

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

D1.9 Scenarios of food waste reduction through innovation

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Summary

WP1 focuses on evaluating the efficacy, economic, social, and environmental impacts of innovations based on data from WP2 to WP5 regarding their ability to reduce food loss and waste (FLW). This deliverable (D1.9) builds on the findings of D1.6, D1.7, and D1.8, summarizing the evaluation results and highlighting strengths and weaknesses, aggregated into the following scenarios: Scenario I, "Increasing Resource Efficiency", Scenario II, "Redistributing Surplus Food", Scenario III, "Changing Behaviour", Scenario IV, "Engaging Stakeholders".

All scenarios promote a transition to a low-waste food supply chain, each with its own strengths and weaknesses. While direct impact measurement is not always possible or robust, the investigations provided valuable qualitative insights that improve processes, making them more efficient, targeted, or user-oriented, supporting future replication.

Accurate measurement of food waste is essential to assess innovations' effectiveness, improve them, and provide evidence-based guidance for policymakers. Despite challenges, movements towards food waste reduction are meaningful, with potential positive long-term effects. Continued actions to reduce food waste and explore hotspots will lead to more focused implementation, significantly impacting waste reduction.

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 scale-up 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).

WP1 is focused on the evaluation of the efficacy, the economic and social impacts as well as the environmental impacts of the innovations, based on the results achieved and data gathered in WP2 to 5 about their ability to reduce food loss and waste (FLW). This deliverable (D1.9) builds on the findings of D1.6 “FLW evaluation of innovations”, D1.7 “Socio-economic evaluation of innovations” and D1.8 “Evaluation of the environmental impacts of innovations”. It serves as a summary of the evaluation results, highlighting their strengths and weaknesses, and aggregating them into scenarios in the most generalized way.

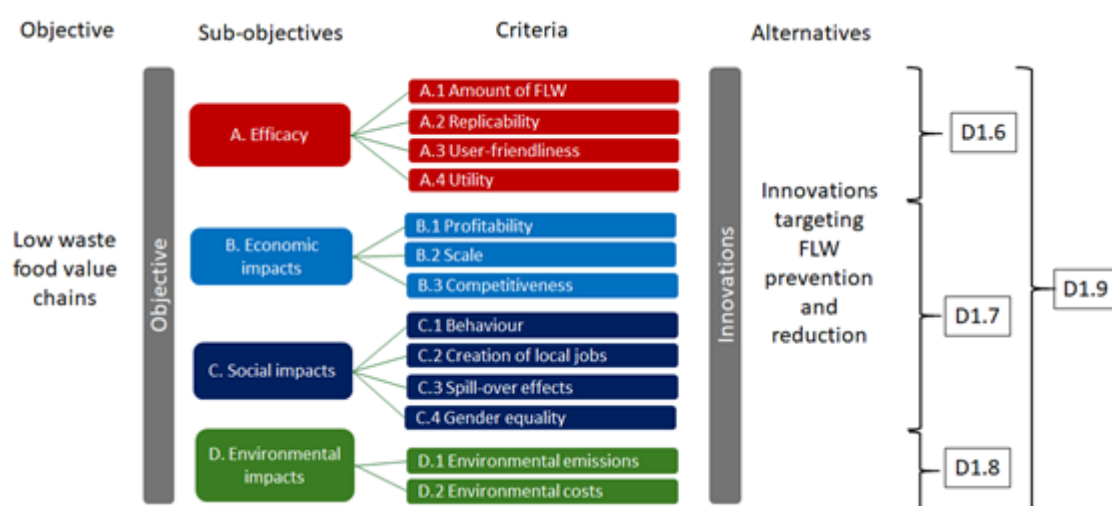


Figure 1: Target hierarchy of the evaluation of LOWINFOOD's innovations and dedicated deliverables presenting the results, the present report D1.9 covers all sub-objectives

1. Goal and scope of the scenario development

A scenario is a methodically developed description of possible future developments based on the analysis of influencing factors and their interactions. It serves to open up different perspectives on the future and highlight potential risks, opportunities and possible courses of action. Scenarios are not predictions, but offer alternative, plausible visions of the possible future's evidence-based assumptions.

The overall objective is to set up future scenarios in which food loss and waste does not occur or at least is significantly reduced and surplus food is redistributed for human consumption as much as possible.

LOWINFOOD's innovations aim to reduce FLW

- by prevention (e.g., prevention of surplus food at source),
- by reuse (e.g., through food redistribution, food donation) and
- by reprocessing (e.g., reprocessing of surplus food for human consumption).

1.1 Criteria for the scenario development

The scenario development was designed according to the following objectives and principles:

- We aimed for extracting the qualitative and quantitative evaluation results of the LOWINFOOD innovations regarding the efficacy (Giordano et al., 2024a), economic and social impacts (Koseoglu et al., 2024a) as well as environmental impacts (Scherhauer et al., 2024a).
- A further aim was to figure out strengths, weaknesses, improvement potential of innovations demonstrated and the possibility to replicate or expand them in similar or different settings and supply chains than in LOWINFOOD.
- We aimed to present food loss and waste reduction scenarios in the form of coherent stories based on qualitative assumptions that are easy to communicate and to be understood by various stakeholders. The development of narrative threads was foreseen to better illustrate feasible scenarios.
- Scenarios were built based on the objective (e.g. engagement of stakeholders, awareness raising). The outcome or the consequence of each scenario could lead to several alternatives, such as food donation or food prevention.

1.2 Method for the scenario development

Scenarios were developed based on the following steps:

- (1) Systematic screening of project outputs
- (2) Grouping of these outputs into scenarios, by means of group discussion
- (3) Definition of titles and features of scenarios
- (4) Consolidation of the results into coherent scenarios
- (5) Design of narrative threads for easier communication

Key results and influencing factors were identified by systematic screening of project outputs, mainly deliverables (D) and scientific publications. Primarily deliverables describing the evaluation of the innovations were considered in this screening step, such as D1.6 “FLW evaluation of innovations” (Giordano et al., 2024a), D1.7 “Socio-economic evaluation of innovations” (Koseoglu et al., 2024a) and D1.8 “Evaluation of the environmental impacts of innovations” (Scherhaufer et al., 2024a). Yet, also deliverables describing the demonstration of innovations were regarded (i.e., Strotmann et al., 2023; Mesiranta et al., 2023) providing more insights to strengths and weaknesses as well as to recommendations. A full list of the project outputs regarded in this deliverable is available in the reference section (chapter 5). Innovation specific outputs (including video materials and published practice abstracts) are mentioned at the end of each innovation description in Appendix II.

The software ATLAS.ti was used to extract text passages out of the materials and to code them according to the following aspects: innovation description, impacts, strengths, weaknesses and recommendations. The aspects were then summarized and discussed in working groups.

The working group was composed of the scientific partners in charge of the evaluation of innovations (JHI, LUKE, BOKU) and the coordinator of the project (UNITUS). Consolidated results and scenario descriptions were reviewed by the scientific (UNIBO, SLU, JHI, ISUN, ELH, BOKU, UNITUS) and external advisory board (F. Schneider, J. Parfitt, K. Parizeau) of the project.

2. Scenarios of FLW reduction through innovation

2.1 Scenario setting

On the journey to a low-waste food chain, innovations such as the ones demonstrated in LOWINFOOD can play a key role in this transition process. The results of LOWINFOOD refer to 14 innovations against food loss and waste, demonstrated in 15 settings across 8 countries (Austria, Finland, Germany, Greece, Italy, Scotland, Sweden, Switzerland), for which the efficacy in reducing FLW, the economic, social and environmental impacts was evaluated. The analysis of the project outputs allowed us to identify 4 scenarios, that are 4 ways through which food loss and waste can be reduced (see Figure 2): increasing resource efficiency¹ (Scenario I), redistributing surplus food (Scenario II), changing consumer behaviour (Scenario III) and engaging stakeholders (Scenario IV). Policy strategies are necessary to stipulate implementation of the scenarios (for policy strategies it is referred to the LOWINFOOD D6.10).

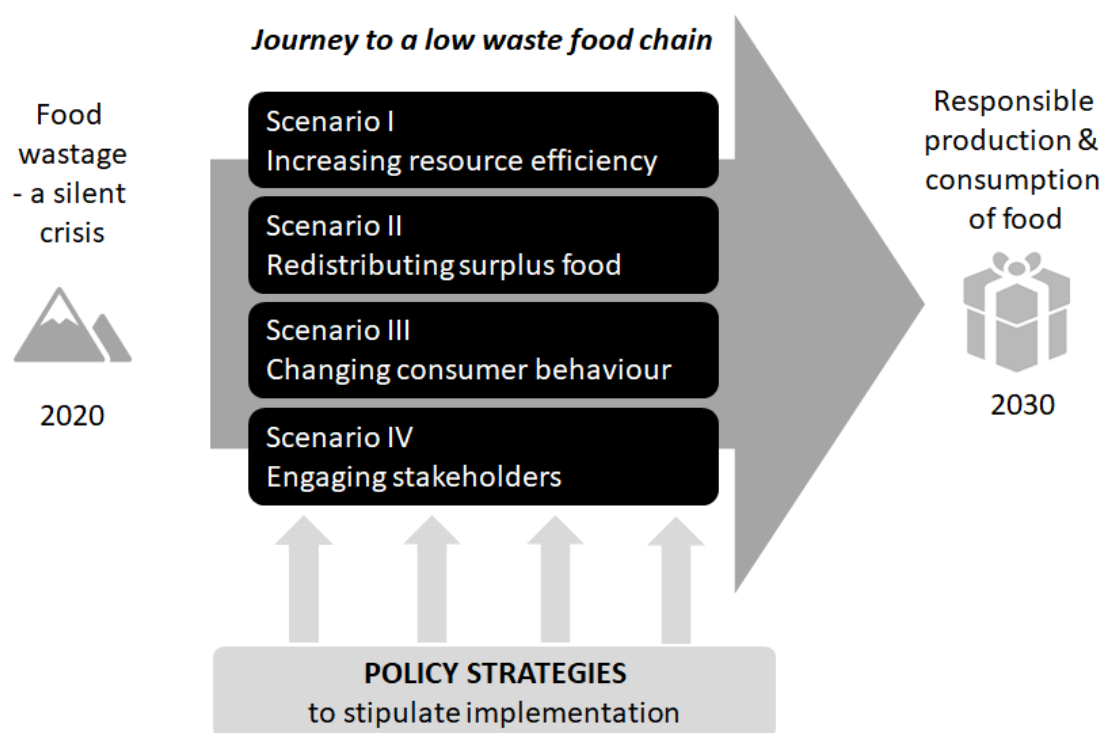


Figure 2: The journey to a low-waste food chain - Scenarios I, II, III, IV based on LOWINFOOD innovations

¹ Efficiency in this context refers to the ability to achieve a desired effect with the least amount of resources. Efficacy, on the other hand, is used in the evaluation and refers to the ability of an intervention to produce a desired effect under ideal conditions.

The journey to a low-waste food chain starts in 2020 when the project LOWINFOOD started (see storyline “Food wastage - a silent crisis” in box 1) and hopefully ends in 2030 when the Sustainable Development Goals of the United Nations are met and FLW is successfully reduced (see storyline “Responsible production and consumption of food” in box 2).

Box 1: Storyline “Food wastage - a silent crisis”

It is the year 2020, and FLW has reached staggering levels. Mountains of discarded bread, spoiled fruits, and uneaten leftovers fill landfills worldwide, releasing methane into the atmosphere while in other parts of the world, people cannot afford food and are affected by malnutrition. It's a problem hiding in plain sight, invisible to those who toss their scraps without thought or who cancel their orders at the last minute, creating mountains of food withdrawn from the market. But change is on the horizon.

Reducing FLW is a key goal at both international and national level. As part of the 2030 Agenda for Sustainable Development, the United Nations committed to the target 12.3 (United Nations, 2015), which aims to halve global per capita FLW at retail and consumer levels by 2030 and reduce losses along production and supply chains, including post-harvest losses. At national level, many countries are implementing their own strategies and programmes that are aligned with these global goals.

LOWINFOOD, as well as numerous other European Horizon projects (e.g. Folou, Chorizo, Wasteless, Breadcrumb), are dedicated to tackling the problem of FLW. These projects focus on identifying FLW prevention and reduction opportunities through research, evaluating innovative solutions, and creating low-waste food supply chains.

Box 2: Storyline “Responsible production and consumption of food”

It is the year 2030. The efforts of all stakeholders in the food value chain, supported by projects like LOWINFOOD, have been successful. The United Nations' sustainability goals have been achieved. Worldwide FLW per capita at the retail and consumer levels has been halved, and food losses along production and supply chains, including post-harvest losses, have been significantly reduced. Responsible consumption and production patterns have been established and ensured.

In this new era, communities thrive on sustainable practices, and the global food system operates with remarkable efficiency. The collective efforts of individuals, businesses, and governments have transformed our relationship with food, fostering a culture of mindfulness and respect for resources. The future looks brighter than ever, as we continue to build on these achievements for the well-being of our planet and future generations.

2.2 Scenario I “Increasing resource efficiency”

Description of the scenario

Resource efficiency refers to the effective and sustainable use of resources to achieve a desired outcome while minimizing waste and environmental impact. It involves optimizing the use of materials, energy, water, and other resources to produce goods and services in a way that reduces the overall resource consumption and environmental footprint.

Scenario I can be aligned to the action described in Caldeira et al. (2019) as “Improvement of the supply chain efficiency”. It entails actions leading to an increase in the efficiency of the food supply chain, by acting either on the processes, the products, or the packaging to promote FLW reduction.

Innovation action

Forecasting software can serve as a tool to increase resource efficiency at companies and organisations (such as bakeries, supermarkets or even hotels). By predicting the demand of food products or meals, the production can be adapted and surplus production avoided. The predictions are based on historical data, current information and various analytical techniques as well as other factors, such as the trust and willingness by staff to adapt to predictions. In LOWINFOOD forecasting was demonstrated by SLU at supermarkets ([la.](#)), by FoodTracks at bakeries ([lb.](#)) as well as by Mitakus at restaurants ([lc.](#)).

Innovative food waste solutions in kitchens such as **AI-based waste analysiss** can furthermore help kitchen managers to design the menu as such to minimise FLW occurring in the kitchen due to poor planning or on the plate due to excessive portion sizes. In LOWINFOOD this was demonstrated by Kitro at hotels ([ld.](#)).

