DGrant Agreement number: 101037031

Project acronym: FRONTSH1P

Project title: A FRONTrunner approach to Systemic circular, Holistic & Inclusive solutions for a new Paradigm of territorial circular economy

Type of action: Innovation Action (IA)

Deliverable Number: D8.2

Replication in Fellow Regions and Beyond

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Delivery type:	Report
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Contractual delivery date:	31.10.2025
Delivery date:	31.10.2025
Dissemination level:	Public

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Partners

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HISTORY OF CHANGES			
Version	Date	Author/ Contributor	Changes
01	24.02.2025	INL	The first draft of structure of the document
02	31.03.2025	CCDR-N, Circulair Friesland, FRL, Gal Irpinia STRESS, Carmasciando, NTUA, PTSE, CRGR, MLEV.	Development of Stage 1 from Replication Regions
03	30.04.2025	CCDR-N, Circulair Friesland, FRL, Gal Irpinia STRESS, Carmasciando, NTUA, PTSE, CRGR, MLEV.	Development of Stage 2 from Replication Regions
04	30.06.2025	CCDR-N, Circulair Friesland, FRL, Gal Irpinia STRESS, Carmasciando, NTUA, PTSE, CRGR, MLEV.	Development of Stage 3 from Replication Regions
05	08.10.2005	CCDR-N, Circulair Friesland, FRL, Gal Irpinia STRESS, Carmasciando, NTUA, PTSE, CRGR, MLEV.	Development of Stage 4 from Replication Regions
06	15.10.2025	INL	Development of Good Practices Section
07	16.10.2025	STRESS	Revision of the document
07	31.10.2025	INL	Final version of the document

Disclaimer

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Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Abbreviations

CCRI - Circular Cities and Regions Initiative
CE – Circular Economy
CEAP - Circular Economy Action Plan
CpEAP – CircuPuncture Economy Action Plan
CSS – Circular Systemic Solutions
CTC – Circular Territorial Cluster
ICT - information and communication technologies
LAP – Local Activity Place
LR – Lodzkie Region
NGO – Non-Governmental Organisation
RCT - Regional Cluster Team
SAT – self-assesment tool
SLOM – Stowarzyszenie Łódzki Obszar Metropolitalny (Lodz Metropolitan Area Association)
TRL - technology readiness level

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Executive summary

This document is the deliverable **8.2 – Replication in fellow regions and beyond** of the **FRONTSH1P project**, which aims at ensuring the green and just transition of the Polish Lodzkie Region towards decarbonization and territorial regeneration through demonstration of four Circular Systemic Solutions (CSS) at TRL7. These solutions address the current challenges and needs of the region, transforming them into opportunities for economic growth, social inclusion, decarbonisation of systems of production and consumption, improvement of the quality of life for citizens, reconnection between the urban and rural context. The CSSs addresses four key strategic sectors: wood packaging (CSS1), food and feed (CSS2), water and nutrients (CSS3), and plastics and rubber (CSS4).

This deliverable is performed under WP8, wich main objectives are:

1) to develop a circular economic business model that will set up the basis for the replication of the 4 CSSs in the territorial clusters;
2) further define methodologies, measures and next steps for the future deployment and exploitation in their territories, based on the tools and methodologies applied in WP7;
3) create Good Practices including information on methodologies and solutions to be communicated to European policy makers and stakeholders.

Objective 1 is achieved through **D8.1 – Replication Strategy Model**, which was prepared based on the experience gained in Lodzkie Region during the development of the CircuPuncture Model and Circupuncture Economy Action Plan. This co-design activity defined the methodology for the replication of the Circular Economy Action Plan (CEAP) created for the Polish Lodzkie Region adapted to the local contexts and needs of the replication regions, which are:

- **Portugal:** North Region,
- **Italy:** Campania region,
- **Greece:** Central region & Livadia Municipality,
- **Netherlands:** Friesland Province

