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ECOFOODCYCLE

Reducing Food Waste and its Environmental Footprint through Sustainable Food Systems

D2.3.1 JOINT ASSESSMENT REPORT

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1. EXECUTIVE SUMMARY

The **ECOFOODCYCLE Joint Assessment Report** aggregates the strategic findings, quantitative data, and behavioral outcomes of **eight distinct small-scale pilot actions (SSPAs)** implemented across Italy and Croatia. Co-funded by the European Union under the Interreg Italy-Croatia Programme 2021–2027, the project bridged traditional sector boundaries to pioneer practical circular economy models at every stage of the food supply chain: from primary production to domestic and organizational consumption.

Over an intensive multi-month implementation window (late 2025 - early 2026), project partners transformed regional infrastructures into living laboratories . Driven by a unified commitment to empirical tracking, partners deployed a conjoined monitoring methodology combining manual tracking matrices, digital meal booking platforms and automated image-processing "smart" disposal bins.

The aggregated outcomes demonstrate massive, measurable progress against food loss indicators across four key sectors: primary production, food services, retail and consumers.

1. **Primary Production:** Redesigned regional post-harvest supply chains through the **Lead Partner (LIRA)** at the *Zero Waste Innovation Lab* in Gospić, Croatia. The pilot successfully intercepted **1,328.08 kg of seasonal plum surpluses**, extracting **132.8 kg of secondary plum pits** that were mechanically separated into two distinct valorization streams: **108.23 kg of woody shells** upcycled into **112 kg of high-efficiency fuel pellets**, and **24.5 kg of inner kernels** cold-pressed into **9.824 liters of cosmetic-grade oil** and **15.5 kg of solid feed press cake**. Concurrently, batch



lioofilization stabilized **71 kg of highly perishable local fruits and vegetables**, reducing raw mass to **8.58 kg of stable, nutrients-preserved products** with extended multi-year shelf lines.

2. **Food Services:** Catalyzed major food loss reductions across institutional canteens and educational culinary environments using a split-phase monitoring methodology:

- a. *Vocational Tiers:* **PP2 (JURRA)** integrated professional compaction infrastructures within the *Commerce and Catering School Karlovac*, driving operational food waste intensity down from **0.32 kg/meal to 0.26 kg/meal**. Concurrently, **PP3 (ZADRA NOVA)** deployed a structured target weighing matrix at the *Hotel, Tourism and Catering School Zadar*, which successfully reduced raw preparation waste and post-serving leftovers through targeted zero-waste cooking modules and student-led recipe codes.
- b. **Primary Education Hubs:** Within the school pilot implemented by the **University of Rijeka (PP4 - EFRI)** at "*Vladimir Gortan*" Elementary School, average food waste dropped by **38.4%** (from 87.4 to 53.8 g per pupil per day), supported by child-centered workshops and a professional food-waste grinder that diverted approximately 6 kg/week of residual lunch waste from the solid stream. Concurrently, **PP6 (EcamRicert - SSPA1)** coordinated a targeted intervention at *Institute Luzzatti Luigi* in Padua. Observational tracking by PP6 operators proved that educational workshops significantly boosted food consumption: children leaving First Course leftovers dropped by **-34.4%** (with fully finished First Courses rising by **+49.8%**), Fruit waste fell by **-47.7%**, and the proportion of trays with unfinished meals decreased by **22.8%**. Automated



Smart Bin tracking (which included serving counter surpluses) recorded total daily waste data for overall catering optimization.

3. **Retailers:** The pilot action "**AI Smart Box**", deployed by the **University of Foggia (PP7)** within active *Mercati di Città La Prima* supermarket locations, successfully proved the viability of using technology to stabilize near-expiry inventory. By integrating dynamic pricing tiers with themed packaging clusters linked to dynamic QR codes, the supermarket staff proactively intercepted perfectly edible products before expiration , routing consumers to an automated AI "Virtual Chef" interactive prompt environment to unlock profitable active commercial margins on structural food losses.
4. **Consumers:** Multiplied domestic and organizational resource management competencies through the enforcement of structured behavioral and community-based protocols:
 - a. *Household Routines:* **PP6 (EcamRicert - SSPA2)** executed the "*Famiglie insieme contro lo spreco alimentare*" program at Villa Vanna , equipping parents and children with technical skills in batch-cooking, vacuum-sealing, and label literacy. This proactive routine **more than doubled the number of households reaching a true "zero waste" status** (rising from 28.6% to 60.0% with zero food discarded per week) and boosted domestic meal planning frequency by **51.4%**.
 - b. *Creative & Cultural Operations:* **PP8 (CNA Abruzzo)** applied rigorous operational green guidelines to active film set productions in Montebello di Bertona and Farindola . Supported by a dynamic WhatsApp pre-booking interface and



portion-controlled biodegradable single meals, the pilot successfully achieved a **100% full meal consumption rate** on the final shooting days, completely eliminating avoidable crew catering losses (from 0.5 kg to 0 kg) and establishing a replicable zero-waste framework.

Ultimately, this joint assessment report evaluates the methodology and outcomes of these diverse settings, highlighting profound behavioral changes and a marked reduction in waste. By pairing theoretical education with technological and operational innovations, the initiatives successfully transitioned participants from reactive food management to proactive, zero-waste practices.

The results confirm the economic viability and self-sufficiency of circular models—successfully adding value to food products nearing their use-by date, transforming agricultural by-products into new resources, and eliminating surpluses even in dynamic and complex environments. In conclusion, combining cross-border policy integration with targeted technical empowerment offers a robust, highly transferable blueprint capable of delivering efficient, low-impact food systems across Europe.



2. INTRODUCTION

2.1. Context and Objectives of the Joint Assessment

Food waste represents one of the most critical environmental, economic, and social challenges within modern food systems. Significant quantities of edible food are systematically discarded throughout the supply chain—from primary production and local food processing to retail distribution, institutional catering, and domestic consumption. This structural inefficiency leads to the unnecessary depletion of vital natural resources such as land, water, soil, energy, and human labor, while generating substantial greenhouse gas emissions that accelerate climate change.

The joint assessment evaluates a series of small pilot actions that introduced practical, measurable, and highly engaging approaches to tackle this issue across various societal levels. By combining theoretical education, targeted behavioral interventions, and innovative processing technologies, the overarching objective of these pilots is to raise awareness, optimize food use efficiency, and embed permanent zero-waste principles into both everyday household consumption and professional practices.