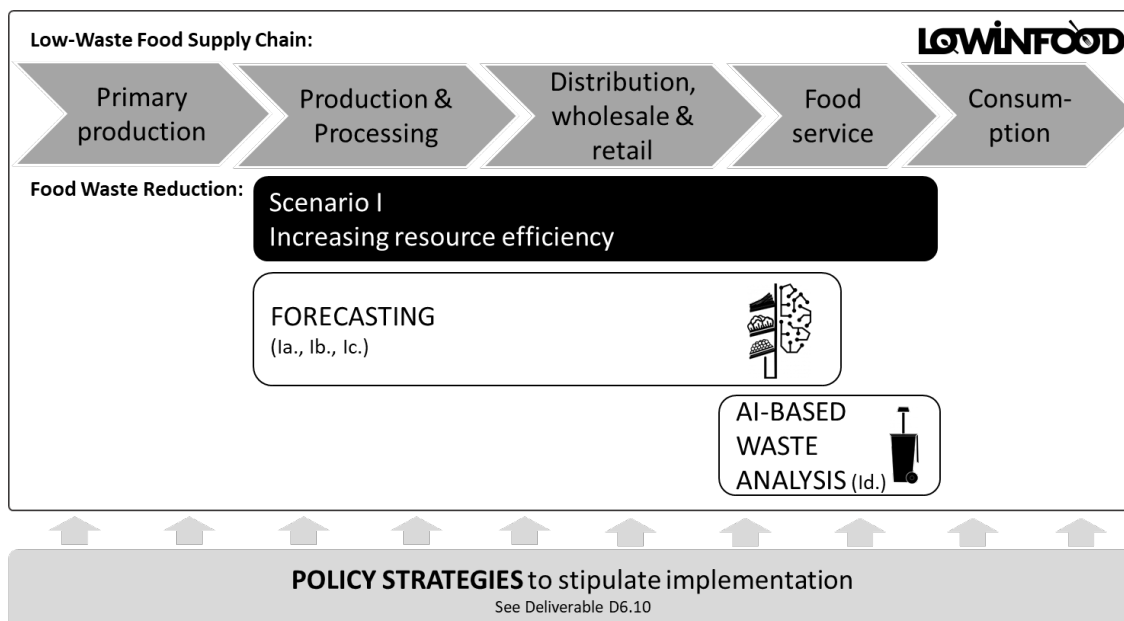


Figure 3: Innovation actions of scenario I “Increasing resource efficiency” (the number in brackets refers to the respective innovations described in Appendix II)

Impacts

Forecasting software can improve sales forecasting accuracy, significantly reducing the average error compared to the “naïve” approach of experienced-based forecasting. However, FLW reduction was not achieved in the test at supermarkets ([Ia.](#)), likely due to the time needed for food category managers to integrate the forecasts into their ordering decisions. The tests helped refine the forecasting software by identifying key products for daily forecasts, tailored to each store and season. Contrary to the tests at bakeries ([Ib.](#)) where on average, a significant amount of returned products could be prevented daily per store by using the software, resulting in a substantial annual reduction across multiple stores. In the test at restaurants ([Ic.](#)), the accuracy of short-term forecasts was generally higher than long-term forecasts and user-generated plans. However, users reported not fully trusting the forecasts and did not take them into consideration when planning. Worker and management engagement significantly influenced the test results. The AI-based waste analysis ([Id.](#)) showed a good potential for reducing food waste in canteens, though its effectiveness varied by country. It was reported to be a simple tool that can be easily implemented in daily practice of kitchen canteens.

Strengths

Automated and AI (Artificial Intelligence) based forecasting: The scenario is promising in contexts where sales forecasting is still based on human experience.

Reduced error rate: If forecasting software is systematically integrated into daily ordering routines, the error rate could be further reduced, leading to less surplus food and reduced FLW. The forecasting simulation that was tested in supermarkets within LOWINFOOD consistently improves the stores' sales forecasting accuracy, reducing the average error from 55% with the naïve forecasting approach to 32%, with the forecasting software (Giordano et al., 2024a, Malefors et al., 2024).

Automated waste quantification and analysis: An automated FLW quantification and analysis significantly improves upon traditional manual methods like waste sorting. The food waste management solution that was tested in LOWINFOOD featured a scale beneath the kitchen bin and a camera to capture waste data, providing kitchen managers with detailed insights through an online dashboard. This empowered hotels and restaurants to make more informed menu and meal planning decisions, resulting in a substantial reduction in FLW quantities.

High potential for improvements through artificial intelligence: This scenario can be even more promising in the future, when artificial intelligence algorithms mature to predict forecasting the most accurately.

Granular datasets: The data inventory for forecasting includes a high level of granularity. Quantities are available on food product level, which enables a determination of hotspots and more targeted actions for reduction. If for example the wastage of citrus products, such as nectarines, lemons, mandarins, or kiwis can be reduced, the environmental impacts can be reduced considerably, as those products require a lot of water next to greenhouse gas emissions (Scherhauser et al., 2024a).

Best choice in supplementation to further reuse activities: Even if reuse activities are already taking place, reducing waste at the source significantly further decreases environmental impacts (Scherhauser et al., 2024a).

Weaknesses

Medium-term predictions: Users might require a forecast period for ordering and procuring raw materials that is not effective for accurate predictions. For example, shorter forecasts tend to be more accurate because they use data from recent days. An extended timespan introduces challenges in accuracy, as the further out the predictions are made, the more potential for deviations from actual sales (Strotmann et al., 2023; Giordano et al., 2024a).

Kitchens with flexible menu planning: Kitchens that already have strategies in place for re-using surplus food, for instance by flexibly adapting their menu for the next day, will only see marginal effects from the use of forecasting software. It is recommended to use forecasting software at restaurants where the staff is less aware of FLW or facilities with less flexibility to adapt their daily production, such as satellite kitchens that have limited storage

facilities and have more structured and long-term menu plans (Strotmann et al., 2023; Giordano et al., 2024a).

Costs for innovative FLW management solutions: The costs for FLW management solutions may emerge as a barrier in certain markets. In Greece, for instance, the high cost of the system was flagged as a significant limitation, potentially challenging its wider adoption (Giordano et al., 2024; Koseoglu et al., 2024a).

Dependence on staff acceptance: General loss of motivation for utilizing forecasting or AI-based waste analysis applications clearly influence the outcome and diminish the overall benefits (Giordano et al., 2024a). However, the more user-friendly and simpler the tools are, the more likely they are to be accepted by staff. Simple tools that do not significantly impact kitchen process flows are more likely to be embraced by staff.

2.3 Scenario II “Redistributing surplus food”

Description of the scenario

The redistribution of surplus food involves collecting excess food (so called surplus food) from sources like grocery stores, restaurants, and farms, and then distributing it to those that have demand for it.

Surplus food arises in the 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.”

Innovation actions

The redistribution of surplus food was tested via several pathways within LOWINFOOD. All actions targeted to bridge the gap between the supply of surplus food and potential buyers or users. Those actions can involve redistribution for donation and for profit.

Regarding donations, we tested a **reporting tool** to manage and redistribute fresh fruits and vegetables withdrawn from the market under EU Common Agricultural Policy (CAP) and to manage refunds to producer organisations ([IIa.](#)).

For redistribution for profit, we had an example about a company acting as an **intermediary organisation** by providing transport, processing or storing surplus fruits and vegetables in a network of surplus food providers and surplus receivers ([IIb.](#)). Another example is a **digital platform** that features a database of raw materials which can be filtered by specific criteria,

as well as a surplus exchange that provides the industry with a marketplace for their leftover stock ([IIc.](#)). In the segment of food service, we evaluated a **mobile application** which tells customers where to buy surplus meals ([IIId.](#)). This innovation can be allocated to the actions of consumer behaviour change as it clearly influences the consumer behaviour. However, looking at the technical side of the action, it is about redistributing food.

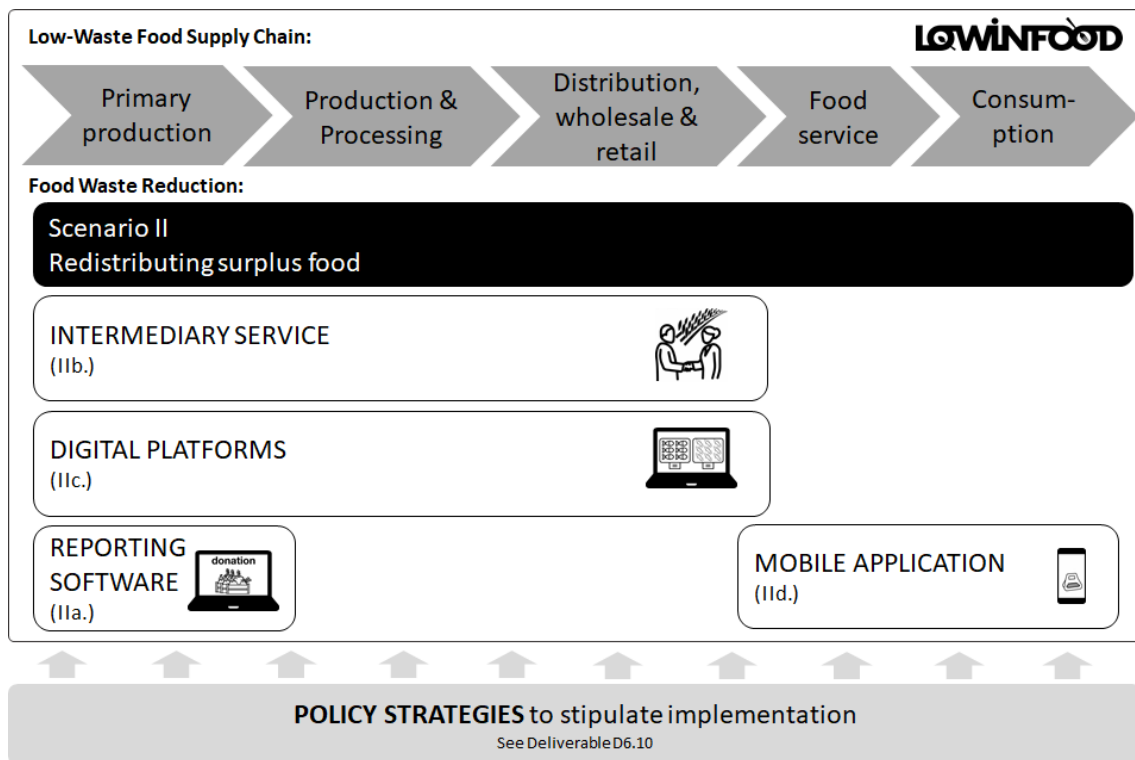


Figure 4: Innovation actions of scenario II "Redistributing surplus food" (the number in brackets refers to the respective innovations described in Appendix II)

Impacts

For the **reporting tool**, a real-time demonstration was not possible: a simulation showed potential benefits for farmers if the platform were fully adopted, including significant recovery of fruits for human consumption and economic revenue for farmers ([IIa.](#)).

In the **intermediary organisation** for redistribution of food the engagement of large-scale processors has increased the traded food products between farmers and processors ([IIb.](#)).

Since the inception of the **digital platform**, the surplus marketplace has saved a substantial amount of food from going to waste, primarily shelf-stable fruits and vegetables in processed forms. However, there were challenges in transferring perishable fruits and vegetables and fish products due to a lack of users in these segments. Non-perishable products are more suitable for trading via the platform ([IIc.](#)).

The **mobile application** has proven to be an effective application for promoting the use of doggy bags and discounted purchases of surplus food from restaurants, reducing both kitchen and plate waste ([Ild.](#)).

Strengths

Additional income: Through redistribution networks or platforms, additional income can be generated for food streams where no revenues were generated before. Innovations in LOWINFOOD showed that surplus food was wasted before cooperation with redistributing companies took place. A reporting tool would undoubtedly benefit farmers within the operative mechanism of the CAP called "Withdrawals from the Market" (European Parliament & Council, 2013). They are incentivized to recover unsold agricultural products and donate them in exchange for an economic reward that covers the production cost (for further info, see Giordano et al., 2024b).

Increased redistributed surplus food: Redistribution for profit, or the reduction of the economic losses due to unsold food, can create additional income or can diminish the production costs, which can in turn stipulate the amount of redistributed food.

Large transfer quantities: When fresh surplus food is processed, larger quantities can be saved from being wasted as the shelf life increases. The actions of the intermediary organization in LOWINFOOD proved that larger quantities can be transferred if products are targeted for processors instead of specific segments such as restaurants.

Strengthened cooperation: Apps and online platforms can help coordinate pickups, track inventory, and connect businesses in real-time, overcoming the need for storage of fresh products for days.

Low time commitment: The time required to place an order for surplus meals from restaurants, or the call to the intermediary organisation, or the time needed to input the surplus F&V products in the platform is low and the process quite efficient.

No additional devices necessary: most users did not need to purchase additional devices to implement the actions, relying instead on existing technology like smartphones, tablets, or computers. This low barrier to entry enhances its potential for widespread adoption.

Processed food most suitable: F&V derivatives with long shelf-life like powders or juices are most suitable to mediate as they have a long shelf-life and this also enables the transaction of large quantities. The unique aspect of the intermediary organisation is that surplus food is processed into forms that are in demand by customers or into long-lasting products. This approach increases the likelihood of finding satisfied buyers and, consequently, the amount of surplus food that is redistributed rather than wasted. During the two-year demonstration period of LOWINFOOD, approximately 95% of the surplus food

purchased by the intermediary organisation was processed before being resold to customers (Giordano et al, 2024a).

High potential for growth: The potential for growth is evident, as only 19% of the surplus food offered to the intermediary organisation can currently be redistributed (Giordano et al, 2024a).

Small efforts for implementation: None of the companies needed to recruit new personnel for the collaboration. Some companies reported a slight increase in weekly work hours that were spent on logistics and organization activities.

Weaknesses

Highly perishable products: The mediation of highly perishable products, like selected fruits (i.e., ripe berries) and vegetables (i.e., lettuce), but also seafood through online platforms is challenging. The need for storing is challenging for sellers.

Limited shelf-life: This limitation is due to the scarcity of demand-side businesses and the unsuitability of some surplus items, like lettuce and radishes, for further processing. Additionally, the short remaining shelf life of surplus items, typically 2–3 months, is insufficient for product development, which requires 6–12 months. Irregular quantities and varying types of surplus food also make it challenging to find more demand-side partners.

Animal products: Efforts to include products of animal origin from primary production or processing for redistribution were abandoned due to strict food safety regulations and could not be implemented by achieving economic benefit (Giordano et al, 2024a).

Long transport distances: Long transport distances can make the redistribution of surplus food economically and environmentally unfeasible.

Good market knowledge required: Lack of knowledge (e.g. current demand, price) of certain market segments can diminish the potential to find suitable buyers for the surplus food (Giordano et al, 2024a).

