies will be detected qualitatively through indicators 11, 12, 16 and 17 in Table 1. Instead, other innovations operate in the interface between different actors of the supply chain; in these cases, the impacts will be assessed both on the downstream and upstream actors. However, a later goal of T1.3 is the elaboration of (qualitative) supply chain scenarios on the basis of the results of the evaluation process. This exercise will allow to broaden the scope of the evaluation by considering potential trade-offs upstream and downstream.

Identification of relevant impact categories:

To identify relevant impact categories in the socio-economic domain, a literature review was implemented. This section illustrates the results of the literature review, and how they were used to identify a final list of impact indicators ranging across different levels and domains.

The studies that investigate the socio-economic impacts of FLW reduction can be grouped based on the levels at which the assessment is implemented. These scales, and the related evaluation decisions, include first the basic measurement unit (e.g. household or companies), which focuses on setting up theoretical frameworks and implementing them to estimate the socio-economic impact. Second, they include supply chain, national or regional (e.g. EU) level macroeconomic assessment, which adopts modelling and scenario analysis techniques and secondary data to estimate macro-economic impacts of reducing FLW. Finally, it includes programme-level assessments, which evaluates the outcome of specific interventions implemented in the scope of specific programmes in different case studies or/and locations (Caldeira et al., 2019; Philippidis et al., 2019; Scherhaufer et al., 2015).

Organisations involved in the generation (and thus evaluation) of FLW can be both commercial organisations, like processing companies, restaurants, agricultural businesses, supermarkets, etc., and non-profit organisations like school canteens (if managed by public companies), and households. As for organisations, the generation of FLW relates to multiple factors internal or external to them, such as information asymmetry; uncertainty in the supply chain and (in)efficiencies in the market such as price transmission, inelasticity of production, and lack of competitiveness; low technological innovation; limited market access; inadequate procurement and stock management in the organisation; etc. (Scherhaufer et al., 2015). Similarly, uncertainty, bad meal planning, poor management of food lead to FW in the households. Lack of awareness about FLW and how to prevent it, and repeated patterns of behaviour that cause waste of food could be applicable to both households and other organisations. Accordingly, the indicators were identified to assess the capacity of the innovations tested in the LOWINFOOD project to address relevant factors and reduce FLW below their baseline levels.

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While the management of an organisation is expected to implement a cost-benefit analysis of any innovations they invest in, innovations targeting FLW at the level of individual companies and cases are not publicly available due to their content of potentially commercially sensitive information. Furthermore, these cost-benefit analysis may neglect FLW and their socio-economic and environmental impacts if these represent externalities for which the organisation does not bear a cost. Thus, not only the FLW innovation literature (Aramyan & Valeeva, 2016; Lombardi & Costantino, 2020; Stenmarck, Jensen, Quested, & Moates, 2016), but also the wider food production and eco-innovation literatures (Beitzen-Heineke, Balta-Ozkan, & Reefke, 2017; Garcia Martinez & Briz, 2000; Horbach, Oltra, & Belin, 2013; Kowalski, 2014; Smol, Kulczycka, & Avdiushchenko, 2017) and available sectoral analyses (Dias-Ferreira, Santos, & Oliveira, 2015) were reviewed to complement the choice of indicators.

The innovations proposed in the scope of the LOWINFOOD project potentially impact three distinct levels: (1) directly, on the implementing organisations; (2) indirectly, on the supply chain and the community where the innovation takes place; and (3) at the project level, in terms of fostering product and market development of innovators and SMEs, and aiding supporting organisations (e.g., the Emilia-Romagna Region) in the demonstrations. While socio-economic outcomes at participating organisations and at project levels will be assessed using the same indicators based on the primary data collected in the LOWINFOOD project, supply chain and community level effects will be later estimated in a scenario-planning exercise, combining the primary data from the questionnaires with extant statistics and literature. Depending on further needs and the quality of the collected data, simple quantitative simulations can also be employed in this part of the analysis. Nevertheless, employment-related aspects such as the number of households supported by the jobs (potentially) created, and spill-over effects on other companies in the region are covered by our final list of indicators.

The relevant impact categories shown in Table 1 are constructed based on the scale of analysis, and by considering whether the implementing organisations can provide the necessary data. Noteworthy, the data need to be provided by the organisations adopting the innovation, not by the innovators (those who developed the innovation). However, the latter will work as facilitating intermediators, e.g. by embedding the surveys in their processes (e.g. in their online platform), so that the implementing organisations can record the data required for assessments when using the innovation.

Data requirements

As a first step, a longer list of indicators was developed; then, this list was reduced by relying on expert opinion (online consultation of LOWINFOOD WP1 partners). More details on this process, including the questionnaire used for the consultation, are provided in ANNEX IV.

Selected socio-economic impact categories and their indicators are shown in Table 1.

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Table 1: Socio-economic indicators selected after discussing with LOWINFOOD partners

Impact category	Indicator
ECONOMIC INDICATORS AT ENTERPRISE LEVEL	
Profitability	1. Change in direct input costs (food inputs)[1] 2. Change in fixed costs due to the innovation (e.g., storage space) 3. Change in variable costs due to innovation (e.g., energy, water) 4. Change in organic waste management costs 5. Change in the selling price of the product(s) involved 6. Creation of new income streams 7. Rate of return on investment 8. Change in access to subsidies and/or other financial benefits
Scale	9. Change in total value of sales of the product(s) involved 10. Change in total hours worked, disaggregated by gender 11. New partnerships upstream and horizontally 12. Downstream diversification (e.g., number and type of buyers)
Competitiveness	13. Change in the productivity of material inputs (input-output ratio)
SOCIAL INDICATORS AT ENTERPRISE LEVEL	
Behaviour	14. Change in the awareness of the FLW problem of the staff and management 15. Change in the attitude towards reduction of FLW of the staff and management
COMMUNITY-(SOCIETY-) AND SUPPLY CHAIN LEVEL INDICATORS	
Creation of local jobs	16. Change in the number of jobs (and full time equivalents), disaggregated by gender
Spill-over effects	17. Similar technological change in other companies (e.g., request to adopt the same innovation)
GENDER-RELATED INDICATORS	
Vertical segregation	18. Share of different genders involved in implementing the innovation, by job grade
Horizontal segregation	19. Share of different genders involved in implementing the innovation, by company sector
Share of genders interviewed	20. Share of different genders interviewed out of the total number of people interviewed
Survey satisfaction	21. Share of different gender interviewees who assessed the survey positively

The final list of data bricks to assess the socio-economic impacts including the unit, data source and frequency is provided for each innovation in Deliverable 1.4.

[1] While the innovation could have an impact on other inputs like packaging, this is not a focus of the LOWINFOOD project. While this first indicator allows us to assess the "direct" impact on food input requirements, the third indicator will provide additional information by focusing on overall variable costs.

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6 Method for the evaluation of environmental impacts

Goal and method

The aim of the environmental evaluation is to provide quantitative data on environmental impacts on natural resources, human health and the environment of FLW prevention and reduction activities from the innovations. The method for the evaluation of environmental impacts follows the rules for LCA based on ISO 14044 (ISO, 2006a, 2006b) and the handbook and guidelines from the International Reference Life Cycle Data (ILCD) System (European Commission, 2010) and the Product Environmental Footprint (PEF) (Zampori and Pant, 2019, European Commission, 2013). Also following FLW related impact assessment approaches developed by the JRC technical report 'Assessment of food waste prevention actions' (Caldeira et al., 2019), H2020 project REFRESH (Unger, Davis, Loubiere, & Östergren, 2016) and Interreg Central Europe STREFOWA will be taken up.

Functional unit

Environmental performance of each innovation is reported against their functional unit. The functional unit quantifies the performance of a product system for use as a reference unit. All assessed innovations aim to reduce FLW at different points within the value chain. Innovations might also deliver other functions, such the increase in efficiencies, providing food to people in need. In line with the aim the functional unit is defined as **tonnes of food prevented from being wasted.**

The corresponding reference unit will be reported for each innovation following the data collection.

System Boundaries

The scope of the assessment includes all activities impacted by the innovations. Grouped into the following categories:

Innovation action: The evaluation includes all activities directly associated with the innovation. LOWINFOOD's innovation actions can be grouped into the following steps of the food waste hierarchy: 1. FW prevention at source (via e.g. forecasting systems, educational concepts) and 2. Food redistribution (surplus food to other stakeholders).

Avoided production: Based on the assumption that food consumption stays constant, FLW prevention increases the efficiency of the supply chain and hence decreases the amount of food required to be produced to satisfy the same demand. Environmental benefits arising from this avoided production are evaluated within the scope of the assessment. Avoided production needs to be evaluated for each innovation.

Baseline system replaced: The baseline covers the system before the innovations are implemented, and includes the current waste management system (e.g. FLW currently ends up at residual waste bin), as this system is replaced by the action when food is no longer wasted or properly recycled.

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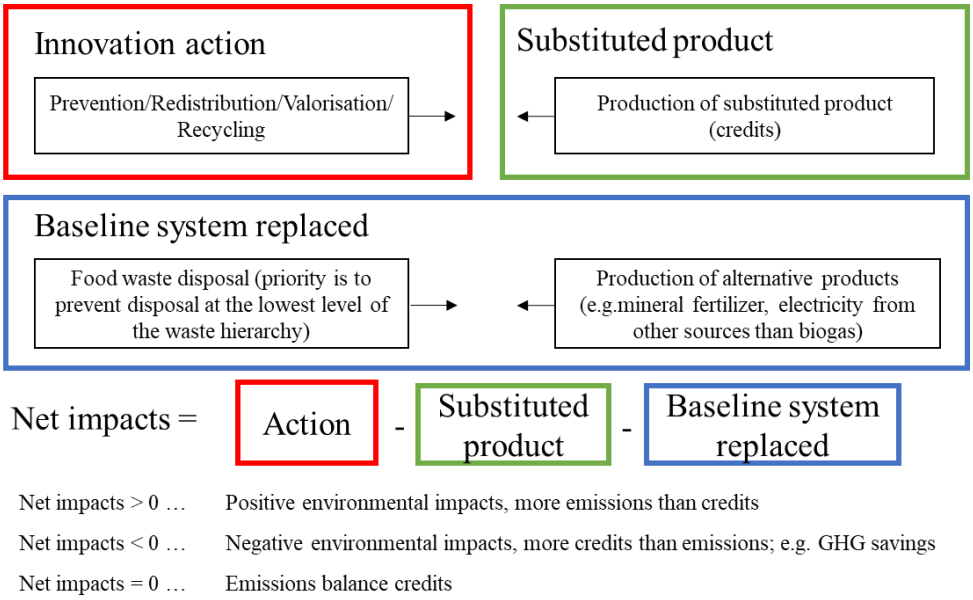

Figure 4: Modelling approach of the environmental impact assessment of FLW prevention and reduction based on Obersteiner and Scherhaufer (2020)

The avoided production and replaced baseline system represent a saving, while the innovation action is a burden; therefore, the algebraic sum of the three components provides the overall net environmental savings.

Identification of relevant impact categories

Selected indicators are based on the Product Environmental Footprint (PEF) method. PEF recommends considering at least three impact categories. The most relevant impact categories shall be identified as all impact categories that cumulatively contribute to at least 80% of the total environmental impact (excluding toxicity related impact categories).

The selection was undertaken based on existing PEF pilot studies on food products and expert consultation within the LOWINFOOD task group. Five Product Environmental Footprint Category Rules (PEFCRs) for feed and food products have been published to date (Dairy, Beer, Wine, Feed and Pet foods). The resulting ranking of impact categories within these five product groups can be found in Table 11 of ANNEX V. Additionally, research partners working in the field of Life Cycle Assessment have been asked for consultation (see ANNEX V).

Impact categories identified as relevant for the assessment of the LOWINFOOD innovations are:

- Climate change
- Acidification
- Eutrophication
- Land use
- Water use
- Resource use

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There is currently no international consensus on a life cycle impact assessment method capturing Biodiversity. However, the other impact categories (i.e. climate change, eutrophication aquatic freshwater, eutrophication aquatic marine, eutrophication terrestrial, acidification, water use, land use, and ecotoxicity freshwater effect) have an impact on biodiversity. In pilot actions where biodiversity is relevant for the scope of an individual innovation this shall be stated. Soil quality is assessed applying the soil quality index based on LANCA (Beck et al 2010 and Bos et al 2016) as applied in the Land Use indicator (PEF Method). The choice of environmental indicators included in the evaluation will be adjusted in case it will become apparent that other indicators will have a higher relevance.

Data Requirements

Data covering all activities associated with the innovation action will be collected during the project. Emissions associated with energy use, transportation activities, the use of ICT equipment, additional packaging requirements and other relevant activities will be reported based on primary data collected during the project and up and downstream activities will be included based on life cycle inventory databases. Additionally, the FLW amounts which will be collected through the evaluation of the efficacy (see chapter 4).

The food diverted from being wasted is assumed to replace food production elsewhere ("substituted product"). This assumption is not necessarily based on evidence. In fact, the extent to which preventing FLW affects food production is not known. Nevertheless, such a phenomenon is expected to take place in the long term (Caldeira et al., 2019). The type and amount of food that is replaced will be defined for each innovation based on the kind of food that is diverted from being wasted and the location in the value chain where the innovation takes place.

For innovations dealing with redistribution the replaced product is the product that the receiving organisation or group of individuals would purchase in case they would not receive the food redistributed. For innovations increasing the supply chain efficiency of a certain product it can be assumed that these will lead to a decrease of demand and consequently a decrease of production of the same product that has been diverted from being wasted. Hence it can be assumed that the same product that is prevented from being waste does not require to be produced.

The calculation of the embedded impacts in food products is based on the types and amounts of food products reported and the stage of the supply chain where the FLW is avoided. The JRC (Caldeira et al., 2019) developed background data for the environmental impact for the production of 32 food commodities, representing the impacts of food consumption of an average European citizen. The background data encompasses five stages of the food supply chain (agricultural production, processing, packaging, retail and use), based on Notarnicola, et al. (2017) and Omolayo et al. (2021). This background data will be applied within LOWINFOOD and extended/adapted if required.

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Before the introduction of the FLW prevention innovation, a greater amount of food ended up as waste. Environmental impact associated with this waste depends on the amount of waste, how the waste was sorted and disposed and the waste management systems available in the region. Amounts and sorting activities will be reported based on primary data. Downstream waste management activities will be reported based on waste statistics and life cycle inventory databases.

Input data for each innovation can be found in the dedicated protocols in D1.2.

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7 Roadmap for data collection

Data collection method

Data is collected in various forms in LOWINFOOD's innovations. The most applied collection method to receive quantitative and qualitative data is the distribution of **questionnaires (Q)**. Questionnaires are targeted to specific actors directly involved in LOWINFOOD innovations. The list of questions is based on the principal input data ('data bricks') which is necessary for the evaluation. However, the phrasing of the question is adapted to actual needs and when necessary, translated to national languages. Principally, open and closed questions as well as questions using a 'Likert-scale' are used. First set of questionnaires were developed for each innovation and are displayed in the ANNEX of D1.2, D1.3, and D1.4. In most of the innovations a specific set of questions is used to ask before implementation or upon registration (in case of registration at a platform, e.g. Leroma market place) and another set to ask after the implementation or at each food transaction. In some innovations a mid-term survey is additionally conducted (T3.3, T5.1, T5.2). Only one set of questions is planned for T2.2, T3.1 and T5.3 to reduce the burdens for stakeholders. For this, the change due to the innovation will be estimated by the respondent. The way of asking questions is not fixed, yet. Most of the questionnaires will be asked by personal interviews, only some will be automatically transferred to the stakeholders (by using online survey methods). The survey will be complemented by quantitative data via acquisition of companies' records about sales, food loss and waste, and other economic data.