2.2. Overview of the 8 Pilot Actions

The joint assessment evaluates a series of small pilot actions that introduced practical, measurable, and highly engaging approaches to tackle this issue across various societal levels. By combining theoretical education, targeted behavioral interventions, and innovative processing technologies, the overarching objective of these pilots is to raise awareness,



optimize food use efficiency, and embed permanent zero-waste principles into both everyday household consumption and professional practices.

1. Primary Production Sector

- **LP - Public Institution Development Agency of Lika-Senj County (LIRA) - Small scale pilot action n. 1:**

Pilot Title: Integrated Approach to Food Waste Prevention in Primary Agriculture.

Location: Development Centre of Lika-Senj County, Gospić, Croatia.

Implementation Period: 13.04.2026 – 15.05.2026.

Core Action: Established the physical *Zero Waste Innovation Lab* equipped with liofilization (freeze-drying) units, a cold oil press, cracking machines, mills, and a pelletizer. The pilot focused on preserving perishable seasonal fruits/vegetables and processing agricultural residues—specifically plum pits—into high-value secondary outputs (plum kernel oil, press cake feed, and biofuel heating pellets).

2. Food Services Sector

- a) **PP2 - Regional Development Agency of Karlovac County (JURRA) - Small scale pilot action n. 2:**

Pilot Title: Food Waste Monitoring and Sustainable Management in a Vocational School Kitchen.

Location: Commerce and Catering School Karlovac, Croatia.

Implementation Period: 07.04.2026 – 15.05.2026.



Core Action: Integrated a professional food waste volume-reduction compactor into the operational school kitchen. The action combined baseline and continuous daily waste tracking with student-staff operational routines to significantly lower waste generation per prepared meal.

b) **PP3 - Zadar County Development Agency (ZADRA NOVA) - Small scale pilot action n.3:**

Pilot Title: From Kitchen to Zero Waste: Food Waste Reduction Pilot in Zadar.

Location: Hotel, Tourism and Catering School Zadar, Croatia.

Implementation Period: 20.04.2026 – 15.05.2026.

Core Action: Deployed a split-phase weighing methodology during practical culinary training. Coupled with educational sessions led by food waste experts and farm study visits, culinary students actively co-created a zero-waste e-cookbook based on upcycling food leftovers.

c) **PP4 - University of Rijeka, Faculty of Economics and Business (EFRI) - Small scale pilot action n. 4:**

Pilot Title: Food Waste Reduction Pilot at "Vladimir Gortan" Elementary School.

Location: "Vladimir Gortan" Elementary School, Rijeka, Croatia.

Implementation Period: 19.11.2025 – 05.12.2025.

Core Action: Executed a baseline-versus-post-intervention lunch weighing and snack tracking protocol with pupils. The school canteen was equipped with a professional food waste grinder to manage residual lunch waste via municipal lines, while interactive workshops and canteen behavioral nudges reduced plate waste.



d) **PP6 - ECAMRICERT S.R.L.** - *Small scale pilot action n. 5:*

Pilot Title: Ecofood Waste Truck.

Location: Institute Luzzatti Luigi, Padua, Italy.

Implementation Period: 01.09.2025 – 18.05.2026.

Core Action: Delivered an interactive educational program featuring game-based SDG board games, an anti-waste recipe workshop, and an educational farm field trip. To evaluate impact, the team combined visual plate-level tracking by PP6 operators with automated QR-code smart disposal bins provided by the school catering service to track cumulative kitchen waste.

3. Retailers Sector

e) **PP7 - University of Foggia (UNIFG)** - *Small scale pilot action n.7:*

Pilot Title: AI Smart Box - EcoFoodCycle.

Location: Mercati di Città La Prima supermarket retail stores, Foggia, Italy.

Implementation Period: 01.04.2026 – 15.05.2026.

Core Action: Introduced fixed-price kraft packaging boxes ("Smart Boxes") assembled by store staff using near-expiry, perfectly edible products. Each box featured a dynamic QR code that routed consumers to an AI "Virtual Chef" prompt tool and customer feedback survey, transforming expected store food losses into profitable commercial margins.



4. Consumers Sector

f) **PP6 - ECAMRICERT S.R.L. - Small scale pilot action n. 6:**

Pilot Title: Famiglie insieme contro lo spreco alimentare.

Location: Villa Vanna, Padua, Italy.

Implementation Period: 09.03.2026 – 30.03.2026.

Core Action: Engaged domestic households in a structured three-phase journey featuring an introductory tools session, a two-week home diary monitoring phase, and a practical chef-led show cooking. The pilot trained parents and children in batch cooking ("meal prep"), vacuum sealing, small-dose freezing, and correct label interpretation to achieve zero-waste home routines.

g) **PP8 - National Confederation of the Craft Sector and SMEs Abruzzo (CNA Abruzzo) - Small scale pilot action n.8:**

Pilot Title: Pilot Project to Reduce Food Waste on a Film Set.

Location: Active film production sets in Montebello di Bertona and Farindola (Pescara), Italy.

Implementation Period: 01.03.2026 – 31.03.2026.

Core Action: Tested an operational Green Protocol for sustainable catering management during live movie shootings. The initiative combined pre-set training with the IFA Cinema School, advance meal pre-booking via WhatsApp, single-portion biodegradable container serving, controlled self-service coffee breaks, and precise daily loss weighing to eliminate catering overproduction on set.



The following images, show a timeline of the implementation period for each pilot action:

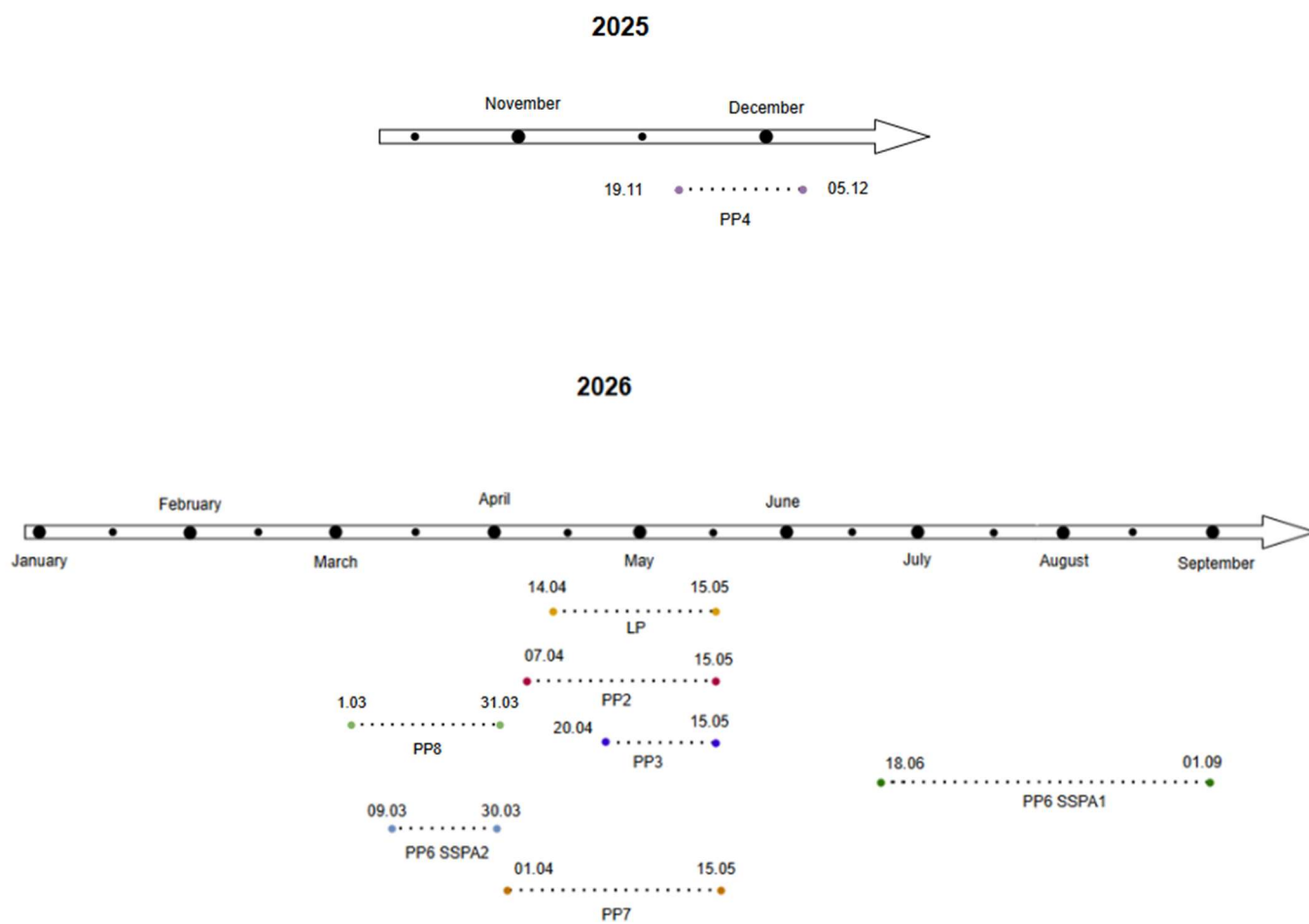


Chart 1: Implementation timeline



3. METHODOLOGY AND IMPLEMENTATION FRAMEWORK

3.1. Methods Used Across the Pilot Actions

The pilot actions uniformly adopted a comprehensive, multi-phase methodological framework designed to integrate data collection with behavioral change. This framework generally consisted of an initial baseline monitoring period to establish starting metrics, an active educational or practical intervention phase, and a subsequent post-intervention monitoring phase to evaluate the resulting impact.

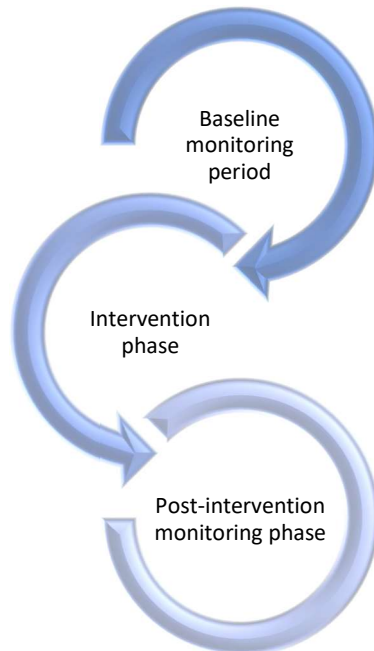


Chart 2: Methodological framework



All the educational interventions were highly experiential, relying on practical applications rather than passive learning. For example, educational settings utilized interactive workshops, team-based games centered on the UN Sustainable Development Goals, and professional live show cooking demonstrations to teach advanced food preservation. Furthermore, technological innovation was a core methodological pillar across several pilots. This included the deployment of smart disposal bins equipped with photographic recognition to automate waste weighing, the configuration of dynamic QR codes linked to artificial intelligence for consumer recipe generation, and the installation of specialised equipment like freeze-dryers, cold oil presses, and industrial food waste processors to physically transform surplus organic matter.

3.2. Data Collection and Joint Monitoring Tools

Data collection strategies were tailored to the specific environment of each pilot, maintaining a strong emphasis on empirical measurement, standardized tracking frameworks, and sector-specific operational metrics.

1. Primary Production Sector

In the agricultural sector, the Lead Partner coordinated data collection at the Zero Waste Innovation Lab in Gospić by combining qualitative and quantitative methods. Monitoring focused on detailed processing logs and technical operational notes, tracking the precise quantities of raw agricultural materials (fresh produce) and secondary residues (plum pits, shells, and kernels) processed. Additionally, equipment operational parameters and stakeholder participation rates were systematically documented.



2. Food Services Sector

In educational and vocational settings, partners relied on structured, daily physical measurements to establish accurate baselines and track progress across both kitchen operations and student canteens:

- **Vocational Catering Schools:**

- PP2 Implemented daily recording of food waste quantities through standardized paper monitoring sheets in the school kitchen. Staff tracked the total number of prepared meals alongside waste volume before and after deploying a food waste compactor, establishing "food waste per meal" as the primary comparative indicator.
- PP3 Utilised an input-output weighing system during practical culinary training sessions. The team recorded exact weight ratios of raw ingredients used versus uneaten food leftovers across two distinct two-week monitoring blocks (baseline vs. post-intervention).

- **Primary Educational Hubs:**

- PP4 Employed daily monitoring tables to log exact kg of lunch food served versus discarded, combined with unit-count tracking of fruits offered versus uneaten during morning snack times.