Success depends on individual commitment: The marketing and persuasive capacity is crucial in building a network for providing and receiving surplus food quickly. Direct contact was determined as a key success factor. LOWINFOOD innovations showed that significant efforts in persuasion and persistence were required to gain support from industry partners, many of whom initially had limited awareness of surplus redistribution. Overall, the innovation test highlights the essential role of trust-based partnerships and adaptability to overcome barriers for surplus redistribution in the food industry, particularly for perishable products (Giordano et al, 2024a).

Significant organizational changes: Three key requirements complicate the process of CAP mechanism. While some EU member states opt for the implementation of CAP emergency

crisis funding regulations, others, such as Austria, choose farmers' insurance instead. The involvement of the respective Ministry of Agriculture or the agency managing CAP funding at the national or regional level is required and recognized Producer Organizations (POs) that can request CAP repayments need to be present. These prerequisites necessitate significant organizational changes in the countries adopting the platform before implementing the reporting tool, which is primarily a technological solution. Additionally, strong commitment from the CAP payment agencies involved is essential for proper monitoring of trucks at both loading and delivery to food charities (Giordano et al, 2024a).

2.4 Scenario III “Changing consumer behaviour”

Description of the scenario

Consumer behaviour change refers to the alteration in the way individuals or groups select, purchase, use, and dispose of goods, services, ideas, or experiences over time.

This scenario is based on the action description of Caldeira et al. (2019) for “consumer behaviour change” that includes *actions promoting a behavioural shift amongst consumers to achieve a reduction in food waste generation*.

Innovation actions

Educational programs at schools ([IIIa.](#)) or the use of **waste trackers** at school canteens ([IIIb.](#)) can change the behaviour of pupils to achieve a reduction in FLW generation.

Similarly, **mobile applications** can encourage household members to better manage their food at home and prevent food from being wasted ([IIIc.](#)).

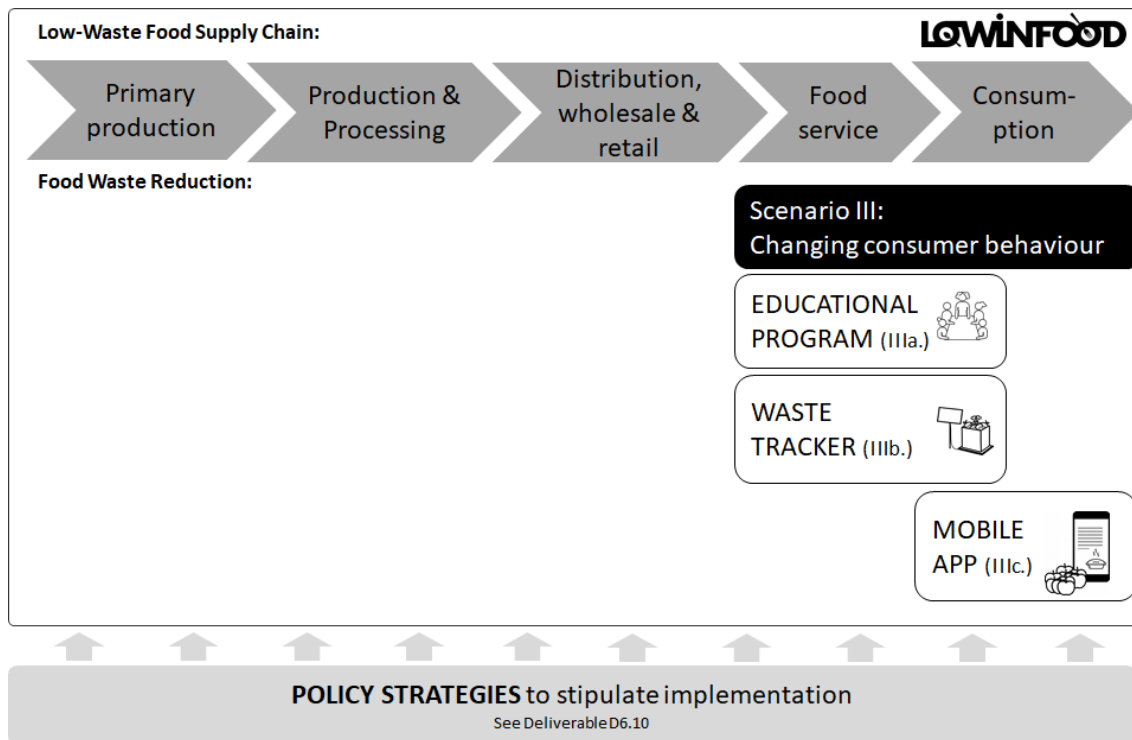


Figure 5: Innovation actions of scenario III "Changing consumer behaviour" (the number in brackets refers to the respective innovations described in Appendix II)

Impacts

Looking at the evaluation results of the LOWINFOOD examples, innovations on behaviour change can be considered successful in several key aspects, especially regarding its impact on reducing FLW, ease of use, and potential for replication. The **educational approach (IIIa.)** did not perform well overall, in some cases partly due to logistical challenges in measuring FLW accurately, in others just because results were not significant from a statistical standpoint.

The data shows a good reduction in FLW quantities during the demonstration phase of the **plate waste tracker** across all investigated countries in the example of [IIIb.](#) (Giordano et al., 2024a).

Regarding the **mobile application (IIIc.)**, statistical tests indicate that the innovation's effectiveness in reducing FLW cannot be conclusively determined, primarily due to the small sample size in this demonstration

Strengths

Implementation at schools:

Increased awareness for pupils: actions such as educational programs but also the plate waste tracker is useful to increase awareness of pupils for the topic of FLW in the long term and create a lasting impact. However, the immediate social impact of educational interventions might not be as salient, as evidenced by surveys of participants before and after demonstration.

Engaging tool for pupils: The waste tracker tool is reported to be very engaging and interesting for pupils, especially for younger pupils the multimedia aspects are tempting (Giordano et al., 2024a).

Functional design and technical simplicity: The functionality of the waste trackers' dashboard including the interface and the overall system design was reported by both kitchen staff and pupils as effective and user-friendly. The tool was regarded as easy to use once introduced. Most staff required minimal training, with no extensive sessions necessary. In most cases, a brief explanation or a simple 5-minute instruction was enough for kitchen staff and teachers to understand and operate the system (Giordano et al., 2024a).

Strong potential for replication: The feedback indicates strong potential for replication, as all schools integrated the innovation without needing additional resources, fitting within existing infrastructures (Giordano et al., 2024). While national differences in school canteens definitely play a role in the way FLW is handled, the demonstration in LOWINFOOD in countries such as Germany, Sweden and Austria revealed that the presented interventions can be successfully applied to multiple settings (Scherhauser et al., 2024a).

Short implementation period: The plate waste tracker requires only a brief implementation period. The advantage is that the same device can then be circulated for shorter periods between different locations, significantly reducing the cost of implementation and replication (Koseoglu et al., 2024a).

Implementation at households:

Valuable assistance: A mobile application for food management at home provides valuable assistance for shopping, storage, and meal planning. Features such as the receipt scanner and integration with market products are well-received, and many users find it user-friendly for family food planning (Giordano et al., 2024a).

Strong potential when cooperating with retailers: Furthermore, the growing trend of online shopping has also impacted the app's effectiveness: the app would work best in partnership with retail companies. Perhaps in the future, with the adoption of two-dimensional (2D) barcodes and data sharing agreements with retailers, more information

from products (e.g. expiry date) can be transferred automatically to the app by scanning the barcode on the item instead of manual import (Mesiranta et al., 2023; Giordano et al., 2024a).

Weaknesses

Implementation at schools:

Tailored approaches: The varying levels of success seen with educational meals underscore the necessity for context-specific adjustments to behavioural interventions. Although the plate waste tracker proves to be universally advantageous, educational programs may need more tailored approaches to effectively engage students and teachers in reducing FLW across diverse cultural or operational settings (Giordano et al., 2024a; Scherhaufer et al., 2024a).

Engagement of staff: The engagement of staff is important. If the kitchen staff at schools does not engage with the system by considering the results in their planning, it will not impact FLW reduction by altering the portion size or the content of the meals (Malefors et al., 2023).

Additional workload but minimal: Overall, minimal time commitment (10 to 15 minutes per day) was reported for kitchen staff at schools, but still additional workload associated with using and maintaining the equipment was stated, especially with the operational tasks required (i.e., carrying the device to and from the tray track, turning the device on, supervising its use, cleaning it) as well as technical issues with the hardware (problems with tablets, loose cable contacts, repeated error messages). Despite these challenges, users rated the system's features positively (Giordano et al., 2024a).

Habituation effect with long-term use: The students get used to the device and stop paying attention to it after a while. The initial attention and the associated decrease in FLW diminishes. Therefore, it makes more sense to use the device repeatedly in shorter periods with interruptions to keep drawing attention to it (Koseoglu et al., 2024a).

Direct impacts not measurable: Educational programs might not change FLW quantities, which is in line with findings from background literature (Piras et al., 2023). The outcomes of these programs are difficult to capture. Furthermore, isolating FLW measurements only to the classes involved in the demonstrations created logistical challenges. In school canteens, where multiple classes eat together, it was difficult to segregate the FLW data for specific groups (Giordano et al., 2024a).

Implementation at households:

Limited user group: The mobile application for households is suitable for a specific target group. Older individuals or those experienced in managing food supplies might find using a mobile application for their home food management redundant or time-consuming.

Younger individuals would see the app more beneficial perhaps later in their life, when they buy more food and groceries. Both of these conclusions are based on the qualitative data collected in an online survey with open questions and interviews. It is hypothesized that the app is more effective in scenarios where all adult family members are sharing food management tasks and thus need to consolidate this work (such as in families with teenagers or in flat-sharing communities) (Mesiranta et al., 2023; Giordano et al., 2024a).

Great dependence on increased user-friendliness: If the mobile application still lacks user-friendliness such as a slow input process, language barriers, difficulties to track food, or difficulties to use different features, a reliable evaluation is hindered and its effect on FLW reduction potential not measurable (Mesiranta et al., 2023; Giordano et al., 2024a).

2.5 Scenario IV “Engaging stakeholders”

Description of the scenario

Stakeholder engagement is crucial for creating effective, inclusive and sustainable solutions to complex problems. Stakeholders bring a variety of perspectives, experiences, and expertise that can lead to more comprehensive and effective solutions. Furthermore, by involving stakeholders in a decision-making process, it can build trust and ensure collaborations to reduce FLW even beyond a specific intervention.

The inclusion of stakeholders is necessary for voluntary agreements within food systems or the creation of local and national FLW prevention programmes. Both actions fall under the category “food waste prevention governance” of Caldeira et al. (2019).

Innovation action

Stakeholder dialogues encompass engagement of different actors of a supply chain horizontally or vertically. Horizontal actors operate at the same stage of the supply chain. They often perform similar roles or functions and may collaborate or compete within the same market or geographic region. Vertical actors represent the entities at different levels or stages of the supply chain. They are linked through sequential relationships, such as upstream suppliers or downstream customers. Furthermore, they can operate locally, nationally, regionally or globally.

In LOWINFOOD we held local **stakeholder dialogues** with vertical actors of the fish supply chain in Germany and Scotland including the stages of primary production, primary and secondary processing, wholesale, retail, catering, distribution as well as innovators, and innovative users of seafood by-products; policymakers, financial institutions, sectoral organisations and networks ([IVa.](#)). Additionally, stakeholder dialogues were organised in the bread supply chain of horizontal actors including craft bakeries in Italy and industrial scale bakeries in Sweden and Finland ([IVb.](#)). Additionally, **supplier-retailer agreements** involving

both bakeries and retailers were investigated exploring solutions of take-back returns of bread in Sweden and Finland (IVc.).

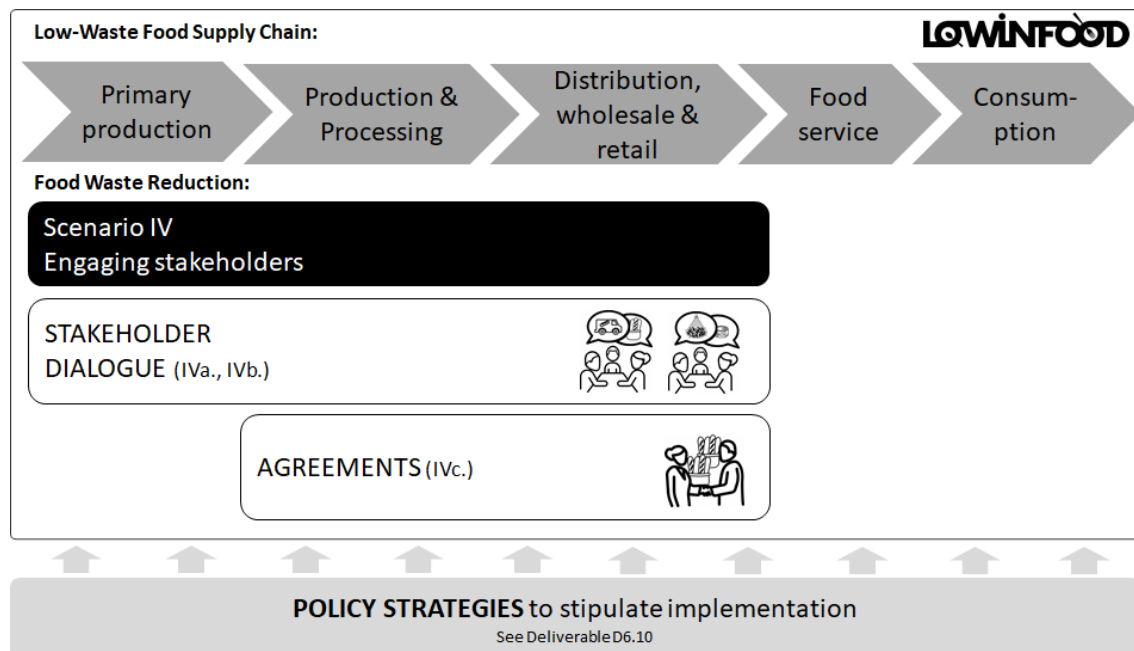


Figure 6: Innovation actions of scenario IV “Engaging stakeholders” (the number in brackets refers to the respective innovations described in Appendix II)

Impacts

The **dialogue with fish companies** revealed their reluctance to share data due to concerns about reputation and competition. Consequently, no FLW data was provided by industry stakeholders, and the dialogue was not aimed at short-term FLW reduction impacts. A baseline management survey was completed by a few stakeholders, but the small and diverse sample prevented the presentation of aggregated data at industry level. One notable finding was that the mass of premium fish materials removed from the value chain was generally minimal, except in one case, indicating significant valorisation potential. An exploratory transaction between a fishmeal and fish oil company and a start-up using fish oil for biosurfactants occurred in the dialogue (IVa.).