Another major source of data will constitute the databases used or owned by innovation partners (e.g. software, apps, database); called here after **innovation database (I)**. Data which can be retrieved from the innovation database and which are used for the evaluation is identified in the consolidation process. The data transfer needs to be settled between the owner of the data (usually the innovation partner) and the data collector (usually the research partner). The format of the data transfer can be in MS Excel or other possibilities. The frequency of the data transfer is depending on the scope of the demonstration phase.

The management of this data, as well as the measures undertaken to secure personal data, are reported in the deliverables 7.3 and 8.2 respectively.

As self-assessment of FLW amounts by households has been demonstrated as problematic in previous research (Giordano et al. 2019), data with regard to FLW amounts need to be collected in certain cases on-site. A **direct quantification (D)** of FLW amounts is therefore carried out in T5.2, T5.3, T5.4, T5.5 and T5.6. The method for the FLW quantification is agreed among research and innovation partners in the consolidation process.

Other data sources (O) include company records (C), national studies, and regional and sectoral studies and statistics when available, as well as expert consultation (E). National studies on, e.g. specific food sectors or FLW studies, might be consulted for presenting the baseline situation or might complement data needs for the evaluation.

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The preliminary status of chosen methods for data collection is given in Table 2 for each innovation. For details per innovation, it is referred to the corresponding deliverables: D1.2 for the FLW protocols, D1.3 for the environmental data protocols, D1.4 for the socio-economic data protocols.

Table 2: List of indicators for the evaluation and respective data collection methods per innovation – status Oct 2021 (Q … questionnaire, I … Innovation database, D … Direct quantification, C … company records, E … expert consultation, O … other sources, / … not applicable to the innovation)

	List of indicators for the evaluation	T2.1	T2.2	T2.3	T2.4	T3.1	T3.2	T3.3	T4.1	T4.2	T5.1	T5.2	T5.3	T5.4	T5.5	T5.6
EFFICACY	Indicators for the efficacy															
	Food waste amounts - absolute indicator	I	I	I + Q	C	C + O	C + Q	C	Q	I	I	D	D	D	D	D
	Food waste amounts - relative indicator	I + Q	I + Q	I + Q	I + Q	I + Q	C	C	Q	I + Q	I + Q	D + Q	D + Q	D + Q	D + Q	D + Q
	Replicability	Q	Q	Q	Q	Q	Q	Q + I	Q	Q	Q	Q	Q	Q	Q	Q
	User-friendliness	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Utility	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SOCIO-ECONOMIC	Economic indicators at enterprise level															
	Profitability	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Scale	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Competitiveness	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Social indicators at enterprise level															
	Behaviour	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Community-(society-) and supply chain level indicators															
	Creation of local jobs	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Spill-over effects	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Gender-related indicators															
	Vertical segregation	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Horizontal segregation	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Share of genders interviewed	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
	Survey satisfaction	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
ENVIRONMENTAL	Environmental indicators for the avoided production															
	Food commodity	I	I	I	I	E	E	D	E	I	I	I	E	E	Q + D	Q
	Stage of the food supply chain	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
	Environmental indicators for the innovation action															
	Computer use	Q	Q	Q	Q	/	/	Q	/	Q	Q	Q	Q	/	Q	Q
	Transport	Q	E	Q	/	/	/	/	Q	Q	/	/	/	/	Q	Q
	Packaging	Q	E	Q	Q	/	Q	/	Q	Q	/	/	/	/	/	Q
	Other activities (storage, etc.)	Q	/	Q	/	/	/	/	Q	Q	/	/	/	/	/	Q
	Environmental indicators for the baseline															
	Food waste management	Q	E	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q

Data facilitators, collectors, and controllers

The collection of data within LOWINFOOD's innovations requires a careful plan to ensure maximum efficiency and maximum confidentiality. For this purpose, **data facilitators** were appointed, which shall represent the link between the innovation partners in WP2-5 and the evaluation partners in WP1. The tasks of data facilitators comprise the development of questionnaires in accordance with the data matrix of WP1; the consolidation of the questionnaires in collaboration with innovation partners; the development of a data collection roadmap (time schedule) and, finally, the provision of processed data to the WP1 evaluation task leaders. The discourse has already been started and a first set of consolidated questionnaires is presented as an Appendix to D1.2, D1.3 and D1.4. Data facilitators are LOWINFOOD research

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partners which are directly involved in the innovations (in most cases they are also the innovation task leader).

Another key role is that of **data collector**. The data collector is the partner who receives the raw data retrieved from questionnaires, surveys, or from the innovation databases. This role can be shared by both a research partner and an innovation partner. For example, the innovation partner collects data via their software tools and databases, or directly from questionnaires. Then, the data is processed by the innovation partner or, if agreed, by the research partner before it can be used for the evaluation. This processing step may include the filtering of data according to the evaluation needs, the filling of data gaps, and the aggregation of data to the reference unit (e.g., transactions per month). The reprocessed (and where required anonymised) data is transferred directly or via the data facilitator to the WP1 evaluation task leader for conducting the evaluation.

Special attention is given to personal data. The LOWINFOOD partners that collect personal data are called **data controllers**. The data controller is responsible for the security of personal data against loss, theft, and unauthorised access. The data controller commits to restrict as far as possible the number of staff members in their organisation that have access to original and non-processed personal data, in order to avoid any data breaches, and is responsible for their appropriate management according to the principles described in D8.2. In practice, the data controller needs to encrypt any personal data and to anonymise the datasets and the aggregated data before the data is forwarded or further processed.

Further details on the data management are described in D7.3.

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Table 3: LOWINFOOD partners who represent data facilitator, data collectors and data controllers per innovation

Innovation task	Data collector(s)	Personal Data Controller(s) (as for D8.2)	Data facilitator
T2.1	**UNIBO**, RER	*no Personal Data*	**UNIBO**
T2.2	**BOKU**, UNV	*no Personal Data*	**BOKU**
T2.3	**ISUN**, LER	*no Personal Data*	**ISUN**
T2.4	**FOR**, **UNITUS**, SLU, TAU	*no Personal Data*	**UNITUS**
T3.1	**SLU**, **TAU**, UNITUS, CNA	*no Personal Data*	**SLU** (SE), TAU (FI), UNITUS (IT)
T3.2	TAU, SLU, **UNITUS**, CNA	**UNITUS, SLU, TAU**	**TAU** (FI), SLU (SE), UNITUS (IT)
T3.3	**ISUN**, FT, ADB	**ISUN, ADB, FT**	ISUN
T4.1	**JHI, ISUN**	**JHI, ISUN**	**JHI** (Scotl.), ISUN (DE)
T4.2	**ISUN**, LER	*no Personal Data*	**ISUN** (DE), JHI (Scotl.)
T5.1	**ISUN**, KITRO, HUA, AIE, BLU, THA	*no Personal Data*	**ISUN** (DE and CH), HUA (GR)
T5.2	**ISUN**, SLU, MITA	*no Personal Data*	**ISUN** (DE), SLU (SE)
T5.3	**SLU**, AIE, ISUN, MATO	*no Personal Data*	**SLU** (SE), ISUN (DE), AIE (AT)
T5.4	**SLU**, AIE	*no Personal Data*	**SLU** (SE), AIE (AT)
T5.5	**TAU**, **BOKU**, **HUA**, COZ	**COZ, TAU, BOKU, HUA**	**TAU** (FI), BOKU (AT), HUA (GR)
T5.6	**UNITUS, REG**	**REG**	**UNITUS**

Time schedule

Table 4 shows the time frame for the demonstration phase of the innovations according to the Data Management Plan (D7.3). A detailed schedule will be elaborated in up-coming months, as soon as users of the innovations have been contacted (schools, households recruited for testing, bakeries, etc.).

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Table 4: Time frame for the demonstration phase per innovation – preliminary ranges according to the Grant Agreement and D7.3

Innovation ID	Innovation Title	2021										2022												2023												2024												2025	
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
T2.1	RER Software for F&V																																														
T2.2	UNV cooperation system for F&V																																														
T2.3	Leroma B2B digital market place																																														
T2.4	FORESIGHTEE software for packed F&V																																														
T3.1	Supplier-retailer agreements																																														
T3.2	Stakeholder dialogue in the bread value chain																																														
T3.3	FT Software for bakeries																																														
T4.1	Stakeholder dialogue in the fish value chain																																														
T4.2	Leroma B2B digital market place																																														
T5.1	KITRO Innovative bin																																														
T5.2	MITAKUS Forecasting software for restaurants																																														
T5.3	MATOMATIC Plate waste tracker																																														
T5.4	SLU/AIE Holistic educational approach																																														
T5.5	CozZo Mobile app																																														
T5.6	REGUSTO Mobile app																																														

EVALUATION RESULTS

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8 Outlook

The upcoming years in the project are dedicated to the demonstration of the innovations which will be accompanied by a continuous evaluation. Some innovations start with an evaluation of the baseline, some will be evaluated when implementing the innovation. Most demonstrations start between April and June 2022. The data collection process can then be adjusted, if necessary. A continuous exchange between partners in charge of the evaluation and partners demonstrating the innovation is required to ensure a collection of good quality and complete data sets. By October to December 2023, most of the demonstrations will end. Partners in charge of the evaluation will check if all data is complete to conduct the evaluation. Results will be prepared by the evaluation partners in form of illustrative tables or graphs. The interpretation of results will take place again in a multi-actor approach to consider all aspects, not only from scientific point of view but also from practice.

Results will serve as viable and measurable basis for jointly agreed targets and benchmarks, such as the SDGs, EU's circular economy package, EU's Green Deal and the Paris Agreement on Climate Change. The impact assessment and the demonstration of the efficacy of innovations will be published in peer-reviewed journals and in the final deliverables of the project. This ambitious plan requires a regular exchange not only among research partners but also among companies within LOWINFOOD's consortium and other stakeholders involved. This process will be supported with webinars as well as online meetings and (if possible) physical meetings.

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9 References

Aramyan, L., & Valeeva, N. (2016). *Socio-economic implications of food waste : Economics of innovation. REFRESH report.* Wageningen, The Netherlands.

Beitzen-Heineke, E. F., Balta-Ozkan, N., & Reefke, H. (2017). The prospects of zero-packaging grocery stores to improve the social and environmental impacts of the food supply chain. *Journal of Cleaner Production, 140*, 1528-1541. doi:https://doi.org/10.1016/j.jclepro.2016.09.227

Burgos, S. et al. (2016): EU FUSIONS Food Waste Policy Evaluation Framework

Caldeira, C., De Laurentiis, V., Corrado, S., van Holsteijn, F., & Sala, S. (2019). Quantification of food waste per product group along the food supply chain in the European Union: a mass flow analysis. *Resources, Conservation and Recycling, 149*, 479-488. doi:https://doi.org/10.1016/j.resconrec.2019.06.011

Caldeira, C., De Laurentiis, V., & Sala, S. (2019). *Assessment of food waste prevention actions, EUR 29901 EN*. Luxembourg:

Caldeira, C., Sara, C., & Serenella, S. (2017). Food waste accounting. - Methodologies, challenges and opportunities, EUR 28988 EN ; Luxembourg (Luxembourg): Publications Office of the European Union; 2017; JRC109202 ; doi:10.2760/54845

Corrado, S., Caldeira, C., Eriksson, M., Hanssen, O. J., Hauser, H.-E., van Holsteijn, F., . . . Sala, S. (2019). Food waste accounting methodologies: Challenges, opportunities, and further advancements. *Global Food Security, 20*, 93-100. doi:https://doi.org/10.1016/j.gfs.2019.01.002

Dias-Ferreira, C., Santos, T., & Oliveira, V. (2015). Hospital food waste and environmental and economic indicators--A Portuguese case study. *Waste Manag, 46*, 146-154. doi:10.1016/j.wasman.2015.09.025

EIP- AGRI. (2017). *EIP-AGRI Brochure Horizon 2020 multi-actor projects*

European Commission. (2008). *Directive 2008/98/EC on waste (Waste Framework Directive)*.

European Commission. (2010). *International Reference Life Cycle Data System (ILCD) handbook. General Guide for Life Cycle Assessment. Detailed Guidance*. Luxembourg:

European Commission. (2017). *EU guidelines on food donation*.

FAO (2021). Definitions. *https://www.fao.org/platform-food-loss-waste/old-pages/food-loss/definition/en/, accessed Oct 29th, 2021*

LOWINFOOD has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000439.

Garcia Martinez, M., & Briz, J. (2000). Innovation in the Spanish food & drink industry. *The International Food and Agribusiness Management Review, 3*(2), 155-176. doi:https://doi.org/10.1016/S1096-7508(00)00033-1

Giordano, C., Alboni, F., & Falasconi, L. (2019). Quantities, determinants, and awareness of households' food waste in Italy: A comparison between diary and questionnaires quantities. Sustainability, 11(12), 3381.

Horbach, J., Oltra, V., & Belin, J. (2013). Determinants and Specificities of Eco-Innovations Compared to Other Innovations—An Econometric Analysis for the French and German Industry Based on the Community Innovation Survey. *Industry and Innovation, 20*(6), 523-543. doi:10.1080/13662716.2013.833375

ISO. (2006a). Environmental management - Life cycle assessment - Principles and framework (ISO 14040:2006). Geneva, Switzerland: International Organization for Standardization.

ISO. (2006b). Environmental management -Life cycle assessment - Requirements and guidelines (ISO 14044:2006). Geneva, Switzerland: International Organization for Standardization.

Jones, W., Capra, R., Diekema, A., Teevan, J., Pérez-Quiñones, M., Dinneen, J. D., & Hemminger, B. (2015). "For Telling" the Present: Using the Delphi Method to Understand Personal Information Management Practices *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 3513–3522): Association for Computing Machinery.

Kowalski, Z. (2014). *Implementing Eco-Innovations. Determinants and Effects', Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu*.

Lebersorger, S., & Schneider, F. (2011). Discussion on the methodology for determining food waste in household waste composition studies. *Waste Manag, 31*(9-10), 1924-1933. doi:10.1016/j.wasman.2011.05.023

Linstone, H., & Turoff, M. (1975). *The Delphi Method*: Addison-Wesley.

Lombardi, M., & Costantino, M. (2020). A social innovation model for reducing food waste: the case study of an Italian non-profit organization. *Administrative Sciences*.

Notarnicola, B., Tassielli, G., Renzulli, P. A., Castellani, V., & Sala, S. (2017). Environmental impacts of food consumption in Europe. *Journal of Cleaner Production, 140*, 753-765. doi:10.1016/j.jclepro.2016.06.080

Obersteiner, G., & Scherhaufer, S. (2020). Environmental impact of food waste. In C. Galanakis (Ed.), *Environmental Impact of Agro-Food Industry and Food Consumption* (Vol. 308). London: Elsevier.

Okoli, C., & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Information & Management, 42*(1), 15-29. doi:https://doi.org/10.1016/j.im.2003.11.002

LOWINFOOD has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000439.