- PP6 paired manual observation with AI-driven technology to monitor primary school pupils. Observers used a standardized Dietary Habits Monitoring Form and visual estimation scales to track eating behaviors (e.g., food swapping, portion requests). Simultaneously, catering staff scanned QR codes on smart bins using tablets to trigger top-down photographic AI analysis that recorded cumulative kitchen and serving-counter waste.

3. Retailers Sector

In the commercial retail sector, PP7 integrated data collection directly into existing supermarket store infrastructure using a dual monitoring approach:

- Internal Operational Metrics: Inventory adjustments, sales volumes, and near-expiry food items assembled into "Smart Boxes" were tracked via the store's Point of Sale (POS) system to quantify the exact weight (kg) of food diverted from waste.
- External Consumer Engagement: Consumer interactions and qualitative feedback were continuously captured via a digital Google Form survey, accessed directly by shoppers scanning the dynamic AI "Virtual Chef" QR code printed on the packaging.

4. Consumers Sector

Data collection strategies within the consumer sphere addressed both domestic family routines and dynamic organizational work environments:



- **Domestic Households:** ECAMRICERT focused tracking on domestic family environments using three primary instruments: an initial baseline survey, a final post-pilot questionnaire, and a simplified family kitchen diary. During a two-week active logging phase, households recorded discarded food types, waste frequencies, and leftover reuse. Children were formally involved as co-monitors to foster intergenerational participation.
- **Organizational & Creative Environments / Film Sets:** CNA Abruzzo structured data collection across consecutive movie shooting days. Guided by a preliminary green technical protocol, the monitoring team tracked the number of crew members present, meals prepared versus consumed, unserved portions, and exact weights of food waste, donations, and composted organic matter. Quantitative daily weighing was supplemented by digital meal pre-booking data via WhatsApp and direct on-site qualitative observations

3.3. Stakeholder Engagement Approaches

The successful execution of the pilot actions was driven by a highly inclusive, multi-stakeholder engagement strategy. The core target groups included elementary pupils and vocational culinary students, who served as active participants in data collection and zero-waste practical exercises, alongside their teachers and school management teams who facilitated the logistical integration of these programs into demanding daily schedules. Parents were engaged too, applying new organisational tools and tracking methodologies directly within their home kitchens. Local food producers, farmers, and retail operators



provided vital real-world testing grounds, participating in knowledge exchange through student study visits and facilitating in-store technological deployments. In the cultural sector, engagement spanned an heterogeneous group, including film directors, producers, technical staff, actors, catering operators, and extras. Moreover, municipalities, dietetics offices, and academic experts were involved to ensure that the educational interventions aligned tightly with public health standards and provided rigorous scientific validation to the pilot methodologies.

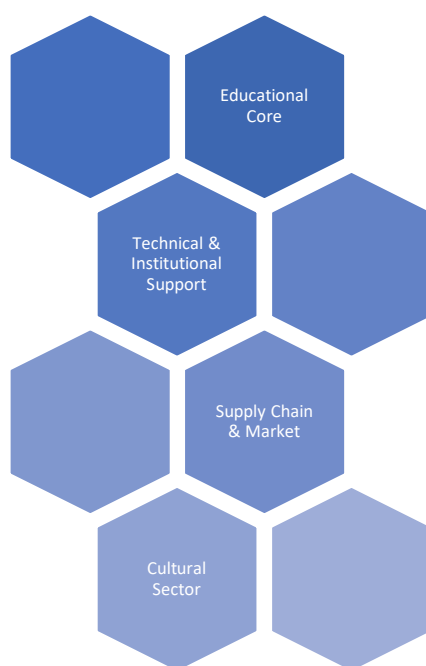


Chart 3: Small Scale Pilot Actions's Ecosystem



4. AGGREGATED RESULTS AND OUTCOMES

4.1. Overall Progress Against Indicators

The monitoring of the small pilot actions demonstrated measurable progress across all tested environments, successfully translating theoretical circular economy principles into tangible outcomes.

The Public Institution Development Agency of Lika-Senj County achieved all its established targets through the successful opening of the Zero Waste Innovation Lab in Gospić. In terms of raw material processing, the pilot tested freeze-drying technologies on approximately 71 kg of fresh fruit and vegetables, resulting in 8.58 kg of preserved products. Furthermore, the facility processed 1,328.08 kg of plums, generating 132.8 kg of plum pits. From these pits, 108.23 kg of woody shell material was extracted to produce 112 kg of heating pellets, whilst 24.5 kg of plum kernels yielded 9.824 litres of cold-pressed oil.

PP2, the Regional Development Agency of Karlovac County, operated within a vocational school kitchen environment and engaged approximately 185 participants. This intervention achieved a tangible reduction in food waste intensity, decreasing the average food waste per meal from a baseline of 0.32 kg to 0.26 kg during the continuous monitoring phase. Additionally, the operational implementation of a food waste processing device demonstrated an estimated reduction potential of 92.5 % regarding the physical volume of residual waste requiring disposal.



PP3, the Zadar County Development Agency, achieved significant waste reductions at the Hotel, Tourism and Catering School by actively involving 30 students and 5 mentors. The total quantity of food waste generated during practical training activities dropped significantly from a baseline of 20.35 kg down to 6.48 kg. Most notably, avoidable food leftovers remaining after meal consumption plummeted from 4.03 kg to just 0.60 kg. The pilot also met its educational targets by completing two study visits to local food producers and developing ten zero-waste recipes for a cookbook.

PP4, the University of Rijeka, successfully engaged 22 pupils at the "Vladimir Gortan" Elementary School. The proportion of uneaten food generated per lunch improved noticeably, falling from a baseline of 27.27% (12.6 kg wasted out of 46.2 kg served) to 19.71% (6.8 kg wasted out of 34.5 kg served). Progress was also recorded during snack times, where the percentage of uneaten fruit decreased from 20.69 % to 17.65 %.

PP6, ECAMRICERT, implemented two distinct pilots (small scale pilot action n.5 and n.6). In small-scale action n.5 at "Institute Luzzatti" Primary School (60 pupils, 444 observed meals), visual tracking by operators proved an overall **-22.8% reduction in trays with unfinished meals**. The percentage of children leaving First Course leftovers dropped from 59.2% to 38.9% (**-34.4%**), while fruit waste fell from 33.8% to 17.6% (**-47.7%**). Fully consumed First Courses rose to 61.1% (**+49.8%**) and Fruit to 82.4% (**+24.3%**). Cumulative smart-bin algorithm measurements (which included unserved serving-counter surpluses) recorded an average total waste of 68.9 g/day/student post-intervention vs. 39.7 g/day/student pre-intervention.