The **dialogues with bakeries** were not conducted to produce short-term impacts that are measurable. Therefore, potential benefits on efficacy, costs or environment could only be determined by long-term evaluation. Alternatively, baseline survey data were used to comment on potential impacts based on simulations (what happens, if ...?). This emphasises the commitment and the direction we need to take. A simulation model used data from a Swedish stakeholder dialogue and secondary sources to calculate waste rates, sales, and production data for private-label bakery products, scaled to a national level. A second

stakeholder dialogue validated and refined these estimates, leading to the development of one baseline and six alternative bread management scenarios ([IVc.](#)).

In Italy direct measurements at craft bakeries took place as a first action of a roadmap to reduce surplus bread. The evaluation focused on three key bread products. The average daily waste for common bread and focaccia bread increased significantly during the demonstration, while the waste for bread rolls showed no significant change in most locations ([IVb.](#)).

Strengths

Awareness increase: Stakeholders involved in the dialogue for fish in Germany agreed that there are hardly any losses in the up-stream stages of the fish supply chain. After digging deeper into the stakeholders' operations and perspectives, it was discovered that certain losses exist. Especially by-catch was mentioned as a major problem in Scotland (Koseoglu et al, 2024b; Koseoglu et al., 2024c). Also, the daily measurement of bread surplus in Italian craft bakeries, which was identified as a first action in the roadmap, increased attention of owners towards the issue of bread waste, especially in a period of rise in production costs (Pietrangeli et al., 2024).

Multiple scenarios: A range of scenarios can be discussed and explored together with stakeholders. These scenarios are not mutually exclusive, meaning combined implementation of multiple scenarios could result in even greater waste reduction than the individual scenarios suggested (Giordano et al., 2024a).

Positive side effects: Engaging stakeholders often leads to outcomes that go beyond the intended objectives. For example, while the primary goal might be to agree on actions to reduce FLW, the process can result in increased collaboration on other matters, such as seen with bakeries in Italy (discussions about suppliers of ingredients) creating positive side effects (Giordano et al., 2024a; Pietrangeli et al., 2024).

Weaknesses

Direct impact not measurable: The direct impact of stakeholder dialogues, particularly in the short term, is difficult to quantify because these discussions often focus on strategy rather than immediate implementation. The impacts are typically long-term and hardly measurable. This isn't necessarily negative, but it is challenging to capture. An exception was the direct measurement at Italian bakeries, which served as the first action of the roadmap. However, the effect of this direct measurement on the quantities could not be proven (Giordano et al., 2024a, Koseoglu et al., 2024a).

Different priorities: Priorities may vary among different stakeholders and between stakeholders and researchers. A clear and systematic approach with stakeholders is therefore of the utmost importance. Success depends on the level of awareness of both the

researchers regarding the initial problem and the stakeholders concerning the FLW issue, as well as on how the problem is formulated.

Researchers perceived as outsiders: It is difficult for researchers to initiate engagement without partnering with industry organizations, as researchers are often perceived as outsiders by the industry and do not initially offer tangible benefits in exchange for stakeholders' time, efforts, and data disclosure.

Lack of data disclosure: The overall lack of collaboration from industry stakeholders regarding discussions on FLW and efforts underscores that not all actors in the food supply chain are prepared to address the issue, with many perceiving it as bearing reputational and financial risks (e.g., fishing companies being asked to adopt new practices and costly innovations). For example, while retailers were willing to discuss their actions to prevent or reduce FLW as part of their corporate social responsibility efforts and likely viewed the interviews as an opportunity for increased visibility, they were still reluctant to share quantitative data (Giordano et al., 2024).

Providing evidence: Evaluating the connection between actions taken and the outcomes achieved is challenging.

3. Learnings and recommendations

While there are numerous methods to reduce FLW, it is crucial to test these ideas in real-world settings to ensure their effectiveness and meaningful impact across the food supply chain, which was the goal in LOWINFOOD. However, this also involves risks and challenges.

The following learnings and recommendations are intended to guide future research projects. These insights raise questions that should be addressed at the outset of future projects involving multiple stakeholders.

3.1 Critical review of evaluation method

How the risk of misinterpretation by respondents can be decreased

Online surveys can increase the number of respondents (increase the sample size), but also have a higher risk of misinterpretation. Personal interviews can narrow down this risk, but also decrease the sample size due to additional effort required. The balance between sample size and quality needs to be considered individually. In LOWINFOOD task leaders decided about the data collection method, as they could estimate the actual situation and local framework conditions (stakeholder engagement, stakeholder knowledge) the best. It was expected that this would decrease errors and increase data quality and sample size.

Despite careful planning, some issues were encountered during data collection. For example, some of the innovation users responded to the questions related to fixed and variable costs in the management surveys based on the overall costs of running their businesses. However, the surveys aimed to only capture the change in the businesses' fixed and variable costs that were relevant to the aim of innovations being demonstrated (e.g., change in equipment and storage costs, raw ingredients, avoided cost of surplus orders, additional labor etc.). These misunderstandings were identified and fixed through dialogue with task leaders during the evaluation period.

It is recommended that data collection is automated whenever possible, especially for technical innovations, and that more regular disclosures of data be ensured to improve the quality of assessment data. Additionally, seeking a standardized data collection method that can be applied across different cases and countries will ensure the comparability of innovations. However, it is also essential to include qualitative information to provide context around the data, balancing robustness and scalability in various situations, respondents, and contexts. Finding the balance between robustness and feasibility remains crucial and must be determined on a case-by-case basis.

To improve data collection for any type of innovation tested, making the process less burdensome for users while ensuring it remains consequential for those involved is essential. The following recommendations are proposed:

- **Prioritize a qualitative survey:** It is recommended that a qualitative survey is conducted first to ensure that the effects can be attributed to the application of the innovation. Initially, questions should be asked such as: "Did the innovation have an influence on sales, the cost of raw materials, etc.?" If the answer to these questions is affirmative, then proceed with a quantitative survey, always with specific reference to "changes that are due to the innovation."
- **Automate Data Collection:** Explore ways to automate data collection, particularly for technical innovations, to reduce the burden on users. This includes linking existing industry statistics and data captured by software/devices with the evaluation metrics. An example to consider is innovation Ib.
- **Streamline Indicators:** Reduce the number of indicators to be collected by deciding what is relevant to measure in collaboration with task leaders and innovation users at the project's outset. Implement a mid-term disclosure to check the quality and quantity of the data being collected, adjust expectations, and discuss mitigation options for impact evaluation.
- **Shared Responsibility:** Ensure that the responsibility for collecting high-quality data for impact evaluation is shared among all stakeholders. This includes compensating innovation users, as was done with hotels, and involving all innovation providers in the data collection process.

By implementing these recommendations, the balance between robustness and feasibility in data collection can be better managed, ensuring more effective and reliable impact evaluations.

How to capture the impacts of the innovation itself

Behavioural reactivity, where participants change their actions because they know they are being observed, may have impacted the results. Generally speaking, it is difficult to capture the sole impacts of the innovation, as most of the conditions influence them too.

For example, it was anticipated in IVb. in Italy, that between the baseline and monitoring phases at craft bakeries, bakery staff would potentially enhance their accuracy in measuring and recording surplus. This improvement could be attributed to the daily observations and practice they accumulated during both baseline and demonstration. So, the change between baseline and demonstration cannot be solely attributed to actions identified in the roadmap but to the effect of direct measurement.

Similarly, in the example of IIc., the behaviour of households might have been influenced by the direct measurement and the sorting analysis of their FLW rather than by the use of the mobile application. Conducting waste audits if subjects know they are being observed can lead to altered behaviours, both consciously (due to social desirability bias) and unconsciously (behavioural reactivity).

Isolating FLW measurements for specific interventions and corresponding target groups posed logistical challenges in IIIa. In environments such as school canteens, where multiple groups dine together, it was difficult to segregate the FLW data for individual groups.

Even if this is primarily a scientific problem. On a practical level, increasing awareness of the FLW issue is beneficial, even if it poses challenges for researchers. However, from a scientific point of view it is recommended that waste audits are organised without participants' awareness to mitigate the effect of behavioural reactivity; to this end, the easiest way is to arrange an agreement with the waste management company. It is easier if the area has door to door collection. Collecting data for a sufficient amount of time ensures the reduction of behavioural activity (between 1 and 2 months). Waste bags can be analysed in the waste management company facilities by researchers or by the same personnel, if adequately instructed.

How to cope with exogenous factors

Factors such as the Russia aggression to Ukraine influenced the monitoring phase. For example, during the project evaluation phase, a period marked by higher wheat and energy costs of producing wheat products was observed. This situation gradually recovered in subsequent years followed by a notable increase of e.g., bread production. If direct measurement of quantities took place in the first period and was compared with the second

period, this might lead to an increase of e.g., bread surplus in absolute terms (as it was the case in IVb in Italy).

Also, the pandemic influenced the demonstration. In case of Ic., all available historical data sets were used to calculate the forecast in 2021. But because of the changes during and after the pandemic, all data from 2021 and before could not be used. This issue limited data availability to create an accurate forecast, as new post-pandemic customer habits would have needed to be considered. It is important to recognize that certain constraints were beyond control and not a shortcoming of the project. Despite best efforts, these limitations have influenced the evaluation results. Therefore, they should be considered when interpreting the data and developing future recommendations.

It is recommended that measurement periods for both the status quo ante and the intervention be as long as possible to average out short-term coincidences. While long-term geopolitical or pandemic disruptions are beyond control, planning for longer evaluation periods is a wise solution. The LOWINFOOD project, for instance, faced extraordinary challenges due to the pandemic and the start of the Russia aggression to Ukraine.

To make research more feasible, it is also recommended to push for replication of cases to obtain a sufficient number of observations, which helps in identifying real trends despite exogenous factors. For example, quantifying FLW in one baking company with 50 outlets is more effective than doing so in 50 different bakeries, each with its specificities. When the right type of data is available, statistical analysis can isolate external shocks and simulate results under consistent conditions, as demonstrated in various parts of the LOWINFOOD project.

How to cope with unsuitable test users

A major challenge encountered in most of the cases was engaging the people and organizations involved in adopting the innovations. The design of the project, with so many innovations to be tested, required that the number of users planned for each innovation was limited. Furthermore, the interested participants were already somewhat aware of FLW issues, and prevention and reduction measures were already in place. As a result, the low-hanging fruit had already been harvested, making further improvements more challenging. During the project phase, it was difficult to engage those actors who had not yet implemented any FLW reduction actions in their businesses.

In IVb. for example, bakeries already performed quite well in terms of surplus bread prevention and therefore for them it is more challenging to improve their performances.

This is similar to kitchens that already integrate their surplus food very flexibly in their menu plans. The effects of innovations such as forecasting software face shortcomings in that case. It is recommended that restaurants, especially smaller establishments that are less aware of FLW, use forecasting software. This is particularly beneficial for facilities with less volatile

menu plans and customer demands, such as satellite kitchens with limited storage and more structured, long-term menu plans.

Also, stakeholders in IVc. noted that there are often well-established and effective structures within the value chain for the further distribution of seafood materials and by-products. This is due to the high economic value of fish commodities, which leads to efficient resource utilization, ensuring that very little goes unused or is used below its potential. Consequently, this makes it challenging for innovations like a redistribution platform such as in IIc. to penetrate the market.

Furthermore, it is assumed that in other EU member states with higher digital literacy rates, the performance of the apps (as in IIIc.) is expected to be better than in the currently tested environments. As digital literacy improves, the apps are likely to perform more effectively in the future.

Many companies view experimentation as a 'waste of time' and prefer to focus on daily tasks. This resistance often arises when different organizational levels have contrasting views on innovation: for example, management may be supportive, while operators see it as an additional burden that detracts from routine activities, or vice versa (Cicatiello et al., 2020). This issue is not limited to companies; public bodies, such as ministries and local administrations, have also shown fragmented engagement in some cases. Fragmentation or internal disagreements can limit an innovation's ability to achieve its goals.

3.2 Recommendations for future evaluation

How to enhance evaluation

Despite promising results in some innovations, it is still recommended to test on a larger sample or for a longer period of time and benefit from relevant secondary data resources when available.

In case of Ia., the innovation should be tested on a larger sample of supermarkets, as the demonstration phase involved only two stores in Italy from the same supermarket chain. Another key aspect is that the innovation needs to be used for a longer period to be well integrated into the daily ordering decision process. It is a promising innovation for contexts where forecasting is primarily based on human experience. Additionally, since forecasting software is already available in many places, a potential next step could be to compare the results of this software with existing ones.

The outcomes of the mobile application at households in IIIc. is likely due to the small sample size: 19 units in Austria, 19 in Finland, and 15 in Greece. While average FLW reductions in Austria and Finland suggest potential positive effects, a larger sample size is needed for more robust conclusions. Another issue is the infrequent use of the mobile app observed in the

case of the most demonstration participants, making it difficult to link the result achieved with the use of the app.

Although time and budget often restrict the involvement of larger sample sizes, it is recommended to consider this in future projects, possibly with incentives for test users.

What is the optimal level of data granularity?

Finding a balance between robustness and feasibility is crucial. High data granularity requires significant effort in data collection, which is often not feasible due to time and budget constraints. Conversely, low data granularity often fails to provide robust conclusions. Finding this balance remains a challenge. In LOWINFOOD, we encountered the following issues in different innovations tests:

- Due to the lack of detailed data records at baseline, a direct comparison of the before and after situation of certain key performance indicators was not possible. Therefore, only the data of the demonstration period was possible to explore in some examples (e.g. in IIa.).
- Data confidentiality, comparability issues due to the diversity of the sample, and completeness, limited willingness to disclose specific waste types and quantities (e.g. in IIb. and IVa).
- Due to the aggregation level of data at demonstration and the lack of disaggregated data records at baseline, a statistical analysis was in some cases not possible (e.g. in IIb.).
- For certain products, the difference in surplus rate between the baseline and demonstration phases was significant across all testing facilities, but for other products in the same innovation there was not significant change between two periods. At the same time, detailed results for individual facilities showed considerable variability. For example, for one product half of the facilities experienced a reduction, while the other half saw an increase. Therefore, both at granular and aggregated levels, it is difficult to conclude that the innovation was effective (e.g. in IVb. in Italy).