Omolayo, Y., Feingold, B. J., Neff, R. A., & Romeiko, X. X. (2021). Life cycle assessment of food loss and waste in the food supply chain. *Resources, Conservation and Recycling, 164*, 105119. doi:https://doi.org/10.1016/j.resconrec.2020.105119

Östergren, K., Gustavsson, J., Bos-Brouwers, H., Timmermans, T., Hansen, O-J., Møller H., Anderson, G., O' Connor, C., Soethoudt, H., Quested, T., Easteal, S., Politano, A., Bellettato, C., Canali, M., Falasconi, L., Gaiani, S., Vittuari, M., Schneider, F., Moates, G., Waldron, K., Redlingshöfer, B. (2014). FUSIONS Definitional Framework for Food Waste. Report of the European funded project FUSIONS.

Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N., & Ujang, Z. b. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. *Journal of Cleaner Production, 76*, 106-115. doi:10.1016/j.jclepro.2014.04.020

Philippidis, G., Sartori, M., Ferrari, E., & M'Barek, R. (2019). Waste not, want not: A bio-economic impact assessment of household food waste reductions in the EU. *Resour Conserv Recycl, 146*, 514-522. doi:10.1016/j.resconrec.2019.04.016

Quested, T., & Johnson, H. (2009). *Household food and drink waste in the UK*. Banbury:

Scherhaufer, S., Lebersorger, S., Pertl, A., Obersteiner, G., Schneider, F., Falasconi, L., . . . Easteal, S. (2015). *Criteria for and baseline assessment of environmental and socio-economic impacts of food waste*.

Smol, M., Kulczycka, J., & Avdiushchenko, A. (2017). Circular economy indicators in relation to eco-innovation in European regions. *Clean Technologies and Environmental Policy, 19*(3), 669-678. doi:10.1007/s10098-016-1323-8

Stenmarck, Å., Jensen, C., Quested, T., & Moates, G. (2016). *Estimates of European food waste levels*.

Unger, N., Davis, J., Loubiere, M., & Östergren, K. (2016). *Methodology for evaluating environmental sustainability*.

Vázquez-Ramos, R., Leahy, M., & Estrada Hernández, N. (2007). The Delphi Method in Rehabilitation Counseling Research. *Rehabilitation Counseling Bulletin, 50*(2), 111-118. doi:10.1177/00343552070500020101

Wunder, S., McFarland, K., Hirschnitz-Garbers, M., Parfitt, J., Luyckx, K., Jarosz, D., . . . Van Herpen, E. (2018). *Review of EU policy areas with relevant impact on food waste prevention and valorisation. Report of EU Horizon 2020 REFRESH, D3.3*.

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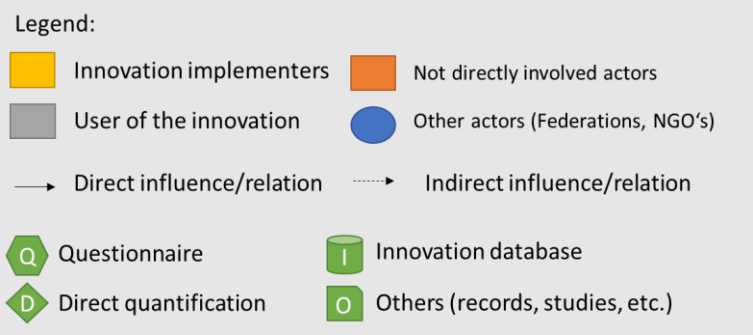
10 ANNEX I. FACTSHEETS

FLW prevention actions presented in factsheets



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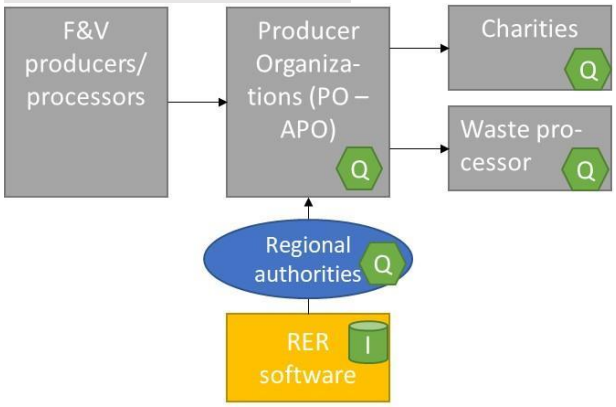
REDISTRIBUTION, Surplus food redistribution	**R1**

TITLE: RER Software for F&V (T2.1)	YEAR: 2021 - 2024
ORGANIZATION: UNIBO, RER, ARE	COUNTRY: IT
SHORT DESCRIPTION: The goal is to scale up the use of a software which is recording all products withdrawn from the markets due to CAP Emergency and prevention tool.	TYPE OF FLW: ● Surplus fruits ● Surplus vegetables
STAGE OF THE FSC: PP	ACTORS: farmers, food processors/manufacturers, charities, waste processors
DATA COLLECTION METHOD:  	Q: are distributed to regional authorities (before and after implementation), to RER Regione Emilia Romagna (once), POS and APOs (before and after implementation), Charitable organizations (before and after implementation), ethanol producing plant (before and after implementation) I: The researchers will retrieve information through the software

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
until Apr. 2024		UNIBO, RER

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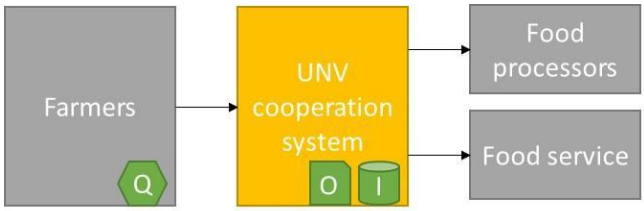
REDISTRIBUTION, Surplus food redistribution	**R2**

TITLE: F&V redistribution in AT (T2.2)	YEAR: 2021 - 2024
ORGANIZATION: UNV, BOKU	COUNTRY: AT
SHORT DESCRIPTION: The goal is to promote the use of surplus F&V and to bridge the gap between farmers and actors in the food service sector in an economic and professional scale in a **network** where UNV acts as an intermediary body to distribute surplus.	TYPE OF FLW: • Surplus fruits • Surplus vegetables
STAGE OF THE FSC: PP, FS	ACTORS: farmers, restaurants, food processors
DATA COLLECTION METHOD: 	Q: are distributed to farmers by UNV (oral interviews) I: data collected via the software is provided in aggregated and anonymous form from UNV to BOKU O: Research on market prices

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
2021 - ongoing	Research on market prices	BOKU
Spring/2022 until	Personal interviews, database records	UNV
First output Dec 2021, then continuously	Output of the innovation database	UNV

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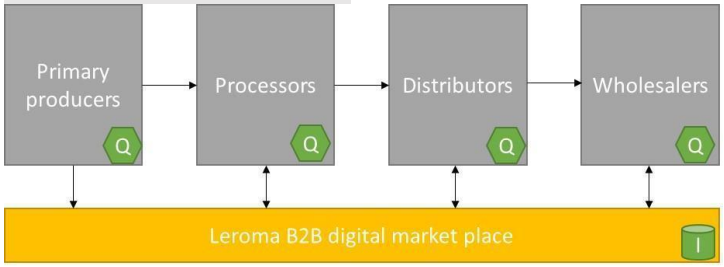
REDISTRIBUTION, Surplus food redistribution	R3

TITLE: Leroma B2B digital marketplace for F&V (T2.3)	YEAR: 2021 - 2024
ORGANIZATION: ISUN, LER	COUNTRY: DE
SHORT DESCRIPTION: The goal is to promote the use of a B2B marketplace for food commodities (prototype: https://leroma.de/) building a bridge between producers and manufacturers or retailers.	TYPE OF FLW: • Surplus fruits • Surplus vegetables
STAGE OF THE FSC: PP, FP, RD	ACTORS: producers, manufacturers, wholesalers, retailers
DATA COLLECTION METHOD: 	Q: are distributed to platform users at registration, after each food transaction to both seller and buyer and to selected companies (at the end of the task) I: data collected via the software

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
2021 - ongoing	Recording of data from transactions	LER, iSuN
Early 2022	Distribution of initial questionnaires (or questionnaire-based interviews) with selected enterprises using Leroma	iSuN
2022-23	Distribution of questionnaires questionnaires (or questionnaire-based interviews) to be filled by sellers respectively purchasers (selected companies as part of a case study) after a food transaction	iSuN
2024	Distribution of questionnaires (or questionnaire-based interviews) with selected enterprises using Leroma at the end of the task	iSuN

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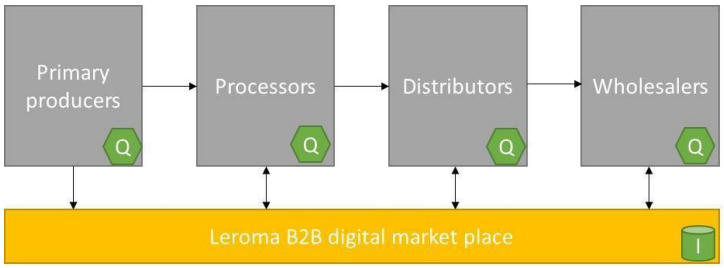
REDISTRIBUTION, Surplus food redistribution	**R4**

TITLE: Leroma B2B digital marketplace for fish (T4.2)	YEAR: 2021 - 2024
ORGANIZATION: ISUN, JHI, LER	COUNTRY: DE, Scotland
SHORT DESCRIPTION: The goal is to promote the use of a B2B marketplace for food commodities (prototype: https://leroma.de/) building a bridge between producers and manufacturers or retailers.	TYPE OF FLW: • Surplus fish
STAGE OF THE FSC: PP, FP, RD	ACTORS: producers, manufacturers, wholesalers, retailers
DATA COLLECTION METHOD: 	Q: are distributed to platform users at registration, after each food transaction to both seller and buyer and to selected companies (at the end of the task) I: data collected via the software

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/ Data controller*
2021 - ongoing	Recording of data from transactions	LER, iSuN
Early 2022	Distribution of initial questionnaires (or questionnaire-based interviews) with selected enterprises using Leroma	iSuN
2022-23	Distribution of questionnaires questionnaires (or questionnaire-based interviews) to be filled by sellers respectively purchasers (selected companies as part of a case study) after a food transaction	iSuN
2024	Distribution of questionnaires (or questionnaire-based interviews) with selected enterprises using Leroma at the end of the task	iSuN

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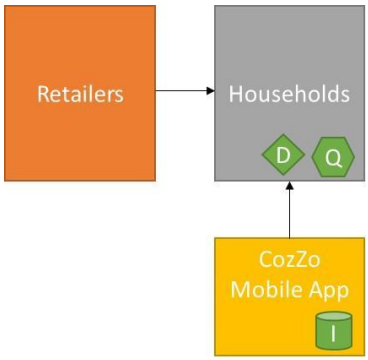
CONSUMER BEHAVIOUR CHANGE, Digital tool for behaviour change	B1

TITLE: CozZo Mobile app (T5.5)	YEAR: 2021 - 2023
ORGANIZATION: TAU, HUA, BOKU, COZ	COUNTRY: AT, FI, GR
SHORT DESCRIPTION: The goal is to provide, improve and demonstrate the efficacy of mobile application which tracks purchased and cooked food enabling more accurate food purchasing and leading to less food wastage.	TYPE OF FLW: ● Avoidable part of food waste
STAGE OF THE FSC: C	ACTORS: consumer
DATA COLLECTION METHOD:  	Q: are distributed to households before and after implementation (test phase) I: data collected via the software is provided by COZ D: Direct quantification of FLW amounts at households is conducted in each country during the test phase

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
Continuously	Data obtained from the software	COZ*
From 2022	Data from demonstration at Finish households	TAU*
From 2022	Data from demonstration at Austrian households	BOKU*
From 2022	Data from demonstration at Greek households	HUA*

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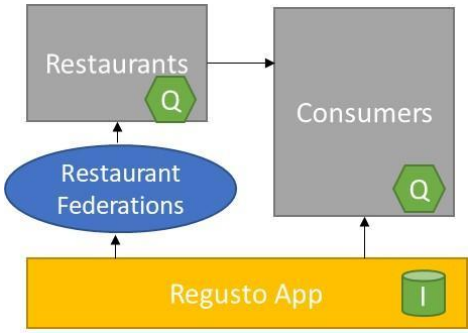
CONSUMER BEHAVIOUR CHANGE, Digital tool for behaviour change	B2

TITLE: REGUSTO Mobile app (T5.6)	YEAR: 2021 - 2023
ORGANIZATION: UNITUS, REG	COUNTRY: IT
SHORT DESCRIPTION: The goal is to improve the mobile application that allows consumers to buy meals at reduced price from restaurants and to monitor the food brought at home up to the bin.	TYPE OF FLW: ● Avoidable part of food waste, more specifically plate waste
STAGE OF THE FSC: FS, C	ACTORS: restaurants, consumers
DATA COLLECTION METHOD:  	Q: are distributed to restaurants and consumers (before and after implementation) I: data collected via the software is provided by REG

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
Until Dec 2023	Personal data is collected by REG	REG*
Until Dec 2023	Other data is collected and processed by UNITUS	UNITUS

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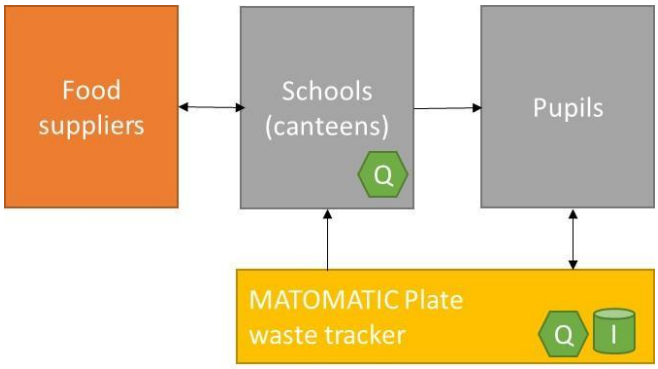
CONSUMER BEHAVIOUR CHANGE, School programs	B3

TITLE: MATOMATIC Plate waste tracker at school (T5.3)	YEAR: 2021 - 2023
ORGANIZATION: MATO, ISUN, SLU, UPP, AIE	COUNTRY: AT, SE
SHORT DESCRIPTION: The goal is to nudge pupils to waste less by informing them about the quantity of food they are leaving in their plate, using a simplified and expressive communication including gamification provided by a technological innovation.	TYPE OF FLW: ● Avoidable part of food waste, more specifically plate waste
STAGE OF THE FSC: FS, C	ACTORS: schools, kitchen staff, pupils
DATA COLLECTION METHOD:  	Q: are distributed to users of the software; that are selected school canteens in Sweden, Germany and Austria (before and after implementation) I: data collected via the software is provided by MATO.