Pilot action n. 6, focusing on domestic households, the intervention engaged a total of 7 participants. This domestic programme achieved profound behavioural shifts: the frequency of proactive meal planning skyrocketed by 51.4%, moving from a baseline of 28.6% to 80.0%. Consumer expertise regarding food labels increased to 80.0%, and the number of households achieving a complete "zero waste" status, rose from 28.6% to 60.0%.

PP7, the University of Foggia, tested the "AI Smart Box" solution in a retail supermarket environment. Against a target of 100 units, the current value stood at 2 units sold during the initial phase. This effort successfully resulted in 3 kg of near-expiry food being saved and actively valorised, working towards the ultimate target of 150 kg.

Finally, PP8, the National Confederation of the Craft Sector and SMEs Abruzzo, implemented their pilot on a film set. Over the course of the monitoring, total food waste was progressively reduced from 0.5 kg down to zero kg. The number of meals prepared but left unserved decreased from 3 to zero. By the final day, the pilot achieved a 100% meal consumption rate, alongside the successful integration of food donation practices and organic waste composting.



Table 1. Summary Table: Progress Aggregated Progress by Sector

Sector of Intervention	Project Partner & Location	Pilot Action Name	Main Monitored Indicators	Key Results & Achievements
Primary Production	LP <i>Gospić, Croatia</i>	Integrated Approach to Food Waste Prevention in Primary Agriculture	• Freeze-dried produce • Plums processed • Plum pits extracted • Oil & pellets produced	Established the Zero Waste Innovation Lab. Stabilized 71 kg of fresh produce. Converted 132.8 kg of pits into high-value oil (24.5 kg kernels), animal feed cake (15.5 kg), and heating pellets (108.23 kg shells).
Food Services	PP2 <i>Karlovac, Croatia</i>	Food Waste Monitoring in a Vocational School Kitchen	• Food waste per meal • Waste volume reduction	Reduced daily food waste intensity across ~185 participants. Operational compactor shrank daily kitchen preparation debris volume by up to 92.5%.
Food Services	PP3 <i>Zadar, Croatia</i>	From Kitchen to Zero Waste	• Prep food waste • Plate leftovers • Zero-waste recipes	Engaged 30 students and 5 mentors. Achieved a drastic reduction in raw prep waste and post-



				serving plate leftovers. Co-created and published an e-cookbook.
Food Services	PP4 <i>Rijeka, Croatia</i>	School Food Waste Reduction	• % uneaten lunch food • Waste per pupil/day • % uneaten snack fruit	Reduced lunch waste per pupil by 38.4%. Deployed a professional grinder processing ~6 kg/week via wastewater lines. Upcycled surplus fruit into fresh smoothies.
Food Services	PP6 <i>Padua, Italy</i>	Ecofood Waste Truck	• Overall waste reduction • Waste per student/day • % uneaten food/meal	Educational workshops drove a -22.8% drop in unfinished trays across 60 pupils. First Course leftovers fell by -34.4% and Fruit waste by -47.7%
Retailers	PP7 <i>Foggia, Italy</i>	AI Smart Box - EcoFoodCycle	• AI Smart Boxes sold • Near-expiry food saved	Introduced fixed-price Kraft boxes for near-expiry products in supermarkets. Linked dynamic QR codes to an AI "Virtual Chef" recipe prompt tool to eliminate home waste.



Italy – Croatia



Consumers	PP6 <i>Padua, Italy</i>	Famiglie insieme contro lo spreco alimentare	• Meal planning rate • Label literacy rate • Zero-waste households	Chef-led training (meal-prep, vacuum sealing) and 2-week family diaries shifted habits. More than doubled the percentage of households achieving total zero weekly waste.
Consumers	PP8 <i>Pescara, Italy</i>	Food Waste Reduction on a Film Set	• Daily film set food waste • Unserved prepared meals • Full meal consumption	Implemented a Green Protocol on dynamic movie sets. Used a WhatsApp pre-booking system and biodegradable single portions, eliminating 100% of avoidable crew catering waste.



4.2. Changes in Consumer and Organizational Behavior

The pilot actions successfully triggered profound cultural and behavioural transformations across all target groups, shifting participants from passive or reactive habits to proactive, resource-efficient practices.

A. Primary Production Sector

Local farmers and small agricultural enterprises underwent a major shift in how they view agricultural by-products. Through practical, hands-on demonstrations, producers learned to reframe seasonal surpluses and organic processing residues, such as plum pits, not as disposable waste, but as valuable secondary raw materials ready to feed new circular economic value chains.

B. Food Services Sector

In educational and vocational settings, direct exposure to practical waste monitoring significantly altered student mindsets:

- **Primary Educational Hubs:** Pupils exhibited spontaneous food-sharing behaviours, improved meal acceptance, and a tangible shift in their daily eating habits.
- **Vocational Catering Schools:** Future culinary professionals actively integrated sustainable workflows into their core competencies. Students demonstrated high motivation to minimise food loss, successfully adopting responsible practices such as precise menu planning, proper surplus storage, and practical composting—ensuring these habits transfer directly into their future hospitality careers.



C. Retailers Sector

Behavioural shifts were successfully stimulated within commercial environments. Supermarket shoppers enthusiastically engaged with digital artificial intelligence tools via QR codes, demonstrating that technological innovation can effectively attract, guide, and educate dynamic consumer segments toward making more sustainable purchasing choices at the point of sale.

D. Consumers Sector

Behavioral transformations were prominently demonstrated across both domestic households and dynamic organizational settings:

- **Domestic Households:** Families underwent a profound transition from a disorganised, reactive "here-and-now" approach to structured, proactive food management. The frequency of weekly meal planning surged, and correct label literacy—specifically distinguishing "use by" expiry dates from "best before" quality indicators—increased to 80.0%. Throughout this process, children played a crucial role as sustainability catalysts within the home.
- **Organizational & Creative Environments (Film Sets):** On a high-pressure movie set, the adoption of a green protocol fostered strong collective responsibility among a dynamic crew. Participants moved from passive consumption to conscious engagement, notably eliminating hidden waste by replacing bulk coffee brewing in advance with an exact, on-demand preparation routine.