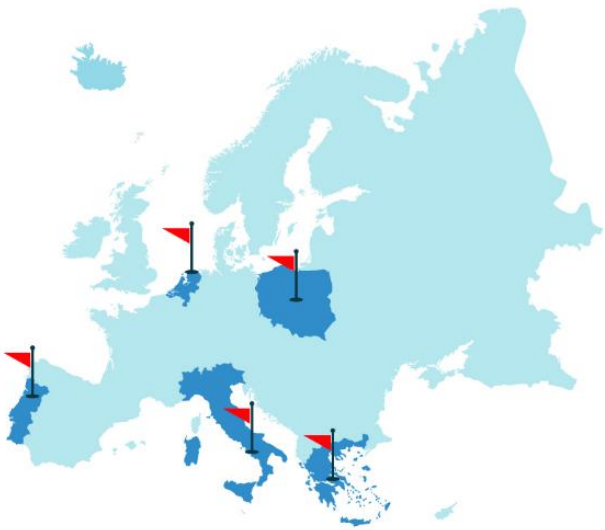

Figure 1 FRONTSH1P Replication Regions

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Objectives 2 and 3 of WP8 are achieved with this deliverable (D8.2), which comprises a Circular Economy Action Plan for each of the replication regions, followed by Good Practices for Regional Replication in Europe.

Following the methodology defined in D8.1, the regions worked towards the definition of 4 Stages: Stage 1 is the Analysis of Conditions, and include the designation of the region, the identification of key resources for implementing circular economy activities (including the establishment of indicators), the characterization of the region through the prism of the identified resources, the analysis of barriers to implement circular economy or green transition solutions, the identification and analysis of the stakeholders (including existing networks and connections between them), engagement of stakeholders, and analysis fo the supply value chain. Stage 2 is the Resources Missions and identification of the CSS of each region. Stage 3 comprises the definition of the Circular Challenges, and, finally, stage 4 is the Action Plan.

Following the actions suggested in the Action Plan for each of the Regional Roadmaps, a section dedicated to good practices for regional replication in Europe concludes this deliverable.

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PORTUGAL REGIONAL ROADMAP: NORTE REGION

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Table of Content

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Table of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101037031

Table of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Abbreviations

AICEP - Portuguese Agency for Investment and Foreign Trade
APA – Portuguese Environmental Agency
AREC - Regional Agenda for the Circular Economy
CCDR-N – Norte Regional Coordination and Development Commission
CCRI - Circular Cities and Regions Initiative
CE – Circular Economy
CEAP - Circular Economy Action Plan
CpEAP – CircuPuncture Economy Action Plan
CSS – Circular Systemic Solutions
CTC – Circular Territorial Cluster
DGAV - General Directorate for Food and Veterinary
EU – European Commission
GPD – Gross Domestic Product
GVA - Gross Value Added
ICT - Information and Communication Technologies
INE – National Institute of Statistics
INEGI - Institute of Science and Innovation in Mechanical and Industrial Engineering
INL - International Iberian Nanotechnology Laboratory
IPB -Instituto Politécnico de Bragança
IPCA - Instituto Politécnico do Cávado e do Ave
IPP -Instituto Politécnico do Porto
IPVC - Instituto Politécnico de Viana do Castelo
LAP – Local Activity Place
LR – Lodzkie Region
NGO – Non-Governmental Organisation
NUTS - Nomenclature of Territorial Units for Statistics
PAEC - Action Plan for the Circular Economy
R&D - Research and Development
RCM - Resolution of the Council of Ministers
RCT - Regional Cluster Team
SME – Small and Medium Enterprises
SAT – self-assesment tool
SLOM – Stowarzyszenie Łódzki Obszar Metropolitalny (Lodz Metropolitan Area Association)
TRL - technology readiness level
UCP - Universidade Católica Portuguesa
UM - Universidade do Minho
UP - Universidade do Porto
UTAD - Universidade de Trás-os-Montes e Alto Douro

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STAGE I: ANALYSIS OF CONDITIONS

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1. Stage I: Analysis of Condition

1.1 Characterization of the Norte Region

The Norte region (NUTS II) has around 3.67 million inhabitants, which represents 35% of the national population (INE, 2023a). It is the most export-oriented region, accounting for 35% of national exports (INE, 2023b). The region is divided into seven intermunicipal communities and one metropolitan area (NUTS III): Alto Minho, Cávado, Ave, Área Metropolitana do Porto, Alto Tâmega e Barroso, Tâmega e Sousa, Douro and Terras de Trás-os-Montes, and composed by eighty-six municipalities (Figure 1).