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
until Dec 2023	Data collected by the software	MATO
until Dec 2023	Data collected from schools in Germany	ISUN
until Dec 2023	Data collected from schools in Sweden	SLU/UPP
until Dec 2023	Data collected from schools in Austria	AIE

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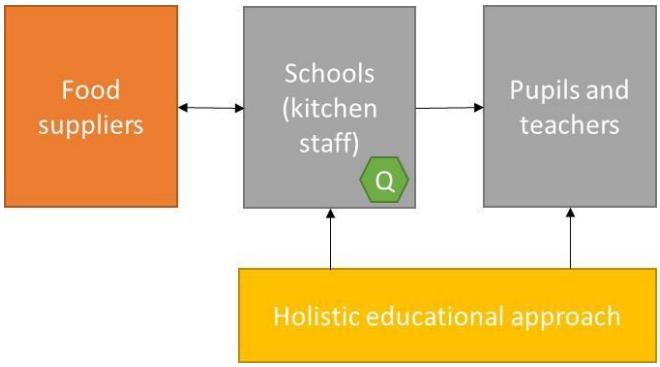
CONSUMER BEHAVIOUR CHANGE, School programs	B4

TITLE: SLU/AIE Holisitc educational approach (T5.4)	YEAR: 2021 - 2023
ORGANIZATION: SLU, AIE, MATO, UPP	COUNTRY: AT, SE
SHORT DESCRIPTION: The goal is to innovate the approach to FLW at school canteens by involving pupils and kitchen staff in educational activities focused on raising the awareness of the FLW issue.	TYPE OF FLW: ● Avoidable part of food waste
STAGE OF THE FSC: FS, C	ACTORS: schools, kitchen staff, pupils
DATA COLLECTION METHOD:  	Q: are distributed to users of the educational approach, that is kitchen staff at selected schools in Sweden and Austria (before and after implementation)

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
Until Dec 2023	Data collected from selected schools in Sweden	SLU/UPP
Until Dec 2023	Data collected from selected schools in Austria	AIE

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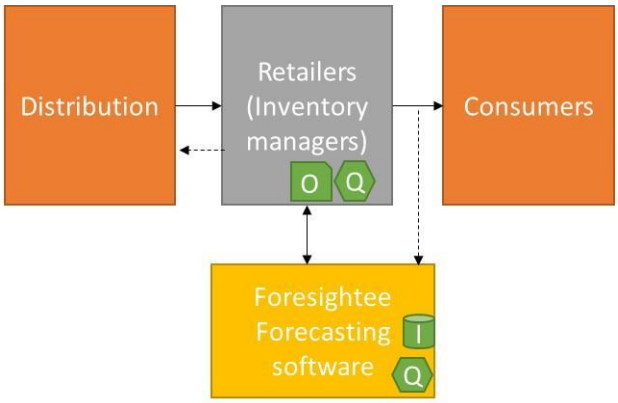
SUPPLY CHAIN EFFICIENCY, Digital tools for supply chain efficiency	S1

TITLE: FORESIGHTEE software for packed F&V (T2.4)	YEAR: 2021 - 2024
ORGANIZATION: FOR, UNITUS, TAU, PICO	COUNTRY: FI
SHORT DESCRIPTION: The goal is to demonstrate the potential waste reduction that can be achieved with better sales forecasts, by using of a newly developed machine learning sales forecasting technology in the operational environment of supermarkets.	TYPE OF FLW: • Surplus fruits • Surplus vegetables
STAGE OF THE FSC: RD	ACTORS: retailers
DATA COLLECTION METHOD: 	Q: are distributed to Retailers and Foresightee I: forecasts provided by the Foresightee software are used to evaluate the efficacy of the innovation O: supermarket store records are used to collect data on waste and sales

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
Until Feb 2024	Data facilitator is UNITUS	FOR, UNITUS, SLU, TAU

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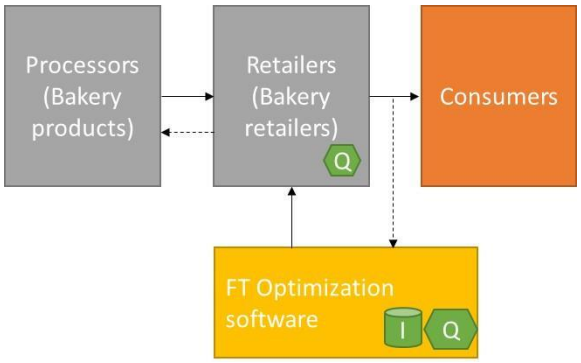
SUPPLY CHAIN EFFICIENCY, Digital tools for supply chain efficiency **S2**

TITLE: FT Software for bakeries (T3.3)	YEAR: 2021 - 2023
ORGANIZATION: ISUN, FT, ADB	COUNTRY: DE
SHORT DESCRIPTION: The goal is to foster market replication of a demand planning software ("FoodTracks") that provides exclusive insights for the purchase orders, sales and human resource management of bakery production sites and their subsidiaries.	TYPE OF FLW: • Surplus bread and bakery products
STAGE OF THE FSC: FP, RD	ACTORS: bakeries, bakery retailers
DATA COLLECTION METHOD: 	Q: are distributed to users of the software, that are bakery retailers. I: data collected via the software by FT

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
Past and ongoing	Past data is used as input for FT system	FT
Until 01/2022	Implementation of FT	FT
04/2022	Latest start of 12 months data collection	FT, ISUN
Until 04/2023	Ending of data collection	FT, ISUN

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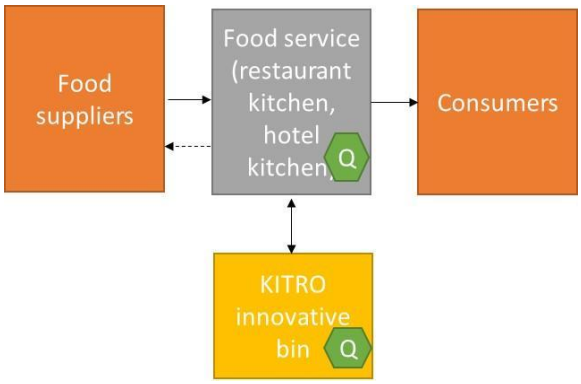
SUPPLY CHAIN EFFICIENCY, Digital tools for supply chain efficiency	S3

TITLE: KITRO Innovative bin (T5.1)	YEAR: 2021 - 2023
ORGANIZATION: ISUN, HUA, KITRO, BLU, THA, AIE	COUNTRY: DE, GR
SHORT DESCRIPTION: The goal is to make informed decisions and optimize work practices by providing restaurants, canteens and hotels with a fully automated FLW management solution by combining image processing and deep learning technologies with a hardware solution.	TYPE OF FLW: ● Avoidable part of food waste
STAGE OF THE FSC: Food service	ACTORS: restaurants, canteens, hotels
DATA COLLECTION METHOD:  	Q: are distributed to users of the software, that are restaurants or hotel canteens in Germany and Greece. I: data collected via the software by KITRO.

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
11/2021-04/2022	Implementation of Kitro	Kitro
Until ca. 04/2023	Collection of baseline and monitoring data in Germany and Greece	Kitro, HUA, THA, BLU, ISUN

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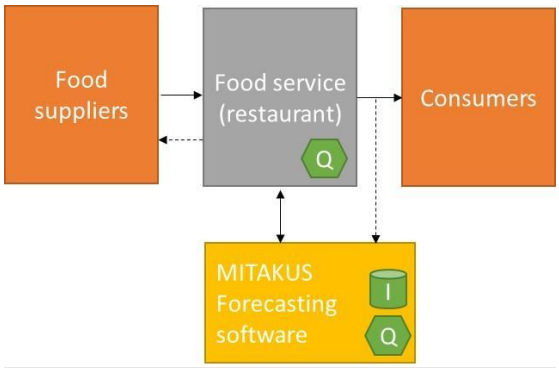
SUPPLY CHAIN EFFICIENCY, Digital tools for supply chain efficiency **S4**

TITLE: MITAKUS Forecasting software for restaurants (T5.2)	YEAR: 2021 - 2023
ORGANIZATION: ISUN, SLU, MITA	COUNTRY: DE, SE
SHORT DESCRIPTION: The goal is to support decision makers in planning the amount and the composition of menus based on past sales data and customer preferences by providing a web-based software working with artificial intelligence algorithm.	TYPE OF FLW: • Avoidable part of food waste • Reduction of overproduction
STAGE OF THE FSC: Food service	ACTORS: restaurants
DATA COLLECTION METHOD: 	Q: are distributed to users of the software, that are selected restaurants in Sweden and Germany. I: data collected via the software by MITA.

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
11/2021-05/2022	Implementation of Mitakus	Mitakus
Until ca. 05/2023	Collection of baseline and monitoring data	Mitakus, ISUN, SLU

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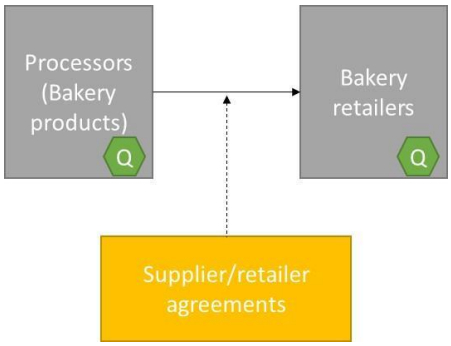
FLW PREVENTION GOVERNANCE, Voluntary agreements	G1

TITLE: Supplier retailer agreements (T3.1)	YEAR: 2021 - 2023
ORGANIZATION: SLU, UNITUS, TAU, CNA	COUNTRY: FI, SE, IT
SHORT DESCRIPTION: The goal is to demonstrate the efficiency of new business models for bread supply by agreements between retail stores and bakeries.	TYPE OF FLW: • Surplus bread
STAGE OF THE FSC: FP, RD	ACTORS: bakeries, retailers
DATA COLLECTION METHOD: 	Q: are distributed to stakeholders of the supplier/retailer agreements, that are commercial and industrial producing companies as well as retailers of bakery products in Finland, Sweden and Italy.

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
Until Oct 2023	Data facilitator is SLU.	SLU, UNITUS, TAU, CNA

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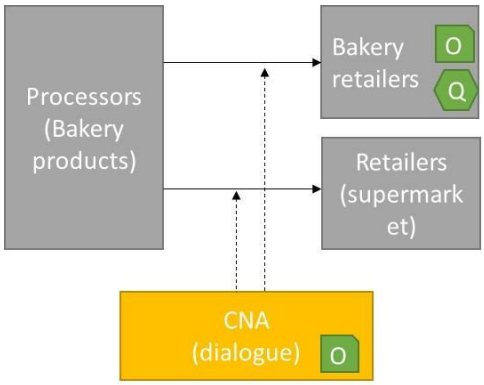
FLW PREVENTION GOVERNANCE, Stakeholder dialogue	G2

TITLE: Stakeholder dialogue in the bread value chain(T3.2)	YEAR: 2021 - 2024
ORGANIZATION: TAU, UNITUS, SLU, CNA	COUNTRY: FI, SE, IT
SHORT DESCRIPTION: The goal is to promote the coordination of bakeries by organising discussion roundtables and analysing organisational, managerial, contractual and logistic issues related to the waste of bread. As a result of the dialogue, a roadmap for bakeries will be agreed upon.	TYPE OF FLW: • Surplus bread
STAGE OF THE FSC: FP, RD	ACTORS: bakeries, bakery retailers, retailers
DATA COLLECTION METHOD: 	Q: are distributed to bakeries before and after implementation. O: company records will complement the survey.

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/ Data controller*
Until Feb 2024	Personal data and other data are collected by UNITUS for Italian dialogue	UNITUS*
Until Feb 2024	Personal data and other data are collected by SLU for Swedish dialogue	SLU*
Until Feb 2024	Personal data and other data are collected by TAU for Finish dialogue	TAU*

FLW PREVENTION GOVERNANCE, Stakeholder dialogue	G3

TITLE: Stakeholder dialogue in the fish sector (T4.1)	YEAR: 2021 - 2024
ORGANIZATION: JHI, ISUN	COUNTRY: Scotland, DE

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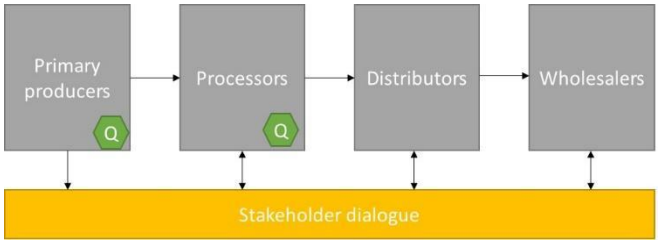
SHORT DESCRIPTION: The goal is to promote coordination between actors in the fish sector by providing an in-depth overview to identify supply chain shortcomings and hotspots of food loss and waste as well as the scope of interventions.	TYPE OF FLW: • Surplus fish
STAGE OF THE FSC: PP, FP, RD	ACTORS: fisheries, processors, distributors, wholesalers
DATA COLLECTION METHOD: 	Q: are distributed to platform users (upon registration), stakeholders (before an event) as well as to both sellers and buyers (at each food transaction)

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/Data controller*
Until Oct 2024	Data facilitator is JHI, personal data is collected by JHI and ISUN,	JHI*, ISUN*

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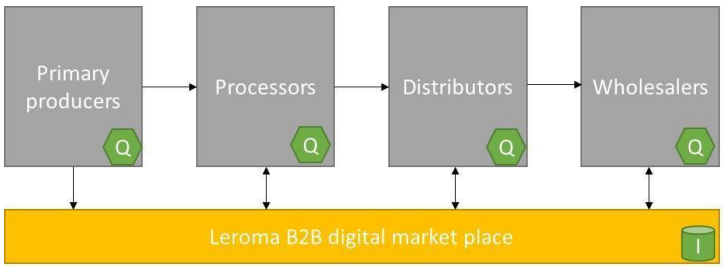
VALORISATION, Value added processing	V1

TITLE: Leroma B2B digital marketplace for F&V (T2.3)	YEAR: 2021 - 2024
ORGANIZATION: ISUN, LER	COUNTRY: DE
SHORT DESCRIPTION: The goal is to promote the use of a B2B market place for food commodities (prototype: https://leroma.de/) building a bridge between producers and manufacturers or retailers.	TYPE OF FLW: • By-products of the F&V industry
STAGE OF THE FSC: PP, FP, RD	ACTORS: producers, manufacturers, wholesalers, retailers
DATA COLLECTION METHOD: 	Q: are distributed to platform users at registration, after each food transaction to both seller and buyer and to selected companies (at the end of the task) I: data collected via the software

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/ Data controller*
2021 - ongoing	Recording of data from transactions	LER, iSuN
Early 2022	Distribution of initial questionnaires (or questionnaire-based interviews) with selected enterprises using Leroma	iSuN
2022-23	Distribution of questionnaires questionnaires (or questionnaire-based interviews) to be filled by sellers respectively purchasers (selected companies as part of a case study) after a food transaction	iSuN
2024	Distribution of questionnaires (or questionnaire-based interviews) with selected enterprises using Leroma at the end of the task	iSuN

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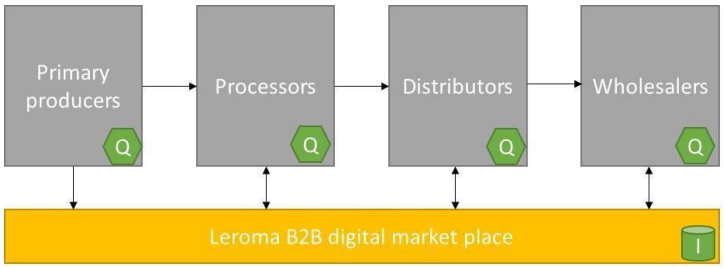
VALORISATION, Value added processing	V2

TITLE: Leroma B2B digital marketplace for fish (T4.2)	YEAR: 2021 - 2024
ORGANIZATION: ISUN, JHI, LER	COUNTRY: DE, Scotland
SHORT DESCRIPTION: The goal is to promote the use of a B2B marketplace for food commodities (prototype: https://leroma.de/) building a bridge between producers and manufacturers or retailers.	TYPE OF FLW: • By-products of fish industry
STAGE OF THE FSC: PP, FP, RD	ACTORS: producers, manufacturers, wholesalers, retailers
DATA COLLECTION METHOD: 	Q: are distributed to platform users at registration, after each food transaction to both seller and buyer and to selected companies (at the end of the task) I: data collected via the software

ROADMAP FOR DATA COLLECTION:

Time period	Description	Data collectors/ Data controller*
2021 - ongoing	Recording of data from transactions	LER, iSuN
Early 2022	Distribution of initial questionnaires (or questionnaire-based interviews) with selected enterprises using Leroma	iSuN
2022-23	Distribution of questionnaires questionnaires (or questionnaire-based interviews) to be filled by sellers respectively purchasers (selected companies as part of a case study) after a food transaction	iSuN
2024	Distribution of questionnaires (or questionnaire-based interviews) with selected enterprises using Leroma at the end of the task	iSuN

11 ANNEX II. CONFERENCE WORKSHOP

LOWINFOOD has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000439.