5. ENVIRONMENTAL IMPACT AND BENEFITS

5.1. Environmental Benefits Achieved

The most direct and immediate environmental benefit achieved across the pilot actions is the significant diversion of perfectly edible food and organic by-products away from municipal solid waste landfills. By actively preventing these organic materials from decomposing in waste facilities, the initiatives directly mitigated the release of harmful greenhouse gas emissions, particularly methane. Furthermore, the interventions validated and protected the massive amounts of water, energy, and soil resources originally invested during the agricultural production phase by ensuring the food was ultimately consumed or repurposed.

Operational innovations, such as the use of commercial food waste processing devices and grinders, drastically reduced the physical volume of residual waste, which subsequently decreases the vehicular collection frequency and associated transport emissions. On the film sets, the strict adoption of biodegradable and compostable tableware ensured that any unavoidable waste was properly managed within an organic disposal system, severely curtailing the use of single-use plastics. In agricultural settings, the application of freeze-drying technologies stabilized highly perishable seasonal fruits and vegetables, preventing post-harvest spoilage and maximising the resource efficiency of primary production systems.



5.2. Transferability and Environmental Scaling

The methodologies deployed in these pilot actions exhibit strong potential for replication and scaling across different European territories. The school-based monitoring protocols and educational workshops utilize low-cost, universal tools and standardised forms, making them easily adaptable to virtually any primary or vocational educational institution. The integration of accessible technologies such as WhatsApp meal booking systems with PP8 and the AI-driven Smart Boxes in the retail sector requires minimal funding and can be scaled in other sectors. Similarly, the Zero Waste Innovation Lab provides a highly flexible, circular economy blueprint that other rural and agricultural regions can adopt to process their own specific local by-products and seasonal surpluses, building resilient local food networks.



6. STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS (SWOT ANALYSIS)

The multi-sectoral execution of the eight small-scale pilot actions (SSPAs) provided invaluable empirical data, operational benchmarks, and systemic insights. To critically evaluate the overall performance of the **ECOFOODCYCLE** framework, this chapter presents a comprehensive **SWOT Analysis**. It combines a cross-cutting strategic overview with a **partner-by-partner operational review**, explicitly highlighting targeted areas for improvement based on the specific field activities and reported results of each Project Partner.



Table 2. Comprehensive Project SWOT Matrix

STRENGTHS (Internal Positives)	WEAKNESSES (Internal Challenges)
• High Empirical Accuracy: Precise data integration via physical weighing, AI smart bins, and store Point of Sale (POS) inventory tracking. • Experiential & Hands-on Approach: High participant engagement through show cooking workshops, farm study visits, and laboratory liofilization. • Broad Cross-Sectoral Coverage: Active, tailored interventions across schools, domestic households, supermarkets, film sets, and primary farms. • Circular Economy Value Creation: Effective valorization of organic residues into high-value outputs (kernel oil, press cake feed, and biofuel pellets).	• Tracking & Administrative Fatigue: High reliance on manual paper-based logging sheets created friction in busy kitchens and school settings. • Operational Staff Strain: Manual assembly and labeling of "Smart Boxes" in supermarkets created operational bottlenecks during peak hours. • Short Active Monitoring Windows: Implementation phases restricted to 2–4 weeks limited the assessment of long-term habit retention. • Serving Counter Surplus Contamination in Bins: Smart-bin scales automated cumulative kitchen surplus alongside plate waste, requiring separate visual tracking to isolate pupil behavior.



OPPORTUNITIES (External Prospects) THREATS (External Risks)

• Policy & Grant Integration: <i>Scaling "Green Protocols" into criteria for public film commissions and regional cultural grants.</i> • Commercial AI Scaling: <i>Broadening dynamic AI packaging and recipe tools across larger commercial supermarket chains.</i> • Rural Lab Replication: <i>Transferring the Zero Waste Innovation Lab blueprint to other agricultural EU regions with seasonal fruit surpluses.</i> • Curricular Institutionalization: <i>Embedding zero-waste culinary and inventory management modules into national vocational school curricula.</i>	• Regulatory & Health Barriers: <i>Strict municipal hygiene and public health laws limiting the redistribution of unserved prepared food.</i> • Hardware Maintenance Costs: <i>Risk of smart bins or specialized processing hardware becoming obsolete without long-term local funding.</i> • Post-Project Engagement Drop: <i>Potential decline in household and consumer engagement without continuous nudges or economic incentives.</i> • Wastewater Regulatory Discrepancies: <i>Divergent municipal laws regarding the discharge of ground organic waste via sewer lines.</i>
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6.1. Cross-cutting Success Factors

A primary strength across all initiatives was the powerful synergy created by combining theoretical environmental education with practical, hands-on application. Experiential learning proved highly effective across sectors—whether it involved culinary students cooking zero-waste recipes, primary pupils extracting and planting recovered pumpkin seeds, or parents mastering vacuum-sealing techniques.

The integration of technology (QR-coded AI smart bins, commercial food waste grinders, freeze-dryers) elevated data collection precision and provided participants with tangible solutions. Furthermore, embedding monitoring activities directly into existing daily routines (mandated practical training hours in vocational schools, family kitchen diaries co-managed by children, WhatsApp catering pre-bookings on film sets) ensured high compliance rates and fostered shared community responsibility.

6.2. Operational Review and areas for improvement

Evaluating the individual performance of each partner reveals specific operational bottlenecks and key areas where implementation could have been optimized.

1. Lead Partner (LP – LIRA) | *Primary Production (Gospić, Croatia)*

- **Strengths:** Successfully established the physical *Zero Waste Innovation Lab*. Exceptional resource conversion metrics (stabilizing 71 kg of fresh produce via freeze-



drying; processing 1,328 kg of plum surpluses into 112 kg of fuel pellets and 9.82 L of cold-pressed oil).

- **Weaknesses & Challenges:** High initial capital expenditure for laboratory processing hardware. Processing seasonal fruit surpluses (plums) created extreme operational peaks followed by idle equipment periods.
- **What Could Have Been Improved:**
 - **Diversification of Raw Inputs:** Instead of focusing predominantly on plums during their peak harvest window, the pilot should have established a pre-scheduled supply agreement with local cooperatives for a wider variety of multi-season organic residues (e.g., apple pomace, berry residues, root vegetable trimmings) to maximize laboratory equipment utilization year-round.
 - **Commercial Certification Pathways:** The pilot generated high-quality outputs (plum kernel oil and feed press cake), but lacked an immediate regulatory testing protocol to certify these outputs for commercial human cosmetic or animal feed markets during the pilot phase.