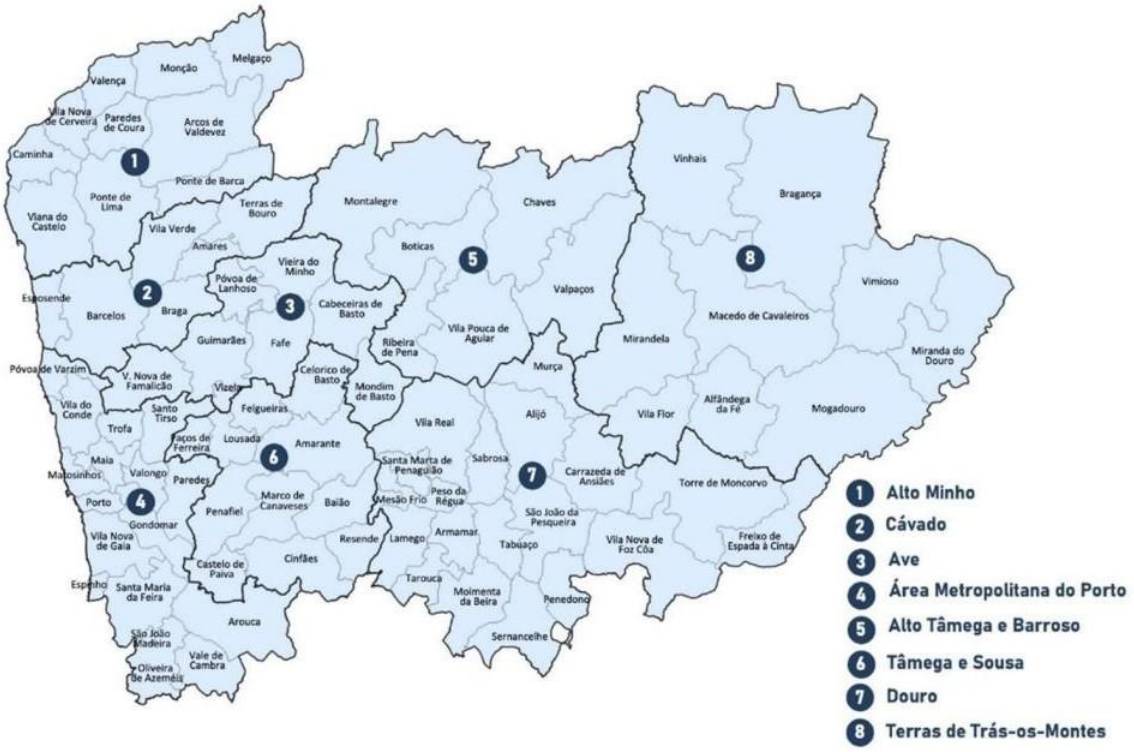

Figure 1– Map of the Norte Region (Source: CCDR-N, n.d.)

This region has the second highest number of enrolments in higher education, with almost 150,000 students in 2022/2023, surpassed only by the Lisbon metropolitan area. In terms of enrolment in higher education, there has been a significant increase over the last 20 years (from 23.9% in 2003/2004 to 42.9% in 2023/2024) and greater convergence with the national average, albeit slightly lower, which currently stands at 43.1% (INE, 2024). In terms of innovation, the Norte is the region with the highest number of institutions and companies with R&D (INE, 2022) and the region with the highest number of patent applications for inventions, mainly at company level (INE, 2023c).