WORKSHOP DESCRIPTION

Workshop title:

Evaluation of innovations against food waste: efficacy, socio-economic, and environmental aspects

Organizer/s (name, surname, affiliation, email address):

S. SCHERHAUFER*, C. CICATIELLO**, C. GIORDANO***, N. KOSEOGLU****, L. FALASCONI***, S. PIRAS****, K. LASARIDI*****, C. CHRONI*****, G. OBERSTEINER*

** BOKU University of Natural Resources and Life Sciences, Institute of Waste Management, Vienna, Austria, silvia.scherhaufer@boku.ac.at*
*** Università degli Studi della Tuscia, Italy, cicatiello@unitus.it*
**** Alma Mater Studiorum Università di Bologna, Italy, claudia.giordano4@unibo.it*
***** The James Hutton Institute, UK, nazli.koseoglu@hutton.ac.uk*
****** Harokopio University, Greece, klasaridi@hua.gr*

Proposed length (1 or 2 sessions/100 or 200 minutes):

1 session/100 minutes

Short Description / Scope of the Workshop:

The evaluation of socio-economic and environmental benefits (or gains) and efforts of implementing innovations for food waste prevention and reduction is critical for taking informed decisions. However, evaluation methods often face challenges when implemented in practice. Methodological robustness (e.g. precision of measurements, availability of time series data, representativeness of data samples, appropriate data validation, management of different types of uncertainty) may hinder the feasibility in practice (costs, data availability, time). The goal is to find the balance between theoretical robustness and feasibility of implementation.

This workshop will examine the challenges of evaluation based on practical examples. The aim of the workshop is to discuss within the scientific community common challenges of evaluation and to share experiences of how to overcome them. Challenges shall be identified and discussed along practical examples which are being implemented in current EU funded projects such as the Horizon 2020 project LOWINFOOD and other innovation actions funded under the same call. Participants from around the world are invited to join the workshop and to share their experiences to accumulate knowledge on the evaluation of food waste prevention activities.

Agenda:

Welcome and moderation *(S. Scherhaufer)*

Short introductory presentations (each 10 min.) and panel discussions (each 15 min):

- Rationale and practical implementation of measures against food waste (*C. Citatiello)*
- Establishing food waste baselines: challenges and options *(K. Lasaridi)*
- Evaluation of the efficacy *(C. Giordano)*
- Panel discussion

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- Evaluation of socio-economic impacts *(N. Koseoglu)*
- Evaluation of environmental impacts *(S. Scherhaufer)*
- Panel discussion

Abstracts:

RATIONALE AND PRACTICAL IMPLEMENTATION OF MEASURES AGAINST FOOD WASTE

Clara Cicatiello [1]

[1] *Department of Innovation in Biological, Agro-food and Forest Systems, University of Tuscia, Via san Camillo de Lellis snc, 01100, Viterbo, Italy, cicatiello@unitus.it*

ABSTRACT: With 26% of global CO_2 emissions coming from the food sector (Poore & Nemecek, 2018) and 17% of the food produced that is lost all through the supply chain (UNEP, 2021), reducing food loss and waste (FLW) is a key challenge to reduce the environmental impact of current food systems, while improving their economic efficiency. Halving the amount of per capita food waste at the retail and consumer levels is listed among the Sustainable Development Goals (SDG n. 12.3) together with the reduction of food losses in the production and processing stages of global food chains. Early studies on FLW provided an overview of the scale of the problem (Parfitt et al., 2010; FAO, 2011), and had a very important role in spreading the awareness about this issue. The design of interventions against food waste shall follow a clear hierarchy of priority (Papargyropoulou et al., 2014) and the generation of FLW shall be avoided with prevention measures whenever possible; as a second option, the food discarded shall be reused for human consumption or as animal feed, while recycling and energy recovery options represent the last alternative before disposing the food waste in landfills. While this hierarchy is agreed among actors and policy makers in theory, it is seldom applied in practice; even the emergence of the discourse about circular economy shifted the attention towards FLW recycling and recovery options rather than on prevention. Moreover, not all options are available at all the stages of the supply chains. 61% of FLW is produced at the household level (UNEP, 2021) where prevention actions might be much more effective than recycling and recovery options. But the same applies to other stages of the supply chain. In the LOWINFOOD H2020 project, a set of innovative measures are being applied to prevent the generation of FLW in different settings, with the aim to demonstrate the extent to which they can avoid the loss and waste of food. The choice of these innovations reflected the idea that preventing FLW is much better than managing it, once it has been discarded.

Keywords: food waste, waste prevention, practical implementation

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ACKNOWLEDGEMENTS

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REFERENCES

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). Global food losses and food waste.Papargyropoulou, E., Lozano, R., Steinberger, J. K., Wright, N., & bin Ujang, Z. (2014). The food waste hierarchy as a framework for the management of food surplus and food waste. Journal of cleaner production, 76, 106-115.

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050. Philosophical transactions of the royal society B: biological sciences, 365(1554), 3065-3081.

Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. Science, 360(6392), 987-992.

United Nations Environment Programme (2021). Food Waste Index Report 2021. Nairobi.

https://sdgs.un.org/goals

EVALUATION OF THE EFFICACY

Claudia Giordano[1]

[1]Department of Agriculture and Food Science, University of Bologna, Viale Fanin 50, 40127 Bologna, Italy

claudia.giordano4@unibo.it

The food waste debate flourished during the past year. The most recent study published by UNEP (2021) reported that around 931 million tons of food waste was generated globally in 2019 alone.

Many food waste reduction initiatives have been implemented in the past ten years, both by governments and private companies. However, assessment of their efficacy, when available, has been based mostly on questionnaires and self-assessments. While the use of questionnaires involves lower costs and resources compared to other methodologies, the reliability of the method is hindered by challenges embedded in self-reporting. Most of the methods considered to be reliable for food waste accounting and monitoring in EU Member states (*see* EC delegated decision 3211 Final, 2019) may require a lot of resources and place a heavy burden on the private companies adopting them. A key question arises from this: how do we balance the need for rigorous monitoring of food waste with the legitimate concern of overwhelming the beneficiaries of the innovations with additional work?

Indeed, one of the issues commonly addressed when estimating the efficacy of a food waste reduction innovation is its convenience for the parties implementing it. Encouraging involved parties to test and adopt a food waste reduction innovation is not easy, especially if the innovation requires additional work on top of routine activities. Whether it is a retailer, a canteen, or a food producer, innovations need to be easier than the usual routine, and they must also reduce food waste significantly to be captivating. Thus, efficacy is not only a matter of reduced waste quantities but one of user-friendliness, utility, and replicability potential as well. Finally, there is the issue of privacy: companies fear that disclosure of information related to food waste could put their reputation at risk.

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We try to address all these issues in the LOWINFOOD project, where14 innovations are tested along with several beneficiaries, among which private and public entities. In this lecture, we will discuss the protocols adopted in LOWINFOOD to evaluate the efficacy, replicability potential, user friendliness and utility of these innovations. Through this session, we hope to advance the debate about food waste reduction initiatives and their rigorous monitoring.

Keywords: food waste, accounting, monitoring, innovations, replicability

ACKNOWLEDGEMENTS

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REFERENCES

EC Delegated Decision C. 3211 Final and Annex. Supplementing Directive 2008/98/EC of the European Parliament and of the Council as Regards a Common Methodology and Minimum Quality Requirements for the Uniform Measurement of Levels of Food Waste. (2019). Available online: http://ec.europa.eu/transparency/regdoc/rep/3/2019/EN/C-2019–3211-F1-EN-MAIN-PART-1.PDF

United Nations Environment Programme (2021). Food Waste Index Report 2021. Nairobi.

EVALUATION OF SOCIOECONOMIC IMPACTS

M. Nazli Koseoglu[1]

[1] *Department of* Social*, Economic and Geographical Sciences, the James Hutton Institute, Craigiebuckler, AB15 8QH Aberdeen, UK, Nazli.Koseoglu@hutton.ac.uk*

ABSTRACT: 20% of the food production in the EU is estimated to be lost or wasted. This has significant socio-economic consequences throughout the supply chains and beyond. Associated costs are estimated at around €143 billion (Stenmarck *et al.,* 2016). The LOWINFOOD project deploys and implements fourteen innovative solutions against the food loss and waste (FWL) problem in various supply chains and locations throughout Europe. We systematically evaluate various performance aspects of these innovations. This part of the workshop focuses on the socio-economic evaluation, which includes the social and economic contributions of the innovations at company and wider levels (i.e., supply chain and territorial). We use indicators identified in the literature and further refined through expert consultation. Aspects related to data collection are discussed and iterated with insights from innovators and researchers involved in the project. Data collection protocols are created out of these efforts, respecting the data disclosure sensitivities of the involved stakeholders, and minimizing the additional burden associated with data collected for them.

While some indicators (e.g., economic indicators at company level) require quantitative evidence from company accounts, others (e.g., social indicators at company level) require qualitative and

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quantitative data collected via staff surveys or interviews conducted with the management. For each indicator, a baseline, i.e., the situation prior to the adoption of the innovation, will be established. Then, the same data will be collected at different points in time after adoption, to be compared over the duration of the project. Appropriate calculation methods have been defined to calculate each indicator from the data. For economic indicators, relevant equations have been defined. For quantitative indicators relying on survey data (e.g., number of employees involved in implementing the innovation), descriptive statistics will be calculated. For purely qualitative indicators (e.g., level of satisfaction with the innovation), we will use Likert scale-based measures and define assessment structures accordingly.

Keywords: food loss and waste, socio-economic evaluation, innovation

ACKNOWLEDGEMENTS

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REFERENCES

Stenmarck, Å., Jensen, C., Quested, T., Moates, G., Cseh, B., Juul, S., … Östergren, K. (2016). *Estimates of European food waste levels: Reducing food waste through social innovation*. *FUSIONS project*. Stockholm, Sweden: IVL Swedish Environmental Research Institute.

EVALUATION OF ENVIRONMENTAL IMPACTS

Silvia Scherhaufer [1]

[1] *Institute of Waste Management, University of Natural Resources and Life Sciences BOKU Vienna, Muthgasse 107, 1190 Vienna, Austria, silvia.scherhaufer@boku.ac.at*

ABSTRACT: This introductory lecture in the workshop "Socio-economic and environmental aspects of food waste management" covers the environmental evaluation of innovations addressing food waste prevention. The aim is to quantify impacts on natural resources, human health and the environment of activities targeting food waste prevention. The method for the evaluation of environmental impacts follows the rules for LCA based on ISO 14044 and the handbook and guidelines from the International Reference Life Cycle Data (ILCD) System as well as the food waste related assessment approaches developed by other EU funded projects. All assessed innovations aim to reduce food loss at different points within the value chain. Innovations might also deliver other functions, such as the increase in efficiencies, providing food to people in need. They can be grouped into the following steps of the food waste hierarchy: 1. FW prevention at source (via e.g. forecasting systems, educational concepts) and 2. Food redistribution (surplus food to other stakeholders). The functional unit is defined as one tonne of food prevented from being wasted and follows a consequentiual approach. The scope of the

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assessment includes all activities impacted by the innovations, in particular: i) Innovation actions, which includes all activities directly associated with the innovation. ii) Avoided production, based on the assumption that food consumption stays constant, food waste prevention (incl. redistribution) increases the efficiency of the supply chain and hence decreases the amount of food required to be produced to satisfy the same demand (applied as credits). Iii) Baseline system replaced, which covers the system before the innovations are implemented, and includes the current waste management system, as this system is replaced by the action when food is no longer wasted or properly recycled. Selected indicators are based on the Environmental Footprint (EF) packages. Those identified as relevant for the assessment of the FSC and food waste are: Climate change, Acidification, Eutrophication, Land use, Water use, Resource use. Central questions to achieve a robust but practical evaluation are discussed during the workshop: Which aggregation level is necessary to evaluate food waste amounts (animal containing vs. vegetal food waste, between different food categories, or even between specific food products)? What is the scope of innovations which are relying on software applications (server capacity, usage of computer devices etc.)?

Keywords: food waste, environment, life cycle assessment

ACKNOWLEDGEMENTS

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12 ANNEX III. The process towards a common methodology for measuring efficacy

Box 1

What is the Delphi method?
According to Okoli and Pawlowski (2004), the Delphi method originated in a series of studies that the RAND Corporation conducted in the 1950s. The goal of the new methodology was to obtain the most reliable consensus of a group of experts. The strength of the Delphi is that it allows interaction among experts free from the group dynamics, as it consists of an anonymous consultation where the feedbacks are merged, elaborated, and shared again by the moderator. Therefore, feelings that might influence a direct discussion will not influence the output. Borrowing Dalkey et Helmer's (1963) words "The controlled interaction appears to be more conducive to independent thought on the part of the experts and to aid them in the gradual formation of a considered opinion. Direct confrontation, on the other hand, all too often induces the hasty formulation of preconceived notions, an inclination to close one's mind to novel ideas, a tendency to defend a stand once taken, or, alternatively and sometimes alternately, a predisposition to be swayed by persuasively stated opinions of others."
The Delphi is based on a multiple-round consultation moderated by a group of researchers who formulate the questions, elaborate, and merge the answers and send them out again for feedback from the experts. There is not an established number of rounds: the Delphi ends when the consensus is reached. Usually, the moderators select the participants, in order to get feedback from actors they consider relevant for their case. In some circumstances, this is not necessary. Then, the first step is for the moderator to clarify the goal of the consultations, the theoretical background of the case to be assessed, the specific questions to be answered. Usually, the first round is based on open-ended questions, to gather the broader point of view of the participants on the issue in a sort of brainstorming. The participants are given a certain amount of time to answer, which cannot be too short as open-ended questions need time to be addressed. The feedback is then collected by the moderator, elaborated and sent back to experts, with a clearer output of the consultation and some elements to be defined. From the second phase onward, close-ended questions, Likert scale, etc can be used. Experts usually vary between 10 and 18 people, and the whole process can take some months.
The final output will be the one with the higher degree of consensus.

Box 2

First Delphi Round to assess efficacy of innovations in Lowinfood

Task 1.2 DELPHI SURVEY to set up the methodology

Dear colleagues, thanks for taking part to our Delphi survey. Through this study, we will set up a methodological framework to assess the efficacy of our innovations in LOWINFOOD projects. By Efficacy, we mean the innovation's actual capacity to reduce food waste (in weight, volume or nr. of items).
The study is structured as following: there are two rounds. In the first round, you are asked to contribute by writing your ideas within 2 weeks; your contribution will be collected by UNIBO and elaborated with others, so that we reach a draft document that will be again sent back to you. You'll be given 2 weeks more to contribute and, finally, we will elaborate the final draft to be shared.
After that, we will start the dialogues with the innovators and the companies that are supporting us in the pilot.