2. PP2 (JURRA) | *Food Services – Vocational School (Karlovac, Croatia)*

- **Strengths:** Integrated high-capacity compaction technology directly into a live vocational kitchen (~185 participants), achieving a **92.5% reduction in physical waste volume** and lowering waste per meal from 0.32 kg to 0.26 kg.



- **Weaknesses & Challenges:** Compaction reduces waste volume and transportation logistics, but does not inherently eliminate the generation of raw food loss at the source.
- **What Could Have Been Improved:**
 - **Upstream Kitchen Process Optimization:** The action relied heavily on downstream physical waste processing (compaction). It could have been significantly improved by pairing the compactor with mandatory **upstream prep-waste logging** in the kitchen, training student chefs on nose-to-tail culinary preparation to prevent waste before it reaches the compactor.
 - **Digitalization of Logs:** Kitchen staff relied on manual paper tracking sheets, which introduced friction during busy meal preparation shifts. An integrated digital touchscreen connected to the compactor scale would have reduced human error.

3. PP3 (ZADRA NOVA) | *Food Services – Vocational School (Zadar, Croatia)*

- **Strengths:** Outstanding quantitative reduction in kitchen preparation waste (from 20.35 kg to 6.48 kg) and plate leftovers (from 4.03 kg to 0.60 kg) among 30 students and 5 mentors. High educational output through study visits and a co-created 10-recipe Zero Waste e-Cookbook.



- **Weaknesses & Challenges:** The pilot cohort was small (35 total individuals), making the intense monitoring highly effective locally, but challenging to extrapolate across larger institutional scales without adaptation.
- **What Could Have Been Improved:**
 - **Institutional Curriculum Integration:** While the e-cookbook was an excellent creative outcome, the pilot could have formally embedded the zero-waste modules into the school's official, accredited multi-year curriculum, ensuring that future student cohorts are automatically trained under the same framework.
 - **Canteen Consumer Nudging:** The pilot focused heavily on culinary students in the kitchen. Expanding the intervention to include the non-culinary students consuming the meals in the dining hall would have addressed broader consumer-side meal acceptance dynamics.

4. PP4 (Univ. of Rijeka – EFRI) | *Food Services – Primary School (Rijeka, Croatia)*

- **Strengths:** Achieved a **38.4% reduction in per-pupil lunch waste** (87.4 g to 53.8 g/day) among 22 primary pupils. Effective combination of educational smoothie-making workshops (valorizing surplus snack fruit) and an operational food waste grinder handling ~6 kg/week.
- **Weaknesses & Challenges:** Deploying food waste grinders discharges ground organic matter directly into municipal sewer lines, which is subject to varying local



environmental regulations and municipal wastewater capacities across different EU regions.

- **What Could Have Been Improved:**

- **Sample Size Expansion:** The trial was limited to 22 pupils over a short 3-week window (late Nov – early Dec 2025). The pilot should have been extended across the entire school population to account for seasonal variations in pupil appetites and wider menu fluctuations.
- **Municipal Composting vs. Grinding:** Rather than relying primarily on sewer disposal via grinders, the pilot could have integrated an on-site aerobic composting unit or garden worm-farm, creating a visible, educational closed-loop system for young pupils.

5. PP6 (ECAMRICERT) | *Food Services – Primary School (Padua, Italy)*

- **Strengths:** Exceptional impact across 60 pupils at "Institute Luzzatti" (444 observed meals). Visual operator tracking proved an overall **-22.8% drop in unfinished trays**, a **-34.4% drop in First Course waste**, and a **-47.7% drop in Fruit waste**. Effective deployment of innovative AI-driven Smart Bins provided by the school catering service.
- **Weaknesses & Challenges:** High dependence on the school catering company's proprietary smart-bin technology. Aggregate smart-bin weight readings included



serving-counter pan surpluses alongside plate waste, inflating total bin weight (68.9 g/day) despite positive student eating behavior

- **What Could Have Been Improved:**

- **Separation of Waste Bin Streams:** Implement two distinct disposal smart bins during lunch service: one dedicated strictly to student plate leftovers and one for serving-counter pan surpluses in order to isolate kitchen overproduction from pupil consumption habits.
- **Direct Menu Feedback Loops:** While the AI smart bins recorded plate waste photo data, this data was primarily used for monitoring. It could have been better linked to a real-time feedback loop with municipal school menu planners to immediately adjust recipe portions or substitute systematically rejected dish components.
- **Parental Engagement Integration:** SSPA1 operated predominantly within the school walls. Establishing direct communication channels with parents (e.g., sharing daily school plate-waste summaries) would have helped align home dinner preparation with school lunch intake.

6. PP6 (ECAMRICERT) | *Consumers – Domestic Households (Padua, Italy)*

- **Strengths:** Profound behavioral transformation in 7 participating families. Proactive meal planning frequency surged from 28.6% to 80.0%, label literacy reached 80.0%,



and households achieving complete "Zero Waste" status more than doubled (28.6% to 60.0%).

- **Weaknesses & Challenges:** The pilot sample was extremely small (7 households / 7 active participants), restricting statistical generalization. Maintaining active daily family diary logging required high continuous motivation.
- **What Could Have Been Improved:**
 - **Mobile App Gamification:** The use of paper/simplified kitchen diaries created logging fatigue. Transitioning the diary to a gamified mobile app (with barcode scanning, expiry notifications, and child-oriented reward badges) would have significantly improved scaling potential and participant retention across a broader demographic.
 - **Extended Follow-Up Monitoring:** The post-intervention assessment took place immediately after the pilot. A follow-up audit 3 to 6 months later should have been planned to evaluate long-term habit retention once active project interactions ceased.

7. PP7 (UNIFG) | *Retailers – Supermarket Stores (Foggia, Italy)*

- **Strengths:** Pioneered an innovative business model ("AI Smart Box") in active *Mercati di Città* supermarket stores. Successfully integrated fixed-price near-expiry packaging with dynamic QR codes linking consumers to an AI "Virtual Chef" prompt tool for home recipe creation.