What are the advantages and disadvantages of using secondary data to complement primary data collected at test locations?

A notable shortcoming is the lack of data on the FLW composition in some cases (e.g. in IIIa. and IIb.). The FLW composition was instead based on the typical food served in schools in the respective countries, rather than the actual food wasted. This can lead to overestimations in some food products, such as animal based products, which considerably influence the environmental impact assessment and at the same time underestimations for other product categories. This distorts impact results and needs to be considered when interpreting the outcomes.

Major differences in the available unit meal costs led to refrain from calculating potential cost savings at the location or country level in IIIa. and IIb. The heterogeneity among locations where innovations were tested, such as public and private schools and their meal provision routes, resulted in significant cost variations between the countries observed and even between the facilities within the country observed. Thus, monetizing avoided plate waste based on local prices would highlight price differences rather than the reduction in plate waste per pupil. Additionally, with the current data, it is challenging to assign a realistic timeframe for cost savings or to assume that the innovation would maintain its impact on students' plate waste behaviour over an entire school year, semester, or month, and how this impact might gradually diminish.

However, estimating the potential impact of an innovation, particularly when direct impact measurement is not possible, represents a significant advancement in knowledge. This approach ensures that potential impacts are communicated, helps identify hotspots, and provides recommendations for future interventions.

3.3 Replicability potential

How can facilitators push replicability

The role of facilitators, meaning organisations that represent and support the interests of certain branches, in the implementation process was essential and is expected to support the broader adoption of innovations beyond projects. While innovations might be demonstrated at a local scale, there is interest in expanding their application to a wider context. For example, providing tools to help stakeholders share best practices for reducing surplus and minimizing waste may lead to knowledge exchange and additional spill over of innovations.

In LOWINFOOD, organisations such as CNA (Confederazione Nazionale dell'Artigianato e della piccola e media impresa Associazione di Viterbo e Civitavecchia), a regional branch of the National Confederation of Crafts and Small and Medium Enterprises in Italy and ADB Nord (Akademie Deutsches Bäckerhandwerk Nord GmbH), a training academy for apprentices in the bakery trade, acted as facilitators and were also project partners of LOWINFOOD. As an example, CNA's role as a facilitator in this process was pivotal and is anticipated to drive the replication of the innovation beyond the LOWINFOOD project. Although the demonstration was carried out locally, CNA expressed interest in scaling up the roadmap to combat bread waste at the national level. For instance, they aim to support craft bakeries by providing tools to share best practices for reducing surplus bread and minimizing waste. Similarly, the ADB Nord can promote the further dissemination of the software in the industry through its spillover effect. They utilize the training booklet (Strotmann et al., 2023) created as part of the LOWINFOOD project to train employees in the bakery industry on the use of forecasting software, as part of the training provided to apprentices and master bakers.

Also, ARELH (Assemblée des Régions Européennes Fruitières Legumières et Horticoles), an assembly of European regions that are involved in the production of fruits, vegetables, and horticultural products, and part of the LOWINFOOD consortium facilitated that process of finding a replicator for the the the reporting software (IIa.).

Transferability to other areas of application

Some technological tools presented in LOWINFOOD, such as the AI-based waste analysis at hotels (Id.) or the waste tracker at schools (IIIb.), have a clear advantage in quantifying and accounting for FLW, aligning with the targets of SDG 12.3 of the United Nations and the European Commission's mandatory food waste reporting requirements for member states. With the right adoption strategies and potential cost reductions, these technological tools can also be beneficial at the household level.

It supports the EU's every-four-year accounting mandate, offering a more efficient and standardized solution than current methods like paper diaries and manual waste sorting analyses. Automated, data-driven approaches would significantly reduce the effort required to meet these regulations while providing highly accurate and reliable data, helping countries achieve their sustainability goals with less administrative burden.

4. Conclusions

All presented scenarios foster the transition to a low-waste food supply chain, each having its own strengths and weaknesses. The measurement of direct impacts is not always possible or robust enough to generate definitive conclusions. However, the research conducted in the scope of the EU LOWINFOOD project consistently revealed positive externalities of demonstration and valuable qualitative insights that improve the process, making it more efficient, targeted, or user-oriented. This progress supports the future replication of innovations.

Scenario II, "Redistributing Surplus Food", seems to be more tangible compared to Scenario I, "Increasing Resource Efficiency", or Scenario III, "Changing Behaviour". However, the latter scenarios could be more impactful in terms of FLW reduction quantities, environmental, and economic impacts. Nevertheless, since Scenario II has significant potential to scale up, it can also have larger impacts than those measured in the project. Scenario IV, "Engaging Stakeholders", is deemed crucial for initiating necessary changes in food supply chains, as such changes requires the involvement of multiple stakeholders. A transition is more successful when all relevant stakeholders are included in a participative approach, making Scenario IV essential for the transition, even if only effects might be measurable in the long-term.

Capturing the real-life impacts of innovations remains complex, but any progress toward FLW reduction is meaningful. Accurate measurement and characterization of FLW are

essential for identifying the most effective reduction, redistribution, and re-valorization strategies. However, challenges persist in engaging all relevant stakeholders, particularly in sectors like meat production, which significantly impacts FLW reduction efforts in both quantity and environmental terms. This issue is not unique to this project but is observed in similar initiatives, underscoring the need for targeted strategies to involve all key actors effectively.

Assessing the effectiveness of innovations requires rigorous measurement, testing, and adaptation to different contexts. While these efforts demand time and resources, the cost of implementing ineffective solutions can be even higher. The project has provided valuable insights for improving methodological frameworks and refining impact evaluation strategies. Given that an innovation successful in one setting may not yield the same results elsewhere, it is crucial to test and identify the right target users and optimal conditions before broader implementation.

A key takeaway is the necessity of not only developing new innovations but also ensuring their practical application within real-world supply chains. The primary value of this project lies in its attempt to implement and assess innovations in real settings, acknowledging that a one-size-fits-all solution does not exist. The effectiveness of interventions varies based on context, making a universal recommendation or ranking of measures impractical at this stage.

Furthermore, evolving regulatory frameworks, such as obligatory EU targets, may reshape the landscape for implementing such interventions in the future, potentially influencing their benefits and feasibility. While we are still learning about the interactions between different interventions and their outcomes, taking action remains more beneficial than inaction. Even if an intervention proves unfeasible in a specific case, the knowledge gained enables the exploration of alternative solutions. Continuing with business as usual is not a viable long-term strategy, reinforcing the need for continuous innovation, evaluation, and adaptation.

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Appendix I. Terms and definitions

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':

- EU definition: **"food waste"** means all food as defined in Article 2 of Regulation (EC) No 178/2002 of the European Parliament and of the Council (*) that has become waste (European Commission, 2018)
- FAO definition: The decrease in quantity or quality of food resulting from decisions and actions by food suppliers at the production, post-harvest, and processing stages of the food supply chain (**'food losses'**) and by retailers, food service providers, and consumers (**'food waste'**) (FAO, 2019).

LOWINFOOD's innovations cover specific parts of food waste, 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". We aim for reducing the following food waste categories including also surplus food:

- **Surplus food:** 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."
- **Surplus bread:** Surplus bread refers to bread that has been baked, delivered to stores, and put on sale but remains unsold by the end of the day (Garrone et al., 2014).
- **Kitchen waste:** is typically arising in restaurants and food service as well as households, but also in retail and other distribution sectors. Kitchen waste covers waste from overproduction, preparation waste and serving as well as plate waste.
- **Plate waste:** this includes food that is served but not eaten. It 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) (Caldeira et al., 2017).

- **By-products:** are defined as circular flows of food removed from the FSC to be used to produce other products such as animal feed or biomaterials (Caldeira et al., 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 context (Corrado et al., 2019).
- **Food waste at household (or post-consumer food waste):** this includes food damaged due to lack of cooling/storage facilities; food not eaten e.g., due to excess, elapsed expiration date, low consumer appeal, and plate waste; and inedible food waste (fruit kernels, bones, etc.)

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Appendix II. Factsheets of the evaluation results of LOWINFOOD's innovations

1a. FORECASTING AT SUPERMARKETS

Name of the innovation: FORECASTING AT SUPERMARKETS		LOWINFOOD- Task-No.: T 2.4	
Company: SLU*		Targeted food category: Fruits & Vegetables at retail	
Details of the demonstration: A software was designed to predict future sales of F&V in supermarkets to optimise orders, the software uses neural networks and machine learning to create forecasts based on store-specific historical sales data. It predicts daily or weekly sales for individual F&V products, helping food category managers reduce over-ordering and as a result minimize in-store food waste. The software provides sales predictions for the next day.			
Country: Italy	Sample size: 2 supermarkets	Baseline period: Sept 2023	Demonstration period: Apr-May 2024
Efficacy results: The software improved sales forecasting accuracy, reducing the average error from 55% (naïve approach) to 32%. Food waste reduction was not achieved, likely due to the time needed for food category managers to integrate the forecasts into their ordering decisions. The test helped improve the forecasting software by defining a list of key products for daily forecasts, tailored to each store and season.			
Economic impacts: As this task was simulation-based and the simulated orders may not have been implemented by the managers of two participating supermarket stores, Store 1 and 2. The potential cost savings was based on the change in the cost of waste reported in different product categories between the figures measured during baseline period and the figures simulated for the demonstration period. While the cost figures increased in the demonstration, the increases were insignificant for Store1 in recorded waste and Store2 in total waste, and more pronounced (over € 30) for Store1 in total waste and Store2 in recorded waste. The specific conditions in each store can explain the different outcome.			
Social impacts: We do not observe any statistically significant changes in a direction opposite to our hypotheses ² , neither in the single statements, nor in the aggregated indicators. A			

² We hypothesised that as a result of being involved in the demonstration of the innovations; the awareness, attitude and behaviour of those who took part in the demonstrations against food loss and waste has changed in a pro-environmental direction. We controlled for this by measuring the difference in their responses to the statements included in the survey before and after taking part in the demonstrations. We expected their agreement

significant positive change is observed in the aggregated indicators of “Moral concern” and “Intention”, while other aggregated indicators do not change significantly.

Environmental impacts:

1 kg of food surplus at supermarkets resulted in 0.15 kg CO₂e, 548 m³ water-eq. and 0.097 EUR environmental costs. It is noticeable that the indicator water use is dominating the environmental impact categories. This is due to certain food products, such as nectarines, lemons, mandarins, kiwis, that consume 4 to 5 times more water compared to an apple.

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Videos accessible at <https://lowinfood.eu/resources/videos/>:

YouTube-Video: Sales-forecasting software for supermarkets

Practice Abstracts accessible at <https://lowinfood.eu/project/results/>:

Practice Abstract No.8 (EN): Reduce retail food waste with forecasting

Practice Abstract No.8 (IT): Prevedere le vendite per ridurre gli sprechi alimentari nella distribuzione

*academic partner conducting the forecasting as the company that was initially foreseen to introduce a forecasting software for supermarkets left the consortium.

1b. FORECASTING AT BAKERIES

Name of the innovation: FORECASTING AT BAKERIES	LOWINFOOD- Task-No.: T 3.3
Company: FoodTracks (FT)	Targeted food category: Surplus bread and bakery products

to statements formulated positively in the survey would increase after the demonstration, while the level of agreement with those formulated negatively would decrease.

Details of the demonstration: FoodTracks is a software solution for enhancing order management and maximizing revenue in the bakery sector. It uses an AI algorithm to analyse historical and real-time data from the bakery's IT system, including ordered, sold, and returned quantities, as well as key master data like order units and shelf life. FoodTracks identifies revenue opportunities and generates accurate order recommendations, factoring in external elements like weather and public holidays to reduce the risk of sell-outs.			
Country: Germany	Sample size:38 bakery sales stores	Baseline period: Jan 2021 – March 2022	Demonstration period: March 2022 – May 2023
Efficacy results: On average 7.1 kg of returned products could be prevented daily per store by the use of FoodTracks. This results in an annual reduction for the three bakeries with 41 sales stores of 106 tons of returned products. The average is statistically significant (Kruskal- Wallis p-value > 0.001).			
Economic impacts: The annual average return on investment from implementation was around €22,000 per bakery. Costs were expressed in terms of cost of raw materials, energy and monthly subscription fees paid to the platform by companies.			
Social impacts: We do not observe any statistically significant changes in a direction opposite to our hypotheses³, neither in the single statements, nor in the aggregated indicators. A significant positive change is observed in “Moral concern” and “Intention” indicators, while other indicators do not change significantly. We conclude that innovations focusing on “supply chain efficiency” are probably the most effective in generating a social impact among employees.			
Environmental impacts: 1 kg of food surplus results in 1.2 kg CO₂e and 0.31 EUR environmental costs. Many reuse activities, such as donation, reworking, valorisation of surplus bread, and animal feeding, were documented at baseline, resulting in high credits (negative values). At demonstration, these credits are diminished due to less surplus production, but impacts from food production are also reduced due to surplus prevention.			