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The advantage of the Delphi is that we can all think individually, according to our time and focus needs; we do not influence each other when thinking and we do not incur in social desirability bias. The survey is anonymous. If we do not reach the full consensus in two rounds, we will schedule a meeting to discuss all together and finalize the document.

In this document, you are required to contribute by providing elements of the methodology with reference to for a) efficacy b) and potential replicability, user-friendliness and utility of the innovations. Some examples are provided with reference to one innovation, RER's. However, you can contribute anywhere in the document by proposing any amendment that you figure out, even to the current structure.
In the first part of the document, our task is reported for your convenience, as from Grant Agreement.
Soon after, the list of innovations is provided, along with a short description of each.
Some background documents are listed, in particular documents from 1 to 3 are very important as they are the common background for us all (GA).
At p. 5, 6 and 7 you will find the three tables to fill out, feel free to add all ideas that comes up to your mind. Under each table, you can report your comments or free contribution: e.g. something you think is missing, or broad considerations on our task. Please, feel free to use all the space you need.
Should you have any issue, contact us at claudia.giordano4@unibo.it and luca.falasconi@unibo.it
Your contribution is expected by the 12th of February. Should you need more time, please let us know ASAP, so we can communicate the new deadline to other participants, too.
Best,
Claudia and Luca

Background documents

1. EC methodological framework (2019) "Delegated Decision establishing a common EU methodology to measure food waste adopted on 3 May 2019" LINK
2. EC Format and quality check report (2019) "Format for reporting of data on food waste and for submission of the quality check report in accordance with Directive 2008/98/EC" LINK
3. UNEP food waste Index (2019) LINK and LINK
4. Waste directive (revised 2018): LINK
5. WRI food loss and waste protocol + measurement case studies: LINK
6. WRI global update on food loss and waste initiatives: LINK
7. Caldeira, Corrado & Sala (2017), Food waste accounting Methodologies, challenges and opportunities, JRC LINK

Definition adopted

EC: Food waste (edible + not edible), see document 1

Innovation	FSC stage	Indicators and unit of measure	KPIs and final target	Actors involved
2.1		Tons of food recovered	5% FW reduction after the	Ops, AOPs, DG

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		and donated in one year; Tons of food recovered and sent to ethanol production in one year;	first pilot (KPI) 10% reduction at the end of the project (final target)	agri (region and/or Ministry), RER, Universities.
2.2		Tons of surplus food sold to restaurants in one year	Per farmer, 10% FW sold after the first pilot (KPI) Per farmer, 20% FW sold at the end of the project (final target)	Restaurants, farmers
2.3				

Space for free comments, proposals and suggestions

Innovation	FSC stage	Scope (boundaries)	Method (baseline and monitoring)
2.1		Agricultural products withdrawn from the markets and relying under the *CAP emergency and prevention tool*.	2 stage accounting methodology. *Baseline*: interviews to national and EU authorities to gather the food loss and waste on farm due to emergency situation of the CAP (Y2); *Monitoring*: recording through software and interviews (Y3 and 4).
2.2		Agricultural products left on field	Baseline: questionnaire to farmers to know their average unsold food products Monitoring: questionnaire after the harvest period **/** questionnaire to restaurants

Innovation	KPIs replicability, user-friendliness, utility	(Mid-term)	Target	After 5 years
2.1	Number of agencies adopting the platform during the pilot; [etc]	1	1	3
2.2				

Space for free comments, proposals and suggestions

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Box 3

Delphi Round to assess efficacy of innovations in Lowinfood

Task 1.2 DELPHI SURVEY to set up the methodology

Dear colleagues,

Thanks for taking part to our Delphi survey.

Starting from the first round of contributions, we are now sending you a preliminary draft of our methodological protocol.

When the consensus around a specific amendment has been reached- for instance, proposed by the majority of partners- the document have been modified accordingly. For instance, KPIs with reference to replicability potential, user friendliness and utility have been mostly NOT added, apart from the UNIBO team, so the table has been moved to the end of the page and the decision will be discussed at the next WP1 meeting (1st of March, 2021). Please, fill out the remaining columns with contents as from instructions.

1. The most consistent work has been done on the column "indicators of efficacy". Where a consensus was reached among different feedbacks, an indicator has been built (see innovation 2.1, for instance); where no consensus was found, you will find the alert "**Go to the additional file**!". It means that you are requested to open the additional file and work on the specific indicator by commenting, merging, proposing new ideas. You can also comment on established indicators in the additional file.
2. When contrasting or competing feedbacks have been received, they have been reported in different colors within the same column in this file. Use the function "comments" to express your opinion.
3. The column KPIs has been temporarily deleted, in order to be filled out directly with innovators.
4. A column "duration of measurement" has been added based on your feedbacks.
5. A column "Open questions to innovators" has been added based on your feedbacks.
6. After the main table, you'll find a section "open issues", with some comments provided by partners and the space to comment them.

The goal is to reach the highest consensus through this round. All issues that remains unsolved after this round will be discussed in a specific meeting, before getting in touch with innovators.

Should you have any issue, contact us at claudia.giordano4@unibo.it and luca.falasconi@unibo.it

Your contribution is expected by the 8th of March. Should you need more time, please let us know ASAP, so we can communicate the new deadline to other participants, too.

Innovation	**FSC and scope** FSC aligned to REFRESH: PP: Primary Production FP: Food Processing RD: Retail and Distribution	Indicators of efficacy	Method (baseline and monitoring) A) or B) indicates a choice	Duration of measurement	Open questions to innovators	Actors involved

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	FS: Food Service C:Consumer/Household		to be selected by partners and by innovators			
2.2	PP FS	**Go to the additional file!**	Direct weighing A) by innovator B) if not by innovator than by partner with a sample		Is the redistributed food weighing every time/regularly/ or is only the number of boxes quantified?	

Table IX

Box 4

ADDITIONAL FILE

Dear All, this additional file has been prepared in order for you to express preferences or ideas on some open issues, on which no consensus has been reached so far.
Each open issue has been assigned a number that corresponds to the open issue highlighted in the main Delphi file. Please write your comments or select the preferred option.
First general issues or issues that refer to all innovations are presented, then issues related to each innovation are reported.

Please note that another file will be prepared with open issues that need to be discussed directly with innovators during the webinars.

General open issues:

#1 Comparing similar innovations: For all innovations, during the meeting it has been suggested that, for comparable innovations, we will have similar indicators in order to better compare the efficacy. To this end some innovations have been grouped and common indicators (**NoCI**) have been added, where needed, to the existing relative indicators.
A first grouping of comparable innovations with indicators follow:

Producers oriented innovations: 2.1 RER Software - 2.2 UNV Cooperation System - 2.3 & 4.2 LEROMA: Already have comparable indicators

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	Current relative indicators	Proposed comparable indicators among similar innovations
2.1	**No2:** Total amount withdrawn over the total of food handled by APOs in one year **No3:** Kg of food donated over the total of food recovered in one year **No4:** Kg of food sent to ethanol production over the total of food recovered in one year **N.B. Disaggregated to product level**	**Keeping all indicators that have emerged from the previous rounds of the Delphi, it has been proposed to add the following indicator for all the producers oriented innovation, since the innovations are focused on farmers surplus products:** **NoCI:** Rate of farmers' surplus recovered (to restaurants, charities, food industry) out of the total farmers' surplus in one year.
2.2	**No2:** Tons of food redistributed (or reused) in one year - Indicative quantities of gleaning potential of different crops **No3:** Tons (or kg) of raw materials recovered and managed by restaurant/total hectares unharvest - recovered yield - Indicative quantities of gleaning potential of different crops **N.B. Disaggregated to product level**	
2.3	**No2:** Total amount of products offered (disaggregated as much as possible) per year **No3:** Total amount of products traded out of the products offered (disaggregated as much as possible) per year	

Please note that innovation 2.2 (UNV cooperation system) has been included in what we labelled as "producers oriented innovation" since it follows a similar logic as in 2.1 and 2.3 / 4.2.
Do you agree with this comparison of innovations/indicators and to add this indicator for Innovations 2.1, 2.2 and 2.3?

Yes	
No	

Space for comments:

Forecasting oriented innovations: 2.4 FORESIGHTEE - 3.3 FT Software - 5.2. MITAKUS

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	Current relative indicators	Proposed comparable indicators among similar innovations
2.4	**No2a:** Tons of product unsold/Tons of product purchased before implantation, disaggregated by product group, per year and unit of sales area **No2b:** Tons of product unsold/Tons of product purchased after implementation, disaggregated by product group, per year and unit of sales area **No3**: Tons of products sold out of tons of products purchased (for comparison).	**Relative Indicators for 2.4 and 3.3 are similar. Keeping all indicators that have emerged from the previous rounds of the Delphi, in order to make the efficacy indicators comparable the following indicators could be added in 5.2:** **No4a**: Tons of food unsold/ tons of food purchased before the innovation, disaggregated by product group per year. **No4b:** Tons of food unsold/ tons of food purchased after the innovation, disaggregated by product group per year. **No5**: Tons of products sold / tons of product purchased **No6**: rate of surplus food on total daily or weekly/monthly orders
3.3	**No2a:** Tons of surplus bread / produced bread per year and unit of sales area before innovation (baseline) **No2b:** Tons of surplus bread / produced bread per year and unit of sales area after innovation **No3:** Tons of surplus bread / produced bread per year and unit of sales area **No4:** rate of surplus bread on total daily or weekly/monthly orders	
5.2	**No2:** Amount of food waste per guest/meal **No3:** quantity of food wasted/ food produced or distributed	

Do you agree with this comparison of innovations/indicators and to add these indicators for Innovations 5.2?

Yes	
No	

Space for comments:

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Stakeholders oriented innovations: 3.1 Supplier/retailer agreement - 3.2 CNA stakeholder dialogue - 4.1 JHI stakeholder dialogue.		
Current relative indicators		**Proposed comparable indicators among similar innovations**
3.1	**No2a:** Tons of surplus bread / purchased bread at retailer and supplier before innovation (baseline) per year and kg delivered. (Second best choice if kg delivered is not available: unit of supermarket sales area) **No2b:** Tons of surplus bread / purchased bread at retailer and supplier after innovation per year and kg delivered. (Second best choice if kg delivered is not available: unit of supermarket sales area) **No3:** rate of surplus bread on total daily or weekly/monthly orders	**Keeping all indicators that have emerged from the previous rounds of the Delphi, indicators No2a, No2b and No3 in innovations 3.1. and 3.2. are already similar and comparable. They could be adopted in innovation 4.1 as well as follows:** No2a: Tons of fish wasted / total fish traded by the company before the innovation No2b: Tons of fish wasted / total fish traded by the company after the innovation No 3: Rate of fish wasted on total daily or weekly/monthly fish traded **N.B. Please note that these indicators will be discussed with JHI**
3.2	**No2a:** Tons of surplus bread produced by specialized bakeries and commercialized through supermarkets/ purchased bread before the innovation (baseline) per year and kg delivered (Second best choice if kg delivered is not available: unit of supermarket sales area) **No2b:** Tons of surplus bread produced by specialized bakeries and commercialized through supermarkets / purchased bread after the innovation per year and kg delivered (Second best choice if kg delivered is not available: unit of supermarket sales area) **No3:** rate of surplus bread on total daily or weekly/monthly orders	
4.1	**No2**: Rate of fish wasted, out of the total fish traded by a single company, (to get a magnitude of the phenomenon)	

Do you agree with this comparison of innovations/indicators and to add these indicators for Innovations 4.1?

Yes	

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No	

Space for comments:

Plate waste oriented innovations: 5.1 KITRO – 5.3 MATOMATIC
These innovations have similarities and their indicators could be comparable. Please, feel free to add comments if you don't agree.

Space for comments:

Household oriented innovations: 5.5 COGZUM- 5.6 REGUSTO		
Current relative indicators		**Proposed comparable indicators among similar innovations**
5.5	No2a: Household Food Wasted before the innovation/ Household Food Purchase/. No2b: Household Food Wasted after the innovation / Household Food Purchase/	**All indicators that have emerged from the previous rounds of the Delphi are maintained.** **These two innovations are related to households but they differ in tackling the FW: 5.5 tries to avoid Household FW while 5.6 tries to avoid restaurants FW. On the other hand, both are aiming at reducing consumers' food provision costs. To this end they might be comparable by including the following indicators** **NoCIa**: Cost of weekly household food purchasing before the innovation **NoCIb**: Cost of weekly household food purchasing after the innovation The other relative indicators of the two innovations remain the same as proposed in previous rounds of the Delphi. For innovation 5.6 The relative indicator No4, will be split into: **No4a**: Rate of saved food ending non-consumed and disposed before the innovation **No4b**: Rate of saved food ending non-consumed and disposed after the innovation
5.6	**No2** Tons of food saved by Regusto but wasted at consumer + relative value: grams of food saved per user per month **No3** Quantity of food saved through doggy bags, per user, per month (before and after the innovation) **No4** Rate of saved food	

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	ending non-consumed and disposed **(before and after innovation)**	

Do you agree with this comparison of innovations/indicators and to add these indicators for Innovations 5.5 and 5.6?

Yes	
No	

Space for comments:

#2 Interviews as additional voluntary monitoring → It has been suggested that we conduct an additional (voluntary) measurement to address potential further sources of food waste of the food traded through innovation. For example: Is the food saved from being wasted through Leroma wasted then somewhere else?
This line of reasoning is valid for all innovations and while it could provide additional value to the project it also requires additional effort.

Do you think this monitoring should be done for all innovation?

Space for ideas/comments:

Innovation 2.3 – Leroma B2B digital market place

#3 Definitions: The absolute indicator in Leroma is:

No1: Tons of products saved from being wasted (Calculated as the difference between the tons of products saved from being wasted before (**No1a**) and after (**No1b**) implementing the innovation)

It has been proposed during the last round of the Delphi to adopt a common terminology across projects and to use the definition of Food side-flows when referring to products.

Which definition do you prefer to be adopted?

a. Food surplus

b. Food side-flows (from REFRESH) - defined as a material flow of food and inedible parts of food from the FSC of the driving product, including wasted driving product, and also final disposal of inedible and edible parts of unconsumed food product after use, e.g. plate leftovers. The stakeholder

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in the FSC producing this flow tries to have as little as possible of it, “the less, the better” applies for this flow.

If interested in knowing more about this definition please refer to the following report: Davis, J., De Menna, F., Unger, N., Östergren, K., Loubiere, M., & Vittuari, M. (2017). Generic strategy LCA and LCC - Guidance for LCA and LCC focused on prevention, valorisation and treatment of side flows from the food supply chain.

Space for ideas/comments:

#4 Measurement *Which duration of measurement fits the Leroma innovation better?*

a. Year
b. Pre-demonstration + demonstration time

a	
b	

Innovation 5.1 – KITRO Innovative bin

#5 Absolute indicator: A new proposal is to use as absolute indicator: [(Number of guests (after) * Waste per guest (before)] – [Number of guests (after) * Waste per guest (after)], this will reflect the decrease of waste per person - *Please see the ppt file in the shared folder for further information*

Do you agree with using this calculation for the absolute indicator?