- **Weaknesses & Challenges:** Operational bottleneck during the initial rollout: achieved only 2 units sold (saving 3 kg of food) during the early monitoring window against an ambitious target of 100 boxes / 150 kg, due to the manual labor required by store staff to assemble boxes during active trading hours.
- **What Could Have Been Improved:**
 - **Automated POS Inventory Identification:** Box assembly was done manually by floor staff, creating operational friction. The workflow should have been automated through the supermarket's automated Point of Sale (POS) inventory system, generating automatic store alerts for items 48 hours from expiry and printing discounted "Smart Box" bundle labels automatically.
 - **In-Store Marketing & Shelf Placement:** Initial consumer traction was low because the "Smart Boxes" were placed in standard discount areas. Dedicated, high-visibility "AI Smart Corner" displays near store entrances, supported by explanatory signage, would have driven much higher impulse purchasing.

8. PP8 (CNA Abruzzo) | *Consumers / Creative Sector – Film Set (Pescara, Italy)*

- **Strengths:** Achieved a **100% meal consumption rate and zero food waste (0.5 kg to 0 kg)** on active film sets in Farindola and Montebello di Bertona. Flawless operational execution combining WhatsApp pre-booking, biodegradable single portions, on-demand coffee brewing, and food donation.



- **Weaknesses & Challenges:** The dynamic, unpredictable schedule of film productions (overtime, scene delays, weather shifts) makes strict catering pre-booking difficult to enforce without strong director and producer buy-in.
- **What Could Have Been Improved:**
 - **Formal Standardization into Regional Film Commission Criteria:** The pilot proved the effectiveness of the "Green Protocol" on set, but its application remained a voluntary pilot action. The partner should have leveraged this success to formally integrate the protocol into the official funding criteria of the *Abruzzo Film Commission*, making zero-waste catering a mandatory scoring requirement for future film grant recipients.
 - **Surplus Redistribution Partnerships:** While waste was reduced to zero on final days, early production days generated minor unserved portions. Establishing pre-arranged, health-compliant collection agreements with local food banks or animal shelters near remote filming locations would have ensured 100% valorization throughout all shooting phases.

6.3. Key Lessons Learned

Synthesizing the empirical outcomes and operational challenges across all eight pilot actions yields five core lessons for future circular economy interventions:

1. **Baseline Tracking Must Be Paired with Nudges:** Empirical waste logging establishes an essential evidence base, but measurement alone does not reduce waste.



Significant reductions occurred only when measurement was directly combined with practical, age-appropriate behavioral nudges (e.g., cooking workshops, portion choice, AI recipe prompts).

2. **Normalized Metrics Are Essential for Comparability:** Reporting absolute waste quantities in kilograms can be misleading due to fluctuating daily attendance, production crew sizes, or varying menu weights. Future assessment frameworks must mandate normalized indicators—such as **grams per pupil/meal/day**—to ensure rigorous cross-cutting evaluations.
3. **By-Products as Secondary Resources Create Economic Self-Sufficiency:** The Lead Partner's pilot proved that organic residues (such as plum pits) should never be treated as waste disposal liabilities. Transforming residues into high-value secondary outputs (cold-pressed oil, animal feed, biofuel pellets) creates self-sustaining economic incentives that outlast public grant funding.
4. **Intergenerational Engagement Amplifies Impact:** Engaging children as active "sustainability catalysts" in schools (PP4, PP6) and co-monitors in household kitchen diaries (PP6-SSPA2) proved to be the most effective mechanism for breaking entrenched adult habits and driving durable, long-term home behavior change.
5. **Operational Green Protocols are Strategic Assets:** In organizational settings (PP8 film sets), sustainable management is no longer merely an ethical choice. Integrating structured green workflows optimizes operational costs, eliminates unnecessary logistics, and enhances eligibility within modern EU public funding frameworks.





7. RECOMMENDATIONS AND FUTURE OUTLOOK

7.1. Recommendations for Improvement

To enhance the efficacy of future iterations, closer and more continuous collaboration with municipal dietitians is strongly recommended to better balance nutritional standards with actual student taste preferences, thereby reducing physiological food waste. Data collection frameworks should pivot toward digital, user-friendly mobile applications to eliminate the friction and fatigue associated with paper-based tracking for both households and scientific observers. Furthermore, it is critical to extend the monitoring periods and expand the participant sample sizes in future projects to account for day-to-day variabilities, validate the models on a wider urban scale, and produce highly robust, long-term environmental impact assessments.

7.2. Operational Guidelines for Future Replications

Successfully transferring the small-scale pilot models to new contexts requires establishing a robust multi-stakeholder governance structure before any activities commence. Implementers must build strategic partnerships connecting logistical hosts, such as school management boards or retail managers, with academic institutions and municipal authorities to ensure zero-waste initiatives are embedded into existing daily routines. In educational settings, preparations demand reliable weighing tools, standardised recording sheets, and clear coordination between teaching staff and canteen personnel. Furthermore, whenever practical food preparation or leftover valorisation is involved, institutions must document rigorous food-safety and allergen management protocols to comply fully with



public health standards. If the replication involves physical waste treatment hardware, such as professional food waste grinders, project managers are strictly required to verify that operating procedures align with municipal wastewater regulations and the capacities of local receiving systems. For future replications within the commercial retail sector, operational setups must prioritise shop-floor efficiency and food safety. Store managers must implement fast-track digital training for staff handling dynamic QR codes, strategically schedule box assembly to avoid burdening employees during peak trading hours, and enforce rigid protocols to maintain the cold chain for all perishable goods. In agricultural innovation hubs, operations must begin with written protocols for equipment usage, quality control, and product development, ensuring the chosen technologies can physically adapt to varying seasonal raw materials. Finally, when organising community or household workshops, implementers must elevate the intervention's perceived value by securing recognised professional figures, such as academic researchers or professional chefs. Moving beyond generic awareness campaigns and providing tangible technical instruction guarantees higher participant retention and ensures the successful, long-term transfer of zero-waste competencies.

7.3. Sustainability Beyond Project Duration

The long-term sustainability of these small-scale pilot actions is deeply rooted in the permanent acquisition of skills and the integration of zero-waste principles into institutional frameworks. Vocational schools will continue to utilise the provided food processing equipment and the digital zero-waste cookbooks, ensuring that sustainable food management becomes a mandatory, core competency for all future hospitality graduates



passing through their doors. Household participants are fully expected to maintain the economic and time-saving benefits of the professional preservation techniques they acquired long after the official project concludes. Physical infrastructures, such as the Zero Waste Innovation Lab, will serve as enduring regional platforms for continuous education, product testing, and collaboration between agricultural producers and food innovators. Lastly, because business models like the AI Smart Box generate profitable active margins from guaranteed near-expiry food losses, retailers are economically incentivised to integrate them permanently into their daily, post-project operations.