³ see footnote 2 on page 39

References:

Websites: <https://www.foodtracks.de/en/>

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Scherhaufer S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K.; Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

YouTube-Videos accessible at <https://lowinfood.eu/resources/videos/>:

LOWINFOOD innovations: [FoodTracks, better decisions for bakeries](#)

Implementing LOWINFOOD innovations: [Software for optimization of bakeries' production](#)

Practice Abstracts accessible at <https://lowinfood.eu/project/results/>:

Practice Abstract No.2 (EN): FoodTracks – Better decisions for bakeries

Practice Abstract No.2 (DE): FoodTracks – Besser entscheiden

1c. FORECASTING AT RESTAURANTS

Name of the innovation: FORECASTING AT RESTAURANTS		LOWINFOOD- Task-No.: T 5.1	
Company: Mitakus		Targeted food category: Surplus food at restaurants	
Details of the demonstration: Mitakus is designed for kitchen managers to use forecasts in planning meals. The web-based software generates precise forecasts and menu recommendations using AI algorithms based on factors like weather, holidays, events, and dietary restrictions. These predictions help food service operators and restaurants reduce overproduction and underproduction, and find the perfect menu to meet guest's demand and preferences. Mitakus calculated both long-term forecasts of consumer demand (six weeks in advance) and short-term forecasts (daily updates). These were compared to users' own long-term predictions based on experience. Real sales were recorded to determine if Mitakus improved planning accuracy compared to the existing forecasting system.			
Country: Germany	Sample size: 2 canteens	Baseline period: May 2022 – Jun 2023	Demonstration period: Feb 2023 – Nov 2023

Efficacy results: For DE1, Mitakus short-term forecasts were the most accurate (20% deviation from actual sales), followed by long-term forecasts (26%), while the user's own planning had the highest deviation (57%). For DE2, short-term forecasts were again the most accurate (30%), but long-term (73%) and user's own forecasts (34%) had higher deviations. Both users reported not fully trusting the forecasts and sometimes ignoring them, especially during stressful times. Worker and company engagement significantly influenced the forecasting outcomes.
Economic impacts: The lack of economic impact in DE1 and DE2 can be linked to two main reasons. Firstly, the baseline data was collected during the COVID-19 pandemic and as a result, it was not representative of the demonstration period, leading to not so accurate predictions most of the time, and as a result the forecasts were rarely implemented by the canteen staff. Secondly, the chosen facilities might not be the ideal settings to deploy Mitakus platform. The setting in which the canteens operate required high adaptability in the short-term, and their fully equipped kitchens and storage facilities on site allowed for this flexible operation pattern. As a result, both canteens stored and reworked their surplus and were ready to respond quickly if higher than expected customer demand occurred.
Social impacts: While no economic gains or waste reduction was measured, one of the demonstration locations indicated participating in the project has led to reduction in their overall food waste.
Environmental impacts: By targeting the overproduced dishes only, 6 to 5% of the emissions could be reduced because the surplus production was already very small. As most dishes served in both of the participating canteens contains meat (54% of the dishes contain fish, chicken, beef or pork), around 4.5 kg CO₂e per kg of food surplus could be prevented.
References: Websites: no website anymore Deliverables accessible at https://lowinfood.eu/project/results/: Giordano, C.; Alboni, F.; Brunnuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Scherhauser S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K.; Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Strotmann, C., Gerwin, P., Eriksson, M., Wolkow, R. (2024) D5.8 – Report on Demonstration – Mitakus. Lowinfood project, GA No. 101000439. Lowinfood.eu Videos accessible at https://lowinfood.eu/resources/videos/: YouTube-Video: MITAKUS: Technological innovation to better forecast meals in food service YouTube-Video: Software to better forecast meals in food service

Practice Abstracts accessible at <https://lowinfood.eu/project/results/>:

Practice Abstract No.11 (EN): Predicting Food Demand with Mitakus

Practice Abstract No.11 (DE): Die Nachfrage vorhersagen mit Mitakus

Id. AI-BASED WASTE ANALYSIS AT HOTELS

Name of the innovation: AI-BASED WASTE ANALYSIS AT HOTELS		LOWINFOOD- Task-No.: T 3.1	
Company: Kitro		Targeted food category: Plate waste, Serving losses	
Details of the demonstration: Kitro offers an automated food waste management solution for restaurants, canteens, and hotels. Using image processing, deep learning, and a hardware setup, it captures and analyses food waste data. An online dashboard provides detailed insights, helping food services reduce waste. The hardware includes a scale under the waste bin and a device with a camera to record the type and amount of discarded food. The display is only visible to the person designing the menu and plate content, rather than the staff preparing food or customers, as it aims to provide insights for menu and plate design so that what is bought and prepared by catering kitchen will be ordered by customers, and what is served to the customers will not be left uneaten on their plates.			
Country:	Sample size:	Baseline period:	Demonstration period:
Germany	2 hotels (233 days, 217 days)*	Dec 2021 – Jun 2022	Jan 2022 – May 2023
Switzerland	1 hotel (307 days)*	Feb 2022 – Feb 2022	Mar 2022 – Jan 2023
Greece	2 hotels (314 days, 305 days)*	May 2022 – Jun 2022	Jun 2022 – Oct 2023
*... observation days at demonstration			
Efficacy results: Kitro showed a good potential for reducing food waste in canteens, though its effectiveness varied by country. In Greece, canteens cut food waste by half. In Germany, two out of three canteens also saw reductions between the baseline and demonstration phases, In Switzerland, no reduction in food waste was observed.			

Economic impacts:

The innovation's objective of reducing the cost of edible waste was reached in 4 of the 5 participating test locations and quite significant savings compared to baseline (7844, 9695, 4568 and 3659 €/year, respectively). Two different scenarios were created to estimate the innovation's return on investment. The first scenario used the annual subscription cost for the actual numbers of devices used during the demonstration while the second scenario assumed the waste and associated cost reduction could be achieved with a single device subscription in each location.

However, when the current annual subscription cost of 6000 €/year is considered, only two locations under the assumption of achieving the same results using a single device can achieve net cost savings. Therefore, the current subscription cost limits the economic feasibility of adopting Kitro to establishments with very large daily production capacities.

Social impacts:

We do not observe any statistically significant changes in a direction opposite to our hypotheses⁴, neither in the single statements, nor in the aggregated indicators. A significant positive change is observed in "Moral concern" and "Intention", while other aggregated indicators do not change significantly. We conclude that innovations focusing on "supply chain efficiency" are probably the most effective in generating a social impact among employees.

Environmental impacts:

The global warming potential (and the external environmental costs) per kg of food waste was 3.40 kg CO₂e (0.86 EUR) in Germany, 3.82 kg CO₂e (1.73 EUR) in Switzerland and 2.80 kg CO₂e (0.67 EUR) in Greece, which is influenced by the type of menu dishes.

References:

Websites: <https://www.kitro.ch/>

Deliverables accessible at <https://lowinfood.eu/project/results/>:

Giordano, C.; Alboni, F.; Brunnuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

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Videos accessible at <https://lowinfood.eu/resources/videos/>:

YouTube-Video: [KITRO: Automated food waste management in food service using artificial intelligence](#)

YouTube-Video: [Smart bin for restaurants' and hotels' kitchen](#)

Practice Abstracts accessible at <https://lowinfood.eu/project/results/>:

Practice Abstract No.3 (EN): Reduce food waste, save money by AI

Practice Abstract No.3 (DE): Die einfache Art Lebensmittelabfälle in der Gastronomie zu retten

⁴ see footnote 2 on page 39

IIa. REPORTING SOFTWARE AT PRIMARY PRODUCTION

Name of the innovation: REPORTING SOFTWARE AT PRIMARY PRODUCTION		LOWINFOOD- Task-No.: T 2.1	
Company: RER software		Targeted food category: Surplus fruit and vegetables	
Details of the demonstration: The S.I.R. platform (Withdrawal Information System) is an online tool created by the Government of the Region of Emilia-Romagna (RER) in Italy to manage and redistribute fresh fruits and vegetables withdrawn from the market under EU Common Agricultural Policy (CAP) regulations. Since 2012, RER has used the platform to monitor donations of withdrawn produce and refunds to producers' organizations (POs). The surplus produce is redistributed to accredited charities or other venues. The innovation aimed to expand the platform's use beyond Emilia-Romagna to facilitate surplus food donations and farmer refunds via the CAP crisis management fund. Although replication in other EU countries faced recruitment challenges, Romania showed potential as a partner because unlike most other regions of the European Union, a system to compensate producers for their withdrawn agricultural produce under CAP crisis management fund does not already exist in Romania. A theoretical demonstration was simulated to scope for potential gains using the data from a single PO based in Romania, namely Valea Topologului Agricultural Cooperative, and a capacity-building workshop was conducted to showcase the platform's benefits to its potential users, with hopes for future adoption by Romania's Ministry of Agriculture.			
Country: Italy/Romania	Sample size: -	Baseline period: -	Demonstration period: 2023-2024
Efficacy results: Since the Ministry of Agriculture was not involved in the replication, thus a real-time demonstration could not be developed. To address this, we assumed that the Agricultural Cooperative was an Italian PO receiving the same reimbursements from CAP funding, and we simulated the results to showcase the potential benefits for farmers if the platform were fully adopted. In 2024, with full platform implementation, the PO would have recovered 4000 kg of fruits (500 kg of cherries, 3500 kg of strawberries) for human consumption.			

Economic impacts: Looking at the surplus quantities of strawberries, plums, apples, and pears and assuming that the Valea Topologului Agricultural Cooperative was a PO, it would have received €5287.5 per year if all unsold food was donated for human consumption. With half donated for human consumption and half for other purposes, the revenue would have been €3384.7 per year. With all unsold products used for other purposes, the reimbursement would have been €1482 per year. It is important to note that the reimbursement from CAP were based in Italy as these figures currently do not exist for Romania and could be lower in Romania, as funding is tied to the average production costs determined by the Ministry in consultation with POs at national level. However, a purchasing power parity ratio between Italy and Romania is used for adjustment.
Social impacts: Given the small sample size for social impact evaluation, no aggregated indicators could be estimated individually for this task.
Environmental impacts: No environmental impact assessment could be made due to lack of data.
References: Websites: https://www.regione.emilia-romagna.it/ Deliverables accessible at https://lowinfood.eu/project/results/: Giordano, C., Falasconi, L., Di Fiore, N. G., Pinghini, R., Zappi, L., Finco, R., Ziosi, C., Callegari, S., Contrino, L., & Canaj, E. (2024). Report on demonstration vegetables withdraw software (D2.8). Lowinfood project, GA No. 101000439. Lowinfood.eu. Giordano, C.; Alboni, F.; Brunnhuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Scherhauser S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K., Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. YouTube-Videos accessible at https://lowinfood.eu/resources/videos/: LOWINFOOD innovations: Software to manage withdraws of fruit & vegetables and donating them to charities Implementing LOWINFOOD innovations: Software to manage F&V withdraws and donating them to charities Practice Abstracts accessible at https://lowinfood.eu/project/results/:

IIb. SURPLUS NETWORK AT PRIMARY PRODUCTION, PROCESSING AND WHOLESALE

Name of the innovation: SURPLUS NETWORK AT PRIMARY PRODUCTION, PROCESSING AND WHOLESALE		LOWINFOOD- Task-No.: T 2.2	
Company: Unverschwendet (UNV)		Targeted food category: Surplus fruit and vegetables (F&V)	
Details of the demonstration: The innovation entails a cooperation system in Austria that connects farmers, processing industry, and wholesalers to find alternative marketing channels for surplus agricultural products. By redistributing and reprocessing these products, UNV ensures they are made available for human consumption instead of becoming food waste. The goal is to promote the use of surplus F&V and bridge the gap between different actors in the food supply chain on for-profit bases. The company acts as an intermediary, redistributing surplus food from farmers to other food production actors in its network, including UNV itself as a producer of several processed products. Most of the redistributed food is sold B2B (business-to-business) within the food supply chain, while a smaller portion is used in production of UNV's own brand of jams or chutneys. These redistribution actions were not only implemented in the demonstration but were already taking place in the baseline because in the scope of this task, rather than the implementation of a new innovation, the expansion of the already existing network and business model of UNV during EU LOWINFOOD project involvement was evaluated. In the baseline, food surplus was redistributed but to a lesser extent (smaller annual volume) than during the demonstration. The aim of the demonstration was to enlarge the network with cooperating partners and to increase the volume of annual transfers.			
Country: Austria	Sample size: Total amount of food surplus transferred by the company	Baseline period: (2016 – 2021)* *situation before enlargement of network	Demonstration period: Feb 2022 – Jan 2024
Efficacy results: The traded food products between farmers and processors increased from 50 tons in 2019 and 370 tons in 2022, due to the engagement of two large-scale processors. The main food category that is offered to the redistributing company are fresh vegetables, followed by fresh fruit and semi-processed vegetables. Only 19% of the food offered can also be used and successfully transferred.			

Economic impacts:

Only aggregated data and no baseline information about the state of transfer prior to the project was provided which hindered a detailed economic analysis. As a result, we were unable to estimate the scale of the additional income for the surplus providers and the cost savings for surplus receivers. In general, the increase in volume of the transfer during UNV's involvement in the EU LOWINFOOD project is expected to increase the total additional income for those providing surplus food and the total cost savings for those receiving their F&V inputs at costs less than market averages. . Survey responses from four companies who are members of the network provided valuable qualitative insights about their economic gains: Three out of four respondents indicated they were not generating revenue from their surplus through other valorisation routes before collaborating with the company, partially confirming the hypothesis about additional income creation for surplus food providers. UNV as a redistributing company buys the surplus food at around 20 to 40% from the current market price.

Social impacts:

Given the small sample size for social impact evaluation, no significant effect on aggregated indicators could be estimated individually for this task.

Environmental impacts:

About 95% of the surplus food purchased by UNV during the demonstration period of LOWINFOOD (2 years) was processed before being resold to the business customers in their network. This additional processing must be taken into account, including the additional transport. The environmental impact assessment showed that the benefits of avoided food waste (in this case through redistribution for human consumption) offset the additional processing and transport costs. As the impact of processing and transport is largely due to the use of fossil fuels, the environmental impact indicators related to the use of fossil fuels are more affected than other indicators. The Global Warming Potential (GWP) resulted in -0.12 kg CO₂e per kg of redistributed food. In total €44,000 per year of environmental external costs could be saved through redistribution at this volume.

References:

Websites: <https://www.unverschwendet.at/>

Deliverables accessible at <https://lowinfood.eu/project/results/>:

Giordano, C.; Alboni, F.; Brunnuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

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Scherhauser, S., Diesenreiter, C., & Schmied, E. B. N. (2024). *D2.5 Guidelines for surplus food redistribution*. Lowinfood project, GA No. 101000439. Lowinfood.eu.

YouTube-Videos accessible at <https://lowinfood.eu/resources/videos/>:

LOWINFOOD innovations: [Unverschwendet, cooperation between farmers and food service sector](#)

Implementing LOWINFOOD innovations: [Cooperation system between farmers and food service sector](#)

Practice Abstracts accessible at <https://lowinfood.eu/project/results/>:

Practice Abstract No.6 (EN): Marketable products from surplus fruit and vegetables

Practice Abstract No.6 (DE): Marktfähige Produkte aus überschüssigem Obst und Gemüse

IIc. DIGITAL PLATFORM AT PRIMARY PRODUCTION, PROCESSING AND WHOLESALE

Name of the innovation: DIGITAL PLATFORM AT PRIMARY PRODUCTION, PROCESSING AND WHOLESALE		LOWINFOOD- Task-No.: T 2.3 T4.2	
Company: Leroma		Targeted food category: Surplus fruit and vegetables (F&V) Surplus seafood products	
Details of the demonstration: Leroma is a B2B online platform that connects producers with surplus food to processors seeking input materials for their food production. It features a database of raw materials which can be filtered by specific criteria, as well as a surplus exchange that provides the industry with a marketplace for their leftover stock. The goal was to link F&V producers (T2.3) as well as fish producing companies (T4.2) with processors and other actors in the food chain to redistribute surpluses in these categories through this online platform. The mediation of surplus fresh food products was targeted in both tasks.			
Country: Scotland Germany	Sample size: no transactions of fresh food products; only qualitative feedback collected	Baseline period: -	Demonstration period: -
Efficacy results: Since January 2021, the surplus marketplace has saved over 1,000 tons of food from going to waste. In February 2024, a snapshot showed 286 offers of surplus goods, with at least 20 being shelf-stable fruits and vegetables, mostly in processed forms like powder, concentrates, and granules. However, no perishable F&V could be transferred due to a lack of users in this market segment. Similarly, eight fish products were advertised; however, no transaction took place in this product segment. This conclusion applies only to the specific test and scope initially proposed; the platform works with other products and contexts, but this was beyond our demonstration's scope. Non-perishable products are found to be more suitable to be traded via the platform.			
Economic impacts: No economic impact assessment due to lack of data.			