Yes	
No	

Innovation 5.2 – MITAKUS Forecasting software for restaurants

#6 Absolute indicator: (Same as number 5) A new proposal is to use as absolute indicator: [(Number of guests (after) * Waste per guest (before)] – [Number of guests (after) * Waste per guest (after)] , this will reflect the decrease of waste per person - *Please see the ppt file in the shared folder for further information*

Do you agree with using this calculation for the absolute indicator?

Yes	
No	

Innovation 5.3 – MATOMATIC Plate waste tracker

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#7 Absolute indicator: (Same as number 5 and 6) A new proposal is to use as absolute indicator: [(Number of guests (after) * Waste per guest (before)] – [Number of guests (after) * Waste per guest (after)], this will reflect the decrease of waste per person - *Please see the ppt file in the shared folder for further information*

Do you agree with using this calculation for the absolute indicator?

Yes	
No	

#8 Reference Unit: Concerning the reference unit, different suggestions have been made:

a. quantity/number of meals
b. number of meals/dishes served
c. kg waste per kg served dishes (compare with MITAKUS)

Which option do you prefer?

a	
b	
c	

Innovation 5.4 – SLU/AIE Holistic educational approach

#9 Absolute indicator: (Same as number 5, 6 and 7) A new proposal is to use as absolute indicator: [(Number of guests (after) * Waste per guest (before)] – [Number of guests (after) * Waste per guest (after)], this will reflect the decrease of waste per person - *Please see the ppt file in the shared folder for further information*

Do you agree with using this calculation for the absolute indicator?

Yes	
No	

Innovation 5.5 – COGZUM Mobile app

#10 Relative indicators: No relative indicators were suggested here.

We propose to add as relative indicators:
No2a: Quantity of Household Food Purchase/Household Food Wasted before the innovation
No2b: Quantity of Household Food Purchase/Household Food Wasted after the innovation

Do you agree with the relative indicators suggested?

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Yes	
No	

Do you have further suggestions on relative indicators for innovation 5.5?

Space for ideas/comments:

13 ANNEX IV. The process towards a common methodology for measuring socio-economic impacts

Online survey used for the elicitation of expert opinion:

Lowinfood T1.3 consultation on socio-economic indicators

Dear partners, this questionnaire is aimed at gathering your feedback on the socio-economic indicators for evaluating the Lowinfood innovations to reduce food waste. You have this opportunity to suggest changes before the table is discussed with our business partners. Please keep in mind that not all companies which will be proposed (and will possibly implement) the innovations are consortium partners, and therefore they did not commit to provide data. Please keep the table of indicators (Socio-economic indicators) open when filling the questionnaire, because you will be asked questions for each of the indicators included there. These have been numbered both here and in the table to facilitate this task.

Q1 To which partner Institution do you belong?

- o James Hutton Institute (JHI) (1)
- o University of Tuscia (UNITUS) (2)
- o University of Bologna (UNIBO) (3)
- o Fachhochschule Münster (ISUN) (4)
- o Österreichische Ökologie Institut (AIE) (5)
- o Harokopio University (HUA) (6)
- o Other (specify) (7) _____

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Q2 Which is/are your field(s) of expertise?

- ☐ Economics (1)
- ☐ Engineering (2)
- ☐ Sociology (3)
- ☐ Geography (4)
- ☐ Ecology (5)
- ☐ Other (specify) (6) _____

Q3 For the indicator "1. Profitability: variation in direct (food products) input costs", please indicate if you agree with the following statements.

	Strongly agree (1)	Somewhat agree (2)	Neither agree nor disagree (3)	Somewhat disagree (4)	Strongly disagree (5)
It is relevant for our work. (1)					
It is easy to calculate. (2)					
Firms will agree to provide the necessary data. (3)					
Firms will be able to provide the necessary data. (4)					
It overlaps with other indicators. (5)					
We should review it (including possibly removing it). (6)					

(The scale above is used for assessing indicators 2- 43. In the following, only the questions are included in their order of appearance in the survey).

Q5 For the indicator "2. Profitability: variation in the selling price of the product targeted by the innovation", please indicate if you agree with the following statements.

Q6 For the indicator "3. Profitability: variation in fixed costs attributable to the food product targeted by the innovation", please indicate if you agree with the following statements.

Q7 For the indicator "4. Profitability: variation in other variable costs (different from food) attributable to the product targeted by the innovation", please indicate if you agree with the following statements.

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Q9 For the indicator "6. Profitability: output-to-input value ratio and its variation (only related to food products)", please indicate if you agree with the following statements.

Q10 For the indicator "7. Profitability: rate of return on investment over the innovation's (or project's) lifetime", please indicate if you agree with the following statements

Q11 For the indicator "8. Profitability: change in waste management costs (possibly limited to organic waste)", please indicate if you agree with the following statements.

Q12 For the indicator "9. Profitability: subsidies and/or other financial benefits (e.g., qualifying for tax breaks as a result of adopting the innovation)", please indicate if you agree with the following statements.

Q13 For the indicator "10. Scale: total value of sales of the product targeted by the innovation, and its change", please indicate if you agree with the following statements.

Q14 For the indicator "11. Scale: new partnerships upstream and horizontally", please indicate if you agree with the following statements.

Q15 For the indicator "12. Scale: total hours worked by employees of the firm, and its change (to be also calculated by gender)", please indicate if you agree with the following statements.

Q16 For the indicator "13. Downstream diversification: number and type of buyers (market segments), and their change (to be calculated by gender if possible)", please indicate if you agree with the following statements.

Q17 For the indicator "14. Competitiveness: total factor productivity and its change", please indicate if you agree with the following statements.

Q18 For the indicator "15. Competitiveness: productivity of material inputs and its change", please indicate if you agree with the following statements.

Q19 For the indicator "16. Change of awareness of the firm management regarding food waste and losses", please indicate if you agree with the following statements.

Q32 For the indicator "17. Change of attitude towards the reduction of food waste", please indicate if you agree with the following statements.

Q33 For the indicator "18. Willingness to continue with the application of the innovation", please indicate if you agree with the following statements.

Q34 For the indicator "19. Willingness to promote the application of the innovation among partners or subsidiaries", please indicate if you agree with the following statements.

Q35 For the indicator "20. Behavioural changes towards food waste reduction in the company", please indicate if you agree with the following statements.

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Q36 For the indicator "21. Indirect impact on behavioural changes in business / schools / private contexts (transfer to other areas) (to be also calculated by gender)", please indicate if you agree with the following statements.

Q37 For the indicator "22. Increase (or loss) of skills of company employees", please indicate if you agree with the following statements.

Q38 For the indicator "23. Support of employees in dealing with the innovation (to be also calculated by gender)", please indicate if you agree with the following statements.

Q39 For the indicator "24. Improvement of formal qualification status of the employees (to be also calculated by gender)", please indicate if you agree with the following statements.

Q40 For the indicator "25. Increase or decrease of job satisfaction (to be also calculated by gender)", please indicate if you agree with the following statements.

Q41 For the indicator "26. Usability of the innovation (to be also disaggregated by gender of the respondent)", please indicate if you agree with the following statements.

Q42 For the indicator "27. Positive effects vs expectations: share of companies saying that the innovation met their expectations, and average rating", please indicate if you agree with the following statements.

Q43 For the indicator "28. Effort needed vs benefit of the innovation: assessment of non-monetary benefits compared to non-monetary costs", please indicate if you agree with the following statements.

Q20 For the indicator "29. Local jobs: Number of local employees / households who have experienced a reduction / increase in worked hours due to the innovation (to be also disaggregated by gender)", please indicate if you agree with the following statements.

Q44 For the indicator "30. Employment along the value chain: change compared to the situation before adoption (to be also disaggregated by gender)", please indicate if you agree with the following statements.

Q45 For the indicator "31. Regional employment: change compared to the situation before adoption (sign, magnitude) (to be also disaggregated by gender)", please indicate if you agree with the following statements.

Q46 For the indicator "32. Accordance to internationally proclaimed human rights in the supply chain (Principle 1) (to be also calculated by gender)", please indicate if you agree with the following statements.

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Q47 For the indicator "33. Freedom of association and the effective recognition of the right to collective bargaining (Principle 3) (to be also calculated by gender)", please indicate if you agree with the following statements.

Q48 For the indicator "34. Elimination of all forms of forced and compulsory labour (Principle 4) (to be also calculated by gender)", please indicate if you agree with the following statements.

Q49 For the indicator "35. Abolition of child labour (Principle 5) (to be also calculated by gender)", please indicate if you agree with the following statements.

Q50 For the indicator "36. Elimination of discrimination with respect to employment and occupation (Principle 6) (to be also calculated by gender)", please indicate if you agree with the following statements.

Q51 For the indicator "37. Working against corruption in all its forms, including extortion and bribery (Principle 10) (to be also calculated by gender)", please indicate if you agree with the following statements.

Q21 For the indicator "38. Resilience of the supply chain due to more efficient use of resources", please indicate if you agree with the following statements.

Q22 For the indicator "39. Spillover effects: technological change by competitors/other companies because of (successful) demonstration of the innovation", please indicate if you agree with the following statements.

Q52 For the indicator "40. Vertical segregation: share of women involved in implementing the innovation by responsibility in their company", please indicate if you agree with the following statements.

Q53 For the indicator "41. Horizontal segregation: share of women involved in implementing the innovation by area of work, discipline, and department", please indicate if you agree with the following statements.

Q54 For the indicator "42. Share of women / other gender interviewed out of the total number of people interviewed", please indicate if you agree with the following statements.

Q55 For the indicator "43. Survey satisfaction of women and men respondents comparatively", please indicate if you agree with the following statements.

Q29 You answered that companies will not agree to provide the data for calculating the following indicators. Please detail the actions that you suggest in response to this challenge (including removing the indicator, replacing it with another one, etc.).

Q56 You answered that the following indicators overlap with others. Please specify with which indicator(s) each of them overalps.

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Q57 You answered that we would need to review (or remove) the following indicators. Please detail the changes you suggest.

Q25 If you are leading one task or work package between WP2-WP5, do you foresee any challenges for you to find data to complement the information provided by the firms (for the indicators where this is foreseen)? Please detail in which sense and for which specific indicators.

Q26 Do you want to suggest any other indicator(s) besides those already listed in the table? Please detail.

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Table 8: Online survey results based on the responses from WP1 partners

Indicator number	Average relevance [1]	Non relevant [2]	Average easiness [1]	Difficult [2]	Average agree [1]	Not-agrees [2]	Average able [1]	Unable [2]	Average overlap [1]	Yes, overlapping [2]	Average review [1]	Yes, review [2]	Critical values [3]	Decision [4]
1	1.2	0	1.9	2	2.8	6	1.8	2	2.9	8	3.5	3	3	keep as it is
2	2	3	2	3	2.4	5	1.7	1	3.3	6	3.7	4	1.5	review: refine by balancing for inflation and other factors
3	1.7	3	2.7	5	2.8	8	2.7	6	3.4	6	3.1	6	4	unsure: further discussion with partners
4	2	3	3.4	7	3.2	9	3	7	3.1	7	3	6	8	unsure: further discussion with partners
5	1.5	1	2.5	5	3.1	8	2	2	3.7	4	3.4	5	2.5	review: use qualitative data instead
6	1.7	3	3.2	7	3.2	10	2.9	7	2.7	8	2.5	9	9	review: consider if using qualitative data
7	1.2	0	2.7	4	2.9	6	2.7	6	3.7	3	3.6	4	2	keep as it is
8	1.1	0	2.2	3	2.3	3	2.5	4	3.1	6	3.9	3	1	keep as it is
9	2.3	5	2.6	5	2.9	7	2.3	4	3.5	5	2.6	6	4	unsure: further discussion with partners
10	2.3	4	2.1	1	2.9	7	2.1	3	2.5	8	2.5	8	5	unsure: further discussion with partners
11	2	3	2.9	7	2.4	5	2.1	4	3.5	6	3.4	4	2.5	review: use qualitative data instead
12	2.1	1	2.6	4	3.2	8	2.6	5	3.6	5	2.9	6	5	review: limit to the branch involved and check for exogenous factors
13	1.9	2	3	7	2.9	8	2.8	6	3.4	7	3.5	6	5.5	keep as it is (qualitative assessment)
14	2.9	6	3.5	7	3.7	10	3	7	3.1	8	2.2	8	9.5	remove
15	2.4	3	3	7	2.9	6	3	7	3	8	2.5	7	7.5	review: consider replacing with margins
16	1.5	0	2.5	5	2.3	4	2.1	2	3.6	5	3.2	4	0.5	review: refine the specific aspects of awareness to be assessed
17	1.6	1	2.6	4	2.5	5	2.4	3	3.1	6	3.4	5	2	keep as it is (only management)
18	1	0	1.7	2	1.8	2	1.2	0	3.5	4	3.2	5	0.5	remove if already covered in T1.2; otherwise keep as it is
19	1.9	2	2.1	3	2	2	2	2	2.8	8	3	7	3.5	remove if already covered in T1.2; otherwise keep as it is
20	2.1	3	2.8	5	2.8	6	3	6	2.9	8	2.7	7	6.5	review: refine the specific aspects of behaviour to be assessed
21	1.7	3	3.9	8	3.3	8	3.9	9	3.2	7	2.3	8	9	remove

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22	2.6	5	2.9	6	2.8	7	2.4	3	3.2	6	2.6	8	5.5	check if this is already covered in T1.2 and possibly remove
23	3.1	7	2.5	5	2.7	6	2.4	4	3.1	7	2.8	6	6	check if this is already covered in T1.2 and possibly remove
24	3.2	8	3	7	2.6	5	2.7	6	2.8	8	2.4	7	9	remove
25	2.4	4	2.8	5	3.3	8	2.3	3	3.7	5	3.1	7	3.5	unsure: further discussion with partners
26	1.4	0	2.2	3	2.3	4	2.1	3	2.8	7	2.9	5	3.5	check if this is already covered in T1.2 and possibly remove
27	1.8	1	1.7	0	2.2	3	1.6	0	2.8	7	3.6	3	2	remove if already covered in T1.2; otherwise keep as it is
28	2	3	3	5	2.5	5	2.8	6	2.1	9	2.3	7	6.5	remove if already covered in T1.2; otherwise keep as it is
29	2.5	3	3.9	9	3.8	9	3.7	9	3.7	5	2.1	9	8.5	unsure: further discussion with partners
30	1.9	2	3.9	9	3.6	9	3.5	7	3.4	5	2.2	8	8.5	remove: to be assessed in the scenarios
31	2.1	2	3.9	8	3.2	7	3.5	8	2.9	6	1.8	9	10	remove
32	2.7	6	3.6	9	3.7	10	3.7	9	3.6	5	1.5	10	9.5	remove
33	3	6	3.9	10	3.5	10	3.6	9	3.6	5	1.5	10	10	remove
34	3	6	3.9	10	3.9	10	3.5	9	3.5	6	1.6	10	10.5	remove
35	3	6	4	10	3.9	10	3.5	9	3.4	6	1.5	10	10.5	remove
36	2.8	6	4	10	3.8	10	3.7	9	3.5	6	1.6	10	10	remove
37	2.7	4	4.1	10	3.9	10	3.1	8	3.5	6	1.6	10	9	remove
38	1.8	2	3.8	8	3.6	9	3.3	7	3.7	5	2.9	5	8	remove: to be assessed in the scenarios
39	2	3	3.8	8	3.5	8	3.8	8	3.6	5	2.3	7	8.5	review: replace with number of contacts to innovators
40	2.5	5	2.2	3	3	8	2.2	3	3.7	5	3.1	6	3.5	keep as it is (gender)
41	2.3	4	2.2	3	3	8	2.2	3	3.4	5	2.8	7	4	keep as it is (gender)
42	2.2	3	1.5	1	2.3	4	1.9	1	3.5	6	3.4	5	1.5	keep as it is
43	2.8	6	2.3	4	2.8	7	2.1	3	3.4	5	2.7	7	4.5	keep as it is (gender)

Notes: The indicators are identified according to their number in the questionnaire. [1] Average responses to the items of the Likert scale (from 1 "strongly agree" to 5 "strongly disagree"): it is relevant; it is easy to calculate; firms would agree to provide the data; firms will be able to provide the data; it overlaps with other indicators; it should be reviewed/removed. Coloured in red when the average is >3, and in orange when equal to 3. [2] Number of respondents (out of 10) who expressed a critical opinion: "strongly disagree" or "disagree" for relevance, easiness, agreement and ability of the firms to provide the data; "strongly agree" or "agree" for overlapping and review/removal. Coloured in red when >5 and in orange when equal to 5. [3] Number of the previous columns that show critical values (each red column counts for +1 and each orange column counts for +0.5). [4] Each indicator can be (a) kept as it is; (b) moved to the efficacy evaluation; (c) further discussed with partners; (d) reviewed without further discussion; (e) removed. The decision was made by looking jointly at the number of critical values and at further comments provided by the experts in the questionnaire.

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Table 9: Resulting changes in the socioeconomic indicators

Indicators that are removed	Indicators that might be relevant to T1.2	Indicators reviewed	Indicators that need further discussion
14. Competitiveness: total factor productivity **21. Indirect impact on behavioural changes** in businesses / schools / private contexts (transfer to other areas) – to be also calculated **by gender** **24. Improvement of formal qualification** status of the employees – to be also calculated **by gender** **30. Employment along the value chain**: change compared to the situation before adoption (sign, magnitude) – to be also disaggregated **by gender** **31. Regional employment**: change compared to the situation before adoption (sign, magnitude) – to be also disaggregated **by gender** **32.** Accordance with **internationally proclaimed human rights** in the supply chain (**Principle 1**) – to be also calculated **by gender** **33. Freedom of association** and the effective recognition of the right to collective bargaining (**Principle 3**) – to be also calculated **by gender** **34.** Elimination of all forms of **forced and compulsory labour** (**Principle 4**) – to be also calculated **by gender** **35.** Abolition of **child labour** (**Principle 5**) – to be also calculated **by gender** **36.** Elimination of **discrimination** with respect to employment and occupation (**Principle 6**) – to be also calculated **by gender** **37. Working against corruption** in all its forms, including extortion and bribery (**Principle 10**) – to be also calculated **by gender** **38. Resilience of the supply chain** due to more efficient use of resources	**18. Willingness to continue** with the application of the innovation **19. Willingness to promote** the application of the innovation among partners or subsidiaries **22. Increase (or loss)** of skills of company employees **23. Support of employees** in dealing with the innovation (e.g., through training or further education) – to be also calculated **by gender** **26. Usability of the innovation** – to be also disaggregated **by gender** of the respondent **27. Positive effects *vs* expectations**: share of companies saying that the innovation met their expectations, and average rating **28. Effort needed *vs* benefit of the innovation**: Assessment of non-monetary benefits compared to non-monetary costs	**2. Profitability**: **variation in the selling price** **5. Profitability: creating new income streams** **6. Profitability: output-to-input value ratio and its variation** **11. Scale: new partnerships** **12. Scale: total hours worked** **15. Competitiveness: productivity of material inputs** **16. Change of awareness** **20. Behavioural changes** towards food waste reduction in the company **39. Spill-over effects**: technological change by competitors/other companies because of (successful) demonstration of the innovation	**3. Profitability: variation in fixed costs** **4. Profitability: variation in other variable costs** **9. Profitability: subsidies and/or other financial benefits** **10. Scale: total value of sales** **25.** Increase or decrease of **job satisfaction** – to be also calculated **by gender** **29. Local jobs**: Number of employees / households who have experienced a reduction / increase in worked hours due to innovation – to be disaggregated **by gender**

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14 ANNEX V. The process towards a common methodology for measuring environmental impacts

This document shall set the **impact categories[2] and associated indicators[3]** which shall be used when evaluating innovations in LOWINFOOD. It will serve as a basis for discussions to obtain next steps, such as data needed by each innovation to quantify those indicators.

Reasons for assessing environmental impacts based on a LCA approach are that:

- The environmental impact across the value chain is understood;
- Environmental benefits of food waste reduction along the supply chain can be communicated;
- Ensure environmental benefits of the innovation are outweighing burdens associated with the implementation;
- Avoid burden shifting.

The method for the evaluation of environmental impacts follows the rules for **Life Cycle Assessment (LCA) method based on ISO 14044** and the **handbook and guidelines from the International Reference Life Cycle Data System** as well as the food waste related assessment approach developed by H2020 project REFRESH and Interreg Central Europe STREFOWA.

The process of defining the goal and scope for the environmental evaluation including the selection of indicators is seen as an iterative process. Hence, it will be continuously adapted during the elaboration of a common methodology for the evaluation.

First step is to select the impact categories and associated indicators. Generally impact categories and other metrics considered to be of high relevance to the goal of the assessment shall be chosen according to the Product Environmental Footprint method (Commission Recommendation 2013/179/EU) and the EF 3.0 characterisation factors (PEF Method 2019). **The evaluation shall focus on impact categories most relevant for LOWINFOOD's food value chains and innovations. Data availability and use of secondary data might also limit the selection of impact categories** that can be included in the evaluation of individual innovations.

Procedure to select indicators for the environmental assessment:

- Members of the core team are asked to give feedback in the grey sections by March 18 to the following issues:
    - Please comment on our proposed functional unit.
    - Please select impact categories which are feasible to assess in LOWINFOOD innovations and justify your decision in short words.
    - Please also include those impact categories in your selection, which you have already assessed in previous projects/studies related to food or food waste.

[2] Impact category: class representing environmental issues of concern to which life cycle inventory analysis results may be assigned (ISO 14044:2006)
[3] Indicators: quantifiable representation of an impact category (ISO 14044:2006)

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Functional unit[4]

LOWINFOOD's aim is to create low-waste value chains. This will be achieved by innovations to prevent food waste at source by e.g. increasing the efficiency of the value chain and to redistribute food (e.g to people in need). In line with the aim the functional unit is defined as **tonnes of food saved from being wasted during a specified period.**

The specified period refers to the actual period the innovation is implemented and monitored.

An inclusion of a further reference unit (e.g. number of prepared dishes) need to be discussed in a next step.

Comments to the functional unit: _____

Selection of environmental impact categories

The list of impact categories shown in the table below is based on the Environmental Footprint (EF) packages (available in https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml).

[4] Functional unit: quantified performance of a product system for use as a reference unit (ISO 14044:2006)

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Table 10: Environmental Footprint (EF) impact categories with respective impact category indicators and characterization models. (http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml)

EF Impact category	**Impact category Indicator**	**Unit**	**Characterization model** (recommended by PEF, DG Environment)	**Robust -ness**	**Relevance for LOWINFOOD** High/moderate/low	**Justification in short**
Climate change, total	Radiative forcing as global warming potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)	I		
Climate change, fossil	Radiative forcing as global warming potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)	I		
Climate change, biogenic	Radiative forcing as global warming potential (GWP100)	kg $CO_{2\ eq}$	Baseline model of 100 years of the IPCC (based on IPCC 2013)	I		
Ozone depletion	Ozone Depletion Potential (ODP)	kg CFC-11 $_{eq}$	Steady-state ODPs as in (WMO 2014 + integrations)	I		
Human toxicity, cancer	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model 2.1	III		

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			(Fankte et al, 2017)			
Human toxicity, noncancer	Comparative Toxic Unit for humans (CTU_h)	CTUh	USEtox model 2.1 (Fankte et al, 2017)	III		
Particulate matter	Impact on human health	disease incidence	PM method recommended by UNEP (UNEP 2016)	I		
Ionising radiation, human health	Human exposure efficiency relative to U_{235}	kBq $U_{235\ eq}$	Human health effect model as developed by Dreicer et al. 1995 (Frischknecht et al, 2000)	II		
Photochemical ozone	Tropospheric ozone concentration increase	kg $NMVOC_{\ eq}$	LOTOSEUROS model (Van	II		
formation, human health			Zelm et al, 2008) as implemented in ReCiPe 2008			

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Acidification	Accumulated Exceedance (AE)	mol H^+_{eq}	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II		
Eutrophication, terrestrial	Accumulated Exceedance (AE)	mol N_{eq}	Accumulated Exceedance (Seppälä et al. 2006, Posch et al, 2008)	II		
Eutrophication, freshwater	Fraction of nutrients reaching freshwater end compartment (P)	kg P_{eq}	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II		
Eutrophication, marine	Fraction of nutrients reaching marine end compartment (N)	kg N_{eq}	EUTREND model (Struijs et al, 2009) as implemented in ReCiPe	II		

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Ecotoxicity, freshwater	Comparative Toxic Unit for ecosystems (CTU_e)	CTUe	USEtox model 2.1 (Fankte et al, 2017)	III		
Land use	• Total area occupied • Soil quality index • Biotic production • Erosion resistance • Mechanical filtration • Groundwater replenishment	• Squm. • Dimensionless (pt) • kg biotic production • kg soil • m^3 water • m^3 groundwater	Soil quality index based on LANCA (Beck et al. 2010 and Bos et al. 2016)	III		
Water use	User deprivation potential (deprivation-weighted water consumption)	m^3 world $_{eq}$	Available WAter REmaining (AWARE) as recommended by UNEP, 2016	III		
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb $_{eq}$	CML 2002 (Guinée et al., 2002) and van	III		

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			Oers et al. 2002.			
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ	CML 2002 (Guinée et al., 2002) and van Oers et al. 2002	III		
Others:						

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The Product Environmental Footprint Category Guidance recommends identifying most relevant impact categories based on normalised and weighted results of all impact categories. Based on a screening study all impact categories except toxicity indicators are calculated, normalised and weighted. At least three relevant impact categories shall be considered. The most relevant impact categories shall be identified as all impact categories that cumulatively contribute to at least 80%of the total environmental impact (excluding toxicity related impact categories). This should start from the largest to the smallest contributions.

Table 11: Most relevant impact categories for PEF pilot product groups based on the Product Environmental Footprint Category Rules (PEFCR) for Dairy, Beer, Wine, Feed and Pet foods (Most relevant impact categories: ranking 1-3 in green, Medium relevant: ranking 4-6 in yellow; least relevant: ranking >6 in red)

EF Impact category	Dairy products	Beer	Wine	Feed	Pet food
Climate change, total	1	1	2	1	1
Ozone depletion			8		
Human toxicity, cancer					
Human toxicity, noncancer					
Particulate matter	2	2	12	2	2
Ionising radiation, human health			6		
Photochemical ozone formation, human health			9		
Acidification	3	3	1	3	3
Eutrophication, terrestrial	6		5	5	4
Eutrophication, freshwater	4		3		
Eutrophication, marine	5		4		
Ecotoxicity, freshwater					
Land use	7		7	4	
Water use	8	4	13	6 (water scarcity)	5
Resource use, minerals and metals	9	5	11		
Resource use, fossils		6	10		6

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Guinée, J.B. (Ed.), Gorrée, M., Heijungs, R., Huppes, G., Kleijn, R., de Koning, A., Van Oers, L., Wegener Sleeswijk, A., Suh, S.,. Udo de Haes, H.A, De Bruijn, J.A., Van Duin R., Huijbregts, M.A.J. (2002). Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards. Series: Eco-efficiency in industry and science. Kluwer Academic Publishers. Dordrecht (Hardbound, ISBN 1-4020-0228-9; Paperback, ISBN 1-4100 4020-0557-1).

Struijs J., Beusen A., van Jaarsveld H. and Huijbregts M.A.J. (2009): Aquatic Eutrophication. Chapter 6 in: Goedkoop M., Heijungs R., Huijbregts M.A.J., De Schryver A., Struijs J., Van Zelm R. (2009): ReCiPe 2008 - A life cycle impact assessment method which comprises harmonised category indicators at the midpoint and the endpoint level. Report I: Characterisation factors, first edition.

Posch, M., Seppälä, J., Hettelingh, J.P., Johansson, M., Margni M., Jolliet, O. (2008). The role of atmospheric dispersion models and ecosystem sensitivity in the determination of characterisation factors for acidifying and eutrophying emissions in LCIA. International Journal of Life Cycle Assessment (13) pp.477–486

Seppälä J., Posch M., Johansson M. and Hettelingh J.P. (2006): Country-dependent Characterisation Factors for Acidification and Terrestrial Eutrophication Based on Accumulated Exceedance as an Impact Category Indicator. International Journal of Life Cycle Assessment 11(6): 403-416.

Van Zelm R., Huijbregts M.A.J., Den Hollander H.A., Van Jaarsveld H.A., Sauter F.J., Struijs J., Van Wijnen H.J. and Van de Meent D. (2008): European characterisation factors for human health damage of PM10 and ozone in life cycle impact assessment. Atmospheric Environment 42, 441-453.

Van Oers L., de Koning A., Guinee J.B. and Huppes G. (2002): Abiotic Resource Depletion in LCA. Road and Hydraulic Engineering Institute, Ministry of Transport and Water, Amsterdam.

R. Frischknecht, A. Braunschweig, P. Hofstetter, P. Suter, 2000 Human health damages due to ionising radiation in life cycle impact assessment, Environmental Impact Assessment Review, Volume 20, Issue 2, 2000, Pages 159-189, ISSN 0195-9255, https://doi.org/10.1016/S0195-9255(99)00042-6.

Frischknecht R., Steiner R. and Jungbluth N. (2008): The Ecological Scarcity method – Eco-Factors 2006. A method for impact assessment in LCA. Environmental studies no. 0906. Federal Office for the Environment (FOEN), Bern. 188 pp.

LOWINFOOD has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000439.

UNEP (2016) Global guidance for life cycle impact assessment indicators. Volume 1. ISBN: 978-92-807-3630-4. Available at: http://www.lifecycleinitiative.org/life-cycle-impact-assessment-indicators-and-characterization-factors/

Fantke, P., Bijster, M.,Guignard, C., Hauschild, M., Huijbregts, M., Jolliet, O., Kounina, A., Magaud, V., Margni, M., McKone, T.E., Posthuma, L., Rosenbaum, R.K., van de Meent, D., van Zelm, R., 2017.USEtox®2.0 Documentation (Version 1), http://usetox.org. https://doi.org/10.11581/DTU:00000011

World Meteorological Organisation (WMO) (2014), Scientific Assessment of Ozone Depletion: 2014, Global Ozone Research and Monitoring Project Report No. 55, Geneva, Switzerland.

Intergovernmental Panel on Climate Change - IPCC (2013). Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Bos U., Horn R., Beck T., Lindner J.P., Fischer M. (2016). LANCA® - Characterisation Factors for Life Cycle Impact Assessment, Version 2.0, 978-3-8396-0953-8Fraunhofer Verlag, Stuttgart.

Beck, T., Bos, U., Wittstock, B., Baitz, M., Fischer, M., Sedlbauer, K. (2010). 'LANCA Land Use Indicator Value Calculation in Life Cycle Assessment – Method Report', Fraunhofer Institute for Building Physics.

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