Social impacts: No social impact assessment due to lack of data.
Environmental impacts: No environmental impact assessment due to lack of data.
References: Websites: https://www.leroma.de/index.html Deliverables accessible at https://lowinfood.eu/project/results/: Engelmann, T., Casalino, F. (2024): D2.7 Report on demonstration – Leroma. Lowinfood project, GA No. 101000439. Lowinfood.eu. Giordano, C.; Alboni, F.; Brunnhuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Scherhauser S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K.; Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Videos accessible at https://lowinfood.eu/resources/videos/: YouTube-Video: LEROMA, a digital marketplace for fish and F&V industries YouTube-Video: B2B digital market place for reducing food losses Practice Abstracts accessible at https://lowinfood.eu/project/results/: Practice Abstract No.7 (EN): Bringing raw materials to the right place with LEROMA Practice Abstract No.7 (DE): Rohmaterialien mit LEROMA an die richtige Stelle bringen

II.d. MOBILE APPLICATION AT RESTAURANTS

Name of the innovation: MOBILE APPLICATION AT RESTAURANTS	LOWINFOOD- Task-No.: T 5.6
Company: Regusto	Targeted food category: Surplus meals
Details of the demonstration: The innovation targets reduction of two different types of surplus food in catering ('kitchen food waste' in terms of cooked but not served meals) and plate waste reduction ('plate waste' in terms of served but not eaten meals). REGUSTO combines two approaches to address two different types of food surplus: a mobile app allows consumers to purchase surplus meals from restaurants at discounted prices, reducing food waste and a special doggy-bag for storing discounted orders and left-overs. Restaurants sell their surplus fresh meals through the app. App users can find nearby offers using geo-location and proximity marketing. After selecting their meals, users choose the quantities and collection times. Meals are stored in the REGUSTO Bag for pickup. Those eating in the restaurant can also take home their leftovers, if they cannot finish them at restaurant in a REGUSTO bag which eliminates creation of plate waste.	

Country: Italy	Sample size: 5 restaurants à 300 bags (580 survey responses)	Baseline period: March 2022	Demonstration period: Jun 2023 – Jul 2023
Efficacy results: REGUSTO seems to be a successful application to promote the use of doggy-bags and discounted purchases of restaurants' surplus food. Both food waste at kitchens as well as plate waste of customers were reduced in the observed restaurants by selling surplus meals and by offering customers the doggy bag to bring their meals to home. The food waste reduction in restaurant was approximately 9.2% in kitchen food waste (from 282 to 256 kg per month) and 30.4% for consumers (from 230 to 160 kg per month).			
Economic impacts: Key indicators for this innovation include additional income from discounted meal sales, new business streams, and accessing new customers through the app, with no additional expenses for the demonstration. Based on monthly figures, the return on investment (ROI) during the demonstration was estimated at €450, €600, and €540 for three restaurants each. After deducting a 20% commission (similar to Too Good To Go), and the standard price of a REGUSTO bag at €1 per order, significant additional incomes of €1008, €840, and €1038 respectively can still be achieved during the demonstration period from the sale of discounted fresh meals.			
Social impacts: Given the small sample size for social impact evaluation, no significant effect on aggregated indicators could be estimated individually for this task.			
Environmental impacts: The Global Warming Potential (GWP) of the participating restaurants could be reduced by 10% compared to the baseline. Impacts of the innovation action that include additional consumer transport for taking the food to home as well as the use of the smartphone for using the app are neglectable. The majority of the environmental impacts comes from the food supply chain. Relative results show a GWP reduction potential of 3.46 kg CO₂e per kg of food that can be redistributed, which is the impact category with the highest contribution.			

References:

Websites: <https://recuperiamo.org/>

Deliverables accessible at <https://lowinfood.eu/project/results/>:

Giordano, C.; Alboni, F.; Brunnhuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

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Rellini, P., Secondi, L., & Yu, M. (2023, December 31). D5.11: Report on the demonstration – Regusto. Lowinfood project, GA No. 101000439. Lowinfood.eu.

Scherhauser S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K.; Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

YouTube-Videos accessible at <https://lowinfood.eu/resources/videos/>:

LOWINFOOD innovations: [REGUSTO: Mobile app to sell restaurants' surplus food and track delivered products up to the bin](#)

Implementing LOWINFOOD innovations: [Mobile app to sell restaurants' surplus food](#)

Practice Abstracts accessible at <https://lowinfood.eu/project/results/>:

Practice Abstract No.5 (EN): REGUSTO and monitoring of waste on the restaurant-home route

Practice Abstract No.5 (IT): REGUSTO e il monitoraggio degli sprechi nel percorso ristorante-casa

IIIa. EDUCATIONAL PROGRAMS AT SCHOOLS

Name of the innovation: EDUCATIONAL PROGRAMS AT SCHOOLS		LOWINFOOD- Task-No.: Task 5.4	
Company: No company, universities to set put educational programs and teachers that implement it at schools.		Targeted food category: Unspecified food waste	
Details of the demonstration: To use school meals as a learning tool to raise awareness of food waste and promote sustainable habits, the initiative adapts educational materials for meal settings and provides training for teachers and kitchen staff, aiming to reduce food waste and support sustainable meal preparation practices.			
Country: Sweden Austria	Sample size: 5 schools 2 schools	Baseline period: Jan 2021 – Feb 2022	Demonstration period: Feb 2022 – Jun 2022 Oct 2022
Efficacy results:			

The educational approach did not seem to perform well anywhere. However, limitations in the measurement of food waste quantities (logistical challenges to isolate food waste measurements for only the treated classes) were reported.
Economic impacts: No economic impact assessment due to lack of data.
Social impacts: None of the social indicators show the expected change. Statements related to "Intention" change contrary to our hypotheses⁵. After the innovation, students feel less guilty about food waste, are less convinced it's a major economic issue, and doubt their ability to recycle unavoidable food waste. Thus, the innovations aimed at "consumers' behavioural change" had no positive impact on the students in the sample.
Environmental impacts: The prevented emissions for 1 kg of avoided school canteen plate waste equals -3.2 kg CO₂e for the demonstration in Sweden.
References: Websites: https://www.slu.se/; https://ecology.at/ Deliverables accessible at https://lowinfood.eu/project/results/: Giordano, C.; Alboni, F.; Brunnhuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Scherhauser S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K.; Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Sundin, N., Sjölund, A., Kaltenbrunner, K., Orth, D., Malefors, C., Nygårdh, S., & Eriksson, M. (2023) D5.6: Educational concept. Lowinfood project, GA No. 101000439. Lowinfood.eu Scientific publications: Sundin, N., Malefors, C., Strotmann, C., Orth, D., Kaltenbrunner, K., Obersteiner, G., Scherhauser, S., Sjölund, A., Persson Osowski, C., Strid, I., & Eriksson, M. (2024). Sustainability assessment of educational approaches as food waste prevention measures in school catering. <i>Journal of Cleaner Production</i>, 481. https://doi.org/10.1016/j.jclepro.2024.144196 YouTube-Videos accessible at https://lowinfood.eu/resources/videos/: LOWINFOOD innovations: Educational Concept to reduce food waste at schools Implementing LOWINFOOD innovations: Educational approach against food waste at schools Practice Abstracts accessible at https://lowinfood.eu/project/results/: Practice Abstract No.13 (EN): Innovative education reducing food waste in Austrian schools Practice Abstract No.13 (DE): Innovatives Bildungskonzept zur Vermeidung von Lebensmittelabfall

⁵ see footnote 2 on page 39

IIIb. WASTE TRACKER AT SCHOOLS

Name of the innovation: WASTE TRACKER AT SCHOOLS		LOWINFOOD- Task-No.: Task 5.3	
Company: Matomatic		Targeted food category: Plate waste	
Details of the demonstration: The MATOMATIC plate waste tracker features a smart scale that provides primary school students with feedback on their plate waste. It offers tips on reducing food waste and its impacts, and allows students to give feedback to canteen staff on why they wasted food, helping both students and staff improve waste reduction efforts.			
Country:	Sample size:	Baseline period:	Demonstration period:
Sweden	9 schools	Jan 2021- Sept 2021	Sept 2021 – Apr 2022
Germany	3 schools		March 2023 – Jun 2023
Austria	4 schools		Sept 2022 – Nov 2023
Efficacy results: The plate waste tracker reduced food waste in all the testing countries (between 25% and 63%). The innovation worked and was well received by pupils, as educational tool. Some resistance from the school staff in adopting the innovation was recorded in two cases in Germany (they felt overwhelmed already by routinary actions). Otherwise, the innovation was labelled as easy to use and it has the potential to work even better if coupled with an educational intervention during school curricula.			
Economic impacts: Economic incentives or disincentives to reduce food waste were low for schools. There are potential economic gains from the reduction of plate waste, which might translate into reduction of production or ordering less meals to feed the same number of students. To illustrate this, an average reduction in plate waste of 17.9 g/pupil could translate into a potential annual cost saving of €2,350 assuming an average of 144 students per day, 178 school days per year, and €5.12/kg of food input cost for conventional school meals in Germany.			
Social impacts: None of the social indicators show the expected change. Statements related to "Intention" change contrary to our hypotheses ⁶ . After the innovation, students feel less guilty about food waste, are less convinced it's a major economic issue, and doubt their ability to recycle unavoidable food waste. Thus, the innovations aimed at "consumers' behavioural change" had no positive impact on the students in the sample.			

⁶ see footnote 2 on page 37

Environmental impacts: Environmental impacts per kg of food waste depends on the food mix served that was considered in the different countries. The emission factor of the mixed plate waste is the highest in Austria (4.8 kg CO₂e), followed by Sweden (3.3 kg CO₂e) and lowest in Germany (2.2 kg CO₂e). As the composition does not change between baseline and demonstration, this emission factor corresponds to the environmental impacts per kg of food waste. The relative external environmental costs result in €1.3, €0.89 and €0.72 per kg of food waste in Austria, Sweden and Germany by using the plate waste tracker.	
References: Websites: http://matomatic.se/ Deliverables accessible at https://lowinfood.eu/project/results/: Giordano, C.; Alboni, F.; Brunnuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Malefors, C., Strotmann, C., Orth, D., Sjölund, A., Eriksson, M., Sundin, N (2023). D5.9 Report on the demonstration of the plate waste tracker at schools. Lowinfood, 31 December 2023. Lowinfood project, GA No. 101000439. Lowinfood.eu. Scherhauser S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K., Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Scientific publications: Malefors, C., Svensson, E., & Eriksson, M. (2024). Automated quantification tool to monitor plate waste in school canteens. <i>Resources, Conservation and Recycling</i>, 200. https://doi.org/10.1016/j.resconrec.2023.107288 YouTube-Videos accessible at https://lowinfood.eu/resources/videos/: LOWINFOOD innovations: MATOMATIC Plate Waste Tracker to increase children's awareness about food waste in school canteens Implementing LOWINFOOD innovations: Plate waste tracker for school canteens Practice Abstracts accessible at https://lowinfood.eu/project/results/: Practice Abstract No.12 (EN): A plate waste tracker to nudge pupils to reduce food waste Practice Abstract No.12 (SE): Att "nudge" elever att slänga mindre mat Practice Abstract No.12 (DE): Das Bewusstsein in der Schule schärfen, um Lebensmittelabfälle zu reduzieren	

IIIc. MOBILE APPLICATION AT HOME

Name of the innovation: MOBILE APPLICATION AT HOME	LOWINFOOD- Task-No.: Task 5.5
Company: Cozum	Targeted food category: avoidable (edible) food waste

Details of the demonstration: The CozZo mobile app aims to reduce food waste at home by combining a digital shopping planner with automated food and home supplies catalogues. Independent of store choice, it helps plan food shopping and manage food at home. Users add groceries to their "home catalogue" with calculated expiry dates and reminders, reducing food management efforts and helping them buy the right quantities they need, track expiration dates, and see their actual food waste levels.			
Country:	Sample size:	Baseline period:	Demonstration period:
Finland	18 households	March 2022 – May 2023	March 2022 – Jun 2023
Greece	15 households	May 2022 – Jun 2023	May 2022 – Jul 2023
Austria	19 households	March 2022 – Apr 2023	Apr 2022 – Sept 2023
Efficacy results: The t-tests suggest that we cannot state that the innovation is able to reduce food waste, but not even the opposite (p-value: >0.05), unless in the case of Austria. This is mostly imputed to the sample size, which is too small in this demonstration.			
Economic impacts: The changes in the household budgets and in the weight measurements of waste were not very consistent in multiple household and student approach households (e.g., largest reduction in waste measurement taking place in the household where no budget change occurred etc.). However, there might be a lag between buying materials, the lighter in weight yet costlier food items might have spoiled. Also, unlike food waste amounts measured and recorded periodically either by researchers or household members depending on the approach, the household and eating out budgets are mostly based on stated estimates rather than any records of the management survey respondents in each household, thus much less reliable for analysis.			
Social impacts: The level of agreement with the statements and social indicators shows a clear improvement for household members that took part in the demonstration. Specifically, we observe changes in the aggregated indicators of "Attitude," "Moral concern," "Intention" to reduce food waste, and "Behaviour" in the directions of our hypotheses⁷. These changes result from significant shifts in agreement with several statements contributing to these constructs, indicating a beneficial impact on many behavioral indicators of waste reduction.			

⁷ see footnote 2 on page 39

Environmental impacts:

The environmental performance of the three countries differs a lot. The Global Warming Potential per household and week between baseline and demonstration resulted in -1.92 kg CO₂e, -2.86 kg CO₂e and -4.63 kg CO₂e in Austria, Finland and Greece respectively. The total external environmental costs resulted in €-278/year, €-465/year and €-98/year in Austria, Finland and Greece respectively. This is depending on the different food waste composition and on the different reuse, recycling and disposal options applied in all three countries, whereas first has a larger effect on the overall results than latter. In Greece the share of dairy products halved from demonstration to baseline, whereas in Austria the share of dairy products and also meat increased.

References:

Websites: <https://cozzo.app/>

Deliverables accessible at <https://lowinfood.eu/project/results/>:

Giordano, C.; Alboni, F.; Brunnhuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauer, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

Mesiranta, N., Närvänen, E., Scherhauer, S., Ladurner, T., Obersteiner, G., Christina Chroni, K., & Lasaridi, I. D. (2023). D5.10 Report on the demonstration of the CozZo application. Lowinfood, 31 December 2023. Lowinfood project, GA No. 101000439. Lowinfood.eu.

Scherhauer S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K., Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

YouTube-Videos accessible at <https://lowinfood.eu/resources/videos/>:

LOWINFOOD innovations: [CozZo: Mobile application to manage household food provisions and avoid kitchen waste](#)

Implementing LOWINFOOD innovations: [Mobile app to manage household food provisions](#)

Practice Abstracts accessible at <https://lowinfood.eu/project/results/>:

Practice Abstract No.4 (EN): CozZo: Reducing food waste in households using a mobile application

Practice Abstract No.4 (DE): CozZo: Lebensmittelabfälle aus Haushalten mit Hilfe einer App reduzieren

Practice Abstract No.4 (FI): CozZo: Ruokahävikin vähentäminen kotitalouksissa mobiilisovelluksen avulla

Practice Abstract No.4 (GR): CozZo: Λιγότερα απόβλητα τροφίμων στα νοικοκυριά με τη χρήση μίας εφαρμογής

IVa. STAKEHOLDER DIALOGUE OF THE FISH SUPPLY

Name of the innovation: STAKEHOLDER DIALOGUE OF THE FISH SUPPLY (primary production, processing, wholesale, retail, distribution)	LOWINFOOD- Task-No.: T 4.1
Introducing company/organisation: JHI, ISUN	Targeted food category: Surplus fish

Details of the demonstration: Task 4.1 involved a stakeholder dialogue in the seafood supply chain to identify waste hotspots, explore reduction strategies, and find opportunities for material exchanges. The dialogue took place in Scotland and Germany. Given the high value of seafood, the premium materials for human consumption were not mostly wasted so the focus was on increasing the share and value of by-products valorisation. Key industry and policy stakeholders in Scotland and Germany were invited for semi-structured interviews and events. In Germany a stakeholder workshop was organized (June 2023). In Scotland, industry events like the Scottish Skipper Expos (2023 and 2024) were attended. In both countries a final conference was organised to inform the stakeholders about the progress and to explore ways to build on the relationships established during the dialogue. A survey on seafood material revalorization was prepared based on interview insights and disseminated at seafood industry level.			
Country: Scotland Germany	Sample size: 22 interviews 9 interviews	Baseline period: - -	Demonstration period:
Efficacy results: The dialogue revealed that fish companies are a close-knit group, reluctant to disclose data that could harm their reputation or lead to changes in practices. It is not possible to comment on food waste quantities as no transfer of surplus materials to be evaluated took place between industry stakeholders participating in the dialogue, and the dialogue was not primarily intended to produce short-term impacts. However, a baseline management survey was completed by five stakeholders in the Scottish dialogue, including primary and secondary processors. Due to the small and diverse sample size, aggregated data cannot be presented. One notable figure is that the mass of fish materials removed from the value chain was generally nil or <0.02%, but in one case, it was 18.5%, indicating significant valorisation potential. An exploratory transaction of five litres fish oil occurred between a company making fishmeal and fish oil and a start-up using fish oil for biosurfactants.			
Economic impacts: Due to the lack of changes in waste management practices from the dialogue, no additional surveys were distributed to capture the company-level socio-economic impact. Instead, an industry-level survey was disseminated to understand barriers, opportunities, and innovation needs and it received responses beyond Scotland and Germany due to being featured in online industry magazines and promoted in international fairs by WP4 members. Common challenges include the costs of sorting, storing, and transporting surplus, unwanted catch, and mismatched supply and demand. Opportunities include expanding consumer demand for more species, improving scientific understanding of fishing grounds, and exploring new markets. Needed interventions are policy changes to			

reduce costs for small businesses and developing innovations for balancing fish supply and consumer demand and reducing unwanted catch.
Social impacts: Given the small sample size for social impact evaluation, no aggregated indicators could be estimated individually for this task.
Environmental impacts: Due to lack of quantitative data, no environmental impact assessment was conducted.
References: Websites: https://www.hutton.ac.uk/ Deliverables accessible at https://lowinfood.eu/project/results/: Giordano, C.; Alboni, F.; Brunnuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N., Somervail, P., Engelmann, T., & Piras, S. (2024). D4.5 Policy brief: food waste prevention and reduction in the fish supply chain. Lowinfood, 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N., Somervail, P., Engelmann, T., Mzek, T., Williams, I., Casalino, F., & Piras, S. (2024). D4.3: Report on fish supply chain dialogue. Lowinfood, 31 August 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Scherhauser S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K.; Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. YouTube-Videos accessible at https://lowinfood.eu/resources/videos/: LOWINFOOD innovations: Stakeholder dialogue to develop guidelines against food loss and waste in the fish sector Implementing LOWINFOOD innovations: Stakeholder dialogue in the fish value chain Practice Abstracts accessible at https://lowinfood.eu/project/results/: Practice Abstract No.10 (EN): Fish supply chain dialogue to reduce waste in Scotland

IVb. STAKEHOLDER DIALOGUE OF THE BREAD SUPPLY

Name of the innovation: STAKEHOLDER DIALOGUE OF THE BREAD SUPPLY (primary production, processing, wholesale, retail, distribution)	LOWINFOOD- Task-No.: T 3.2
Introducing company/organisation: UNITUS, TAU, SLU	Targeted food category: Surplus bread and bakery products

Details of the demonstration:

T3.2 explores how stakeholder dialogue can minimize food waste in bakeries. The aim was to co-design a roadmap with bakeries to prevent surplus bread and avoid waste. The dialogues took place in Italy, Finland and Sweden, between November 2021 and September 2022.

In Italy the demonstration of strategies was conducted involving artisanal bakeries that sell directly through their own stores, some of which also sell a share of bread they produce to supermarkets or restaurants. Bakeries defined five actions against bread waste and implemented a diary study to measure daily surplus bread.

In Finland qualitative information for the overall experiences in the Finnish bakery industry, not for individual companies, was collected through online workshops and interviews. Data collection aimed at co-creating the bakery industry roadmap, but it has not been used during the project.

In Sweden, two rounds of stakeholder dialogue were conducted with five industry actors in the TBA system, including two industrial bakeries, retailers, and logistic companies. The qualitative information from the first round was used to simulate alternative scenarios in T3.1. Data on surplus bakery products were aggregated and extrapolated based on market share.

Country:	Sample size:	Baseline period:	Demonstration period:
Italy	16 branches from 12 participating bakeries	Feb 2022 - Jun 2022	Feb 2023 - Jun 2023
Finland	2-4 bakeries/1 bakery federation (online workshops)	-	Jan 2022 - Sept 2022
	6 bakeries, 4 retailers (interviews)	-	May 2022 - Sept 2022
Sweden	Interviews		
	2 industrial bakeries, 2 retails, 1 logistical company	-	Nov 2021 - Sep 2022

Efficacy results:

The evaluation in Italy primarily considers three key products that account for 70 to 80% of the total production volume: 1. Common bread: the average daily waste for bread was 5.59%, at baseline while during the demonstration it was 6.89%. The difference in? is statistically significant (P-value= 0.0086).

2. Focaccia bread: the average daily waste for focaccia bread was 4.32 %, while during the demonstration it was 7.60%. The difference in waste is statistically significant (P-value= 6.4e-16). 3. Bread rolls: the average daily waste for bread rolls was 4.84%, while during

the demonstration it was 4.68%. The difference in waste quantities is not statistically significant (P-value= 0.3833).

Economic impacts:

Production cost figures for production and waste disposal were reported as unchanged between baseline to demonstration in Italy. In one of the participating bakeries (IT9) the surplus measurements in the demonstration period were significantly reduced both in terms of weight and value in comparison to baseline measurements.

Social impacts:

Six post-implementation responses were obtained from Italian bakeries (from 4 bakeries), and seven baseline responses from comparable bakeries (from 7 bakeries). All respondents were employees, mostly head cooks or bakery owners involved in implementing the innovation. Overall, most indicators and statements experienced a statistically significant change in the expected direction, suggesting that participating in the innovation had a positive social impact.

Environmental impacts:

Overall bread surplus increased from baseline to demonstration. Therefore, the environmental impacts increased as well. Credits (negative values) at demonstration are though higher than at baseline. This is due to the higher amount of surplus that goes to redistribution (donation) or reworking.

References:

Websites:

Deliverables accessible at <https://lowinfood.eu/project/results/>:

Giordano, C.; Alboni, F.; Brunnhuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu.

Mesiranta, N.; Närvänen, E.; Pietrangeli, R.; Nasso, M.; Blasi, E.; Cicatiello, C.; Fanelli, L.; Sjölund, A.; Bartek, L., & Eriksson, M. (2022). D3.2 Roadmap for tracking and reducing bread waste in bakery-retailer interface. Lowinfood, 31 October 2022. Lowinfood project, GA No. 101000439. Lowinfood.eu.

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Scientific publications:

Pietrangeli, R.; Eriksson, M.; Strotmann, C.; Cicatiello, C.; Nasso, M.; Fanelli, L.; Melaragni, L., & Blasi, E. (2023). Quantification and economic assessment of surplus bread in Italian small-scale bakeries: An explorative study. *Waste Manag*, 169, 301-309. <https://doi.org/10.1016/j.wasman.2023.07.017>

YouTube-Videos accessible at <https://lowinfood.eu/resources/videos/>:

LOWINFOOD innovations: [Stakeholder dialogue to develop guidelines against food loss and waste in bakeries](#)

Implementing LOWINFOOD innovations: [Stakeholder dialogue in the bakery value chain](#)

Practice Abstracts accessible at <https://lowinfood.eu/project/results/>:

Practice Abstract No.1 (EN): Stakeholder dialogues for bakeries in Italy

IVc. VOLUNTARY AGREEMENTS

Name of the innovation: VOLUNTARY AGREEMENTS between producers and retailers		LOWINFOOD- Task-No.: T 3.1	
Main performing company/organisation: SLU		Targeted food category: Surplus bread and bakery products	
Details of the demonstration: New business models for bread supply aiming at reducing waste at the supplier-retailer interface were investigated building on Task 3.2, where stakeholder dialogues in Sweden, Finland, and Italy led to a roadmap to reduce bread waste. It focuses on mapping and modeling current bread flows and exploring new solutions, particularly in the Swedish bread supply chain and the Take-Back Agreement (TBA) system. While TBA in itself does not create waste directly, but its potential cascade effects lead to surplus at the supplier-retailer interface.			
Country: Sweden	Sample size: mapping and modelling the bread supply chain	Baseline period: 2022* *data from 2022 was used for the modelling	Demonstration period: -
Efficacy results: The T3.1 simulation model used data from the Swedish stakeholder dialogue in T3.2 and secondary sources. Calculations for private-label bakery products involved five major supermarket retailers, scaled to estimations at national level. Waste rates, sales, and production data were obtained from the supermarket bakeries and private companies. A second stakeholder dialogue validated and refined the estimates. Based on these insights, one baseline and six alternative bread management scenarios were developed. The simulation of the scenarios with the TBA still in place, i.e. the ‘Shared data’, ‘Optimised shelves’ and ‘Food donation’ scenarios, revealed a potential reduction of bread waste of about 10,500, 2400 and 600 tonnes for each scenario respectively. Since all scenarios were developed with industry expertise, implementing them should reduce bread waste, though the degree of reduction would vary depending on the choice and combination of management approaches among those simulated in the scenarios.			

Economic impacts: Surplus materials, including TBA returns, are currently valorized in re-valorisation routes such as ethanol production and animal feed, earning about €0.1/kg. While preventing losses from TBAs is a priority, higher-value revalorization routes (e.g., selling stale bread for crumbs) can also enhance profitability when returns and surplus are unavoidable. Cost savings arise due to more efficiency in production and processing. Potential cost savings were calculated based on the retail price of common bread adjusted by a cost of production to sale price ratio of 0.65 to come up with potential production costs. €2,800/ton of saved bread waste could be saved by the producers of the bakery products based on this estimation.
Social impacts: No responses were collected.
Environmental impacts: If bread waste prevention actions can be implemented in the bakery sector in Sweden, environmental impacts can potentially be reduced by 27,100 tons CO₂e and environmental external costs by 5.92 Mio EUR. If surplus bread redistribution actions can be implemented in the bakery sector in Sweden, environmental impacts can potentially be reduced by 24 tons CO₂e and external costs by 1.09 Mio EUR.
References: Websites: Deliverables accessible at https://lowinfood.eu/project/results/: Giordano, C.; Alboni, F.; Brunnuber, N.; Carloni, E.; Gianluca di Fiore, N.; Scherhauser, S.; Strotmann, C.; Gerwin, P.; Cicatiello, C. (2024): D 1.6 Evaluation of the efficacy of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Koseoglu, N.; Martínez Sánchez G.; Williams, I.; Piras, S. (2024): D 1.7 Socio-economic evaluation of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Scherhauser S.; Brunnhuber, N.; Eriksson M.; Orth, D.; Chroni, C.; Ablikatoks, K.; Lasaridi, K.; Obersteiner G. (2024): D 1.8 Evaluation of the environmental impacts of innovations. 31 October 2024. Lowinfood project, GA No. 101000439. Lowinfood.eu. Sjölund, A., Bartek, L., Cicatiello, C., Mesiranta, N., & Eriksson, M. (2023). D3.4: Improved business model for bread supply. LOWINFOOD project, GA No. 101000439. Lowinfood.eu. Scientific publications: Bartek, L., Sjölund, A., Brancoli, P., Cicatiello, C., Mesiranta, N., Närvänen, E., Scherhauser, S., Strida, I., & Eriksson, M. (2024). The power of prevention and valorisation - reducing the environmental impact of surplus bread at retail. <i>In Preparation</i>. YouTube-Videos accessible at https://lowinfood.eu/resources/videos/: LOWINFOOD innovations: Innovative supplier/retailer agreements for bakery products Implementing LOWINFOOD innovations: Innovative supplier/retailer agreements for bakery products Practice Abstracts accessible at https://lowinfood.eu/project/results/: Practice Abstract No.9 (EN): Innovating supplier-retailer agreements to avoid waste of bakery products Practice Abstract No.9 (SE): Identifiering av nyttan med åtgärder för minskat svinn av bröd och