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Circular Economy in Portugal and in the Norte Region

In Portugal, the EU's package of measures for the Circular Economy was essentially transposed into the document 'LEADING THE TRANSITION: Action Plan for the Circular Economy (PAEC)', approved by RCM no. 190-A/2017 of 11 December, which consolidated the proposals and measures, adopting three levels of operationalisation: national, sectoral and regional, sectoral and regional. The macro level uses the same rationale as the EU action plan for circular economy - product, consumption, waste/secondary raw materials, with knowledge as the central element for developing solutions. At the meso level, the focus is sectoral, with sector being understood as the value chain associated with a given activity. At the micro level, the focus is on the regions and the acceleration strategies for the circular economy best suited to their socio-economic profile. (CCDR-N, 2021).

In this context, and in conjunction with the PAEC, the Regional Coordination and Development Commissions have begun to draw up Regional Agendas for the Circular Economy (AREC).

Encouraging the transition to a Circular Economy in the north of Portugal is the main objective of its Regional Agenda. Given Norte's business profile, the following areas have been prioritised: Cities and Circular Territories, Construction and Demolition Waste, Goods Transport and Logistics, Textiles and Agri-food. (CCDR-N, 2021)
Therefore, it was logical that CSS2 – Food and Feed would be addressed by the Norte Region in the framework of the Frontsh1p project. However, as it will be demonstrated below, it seemed relevant to also address CSS4 – Plastics and Rubber, as it is a sector closely linked to the agrifood and feed industry but also because it is a sector highly represented in the Norte region.

1.2 Characterisation of industry

Food and Feed

The boundaries between agriculture, food industry, food retail and feed industry are not always clearly defined. The term "agrifood" (or "agrofood") may encompass all these subsectors (including feed), or it may refer more narrowly to agriculture and the food industry. In this report, the scope includes agriculture, fisheries and aquaculture, the food industry, the feed industry and food retail.

Agrifood sector in Portugal

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The Portuguese agrifood sector is fundamental to the country's growth strategy, directly contributing to increasing exports and guaranteeing food self-sufficiency (AICEP, 2025a). It comprises the production and processing of raw materials into food and drink – agriculture, fisheries, processing food and drink industries, extractive industries (salt) -, and distribution to the end consumer (AICEP, 2025b).

In recent years, there has been a significant increase in agrifood exports, demonstrating its growing international recognition (AICEP, 2025a) and the sector's relevance to the country's economy and competitiveness (AICEP, 2025b). Furthermore, the agrifood sector in Portugal corresponds to 12.9% of GDP and 7.9% of total exports (PORDATA, 2024a). The GVA in 2022 was similarly distributed between agriculture, silviculture and fisheries, and the food industries, each totalling 4.6 billion euros (PORDATA, 2024c)

Feed sector in Portugal

According to IBISWorld (2024), animal feed production in Portugal had a revenue of 1.6 billion euros in 2023, a decrease of 1.9% relative to 2019.

Considering the same source, the European animal feed productions market is evolving, driven by a surge in demand for organic, sustainable and high-welfare products. This shift extends into the diets of their livestock and pets. The number of farms practicing organic methods (including in France, which boasts the third-highest area of organic farms globally) is on the rise, boosting demand for organic feeds (IBISWorld, 2024).

ReportLinker (n.d.) states that Portuguese animal feed sales are projected to reach approximately 1.7 billion euros by 2018, up from 1.6 billion euros in 2023, marking an annual growth rate of 0.7%. The country's animal feed imports are expected to decline slightly, reaching around 220 million kilograms by 2028 from 226 million kilograms in 2023 (ReportLinker, n.d.). Conversely, Portuguese animal feed exports are anticipated to grow, reaching approximately 135 million kilograms by 2028, from 116 million kilograms in 2023 (ReportLinker, n.d.).

In news in 2021, according to the country's feed manufacturers' association, the animal feed sector in Portugal feared being caught in the middle of two pressures: an increase in the price of raw materials and a lack of liquidity for livestock producers (IACA, 2021). An increase in the price of raw materials is a driving factor for the transition into a more circular economy.

Agrifood and feed in the Norte Region

Agriculture

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Fodder maize is by far the most abundant crop in the Norte region, with a production of 1.5 million tons in 2023. Wine grapes are the second most abundant crop in Norte, with 301 kt produced in 2023. (Figure 2 and 3)

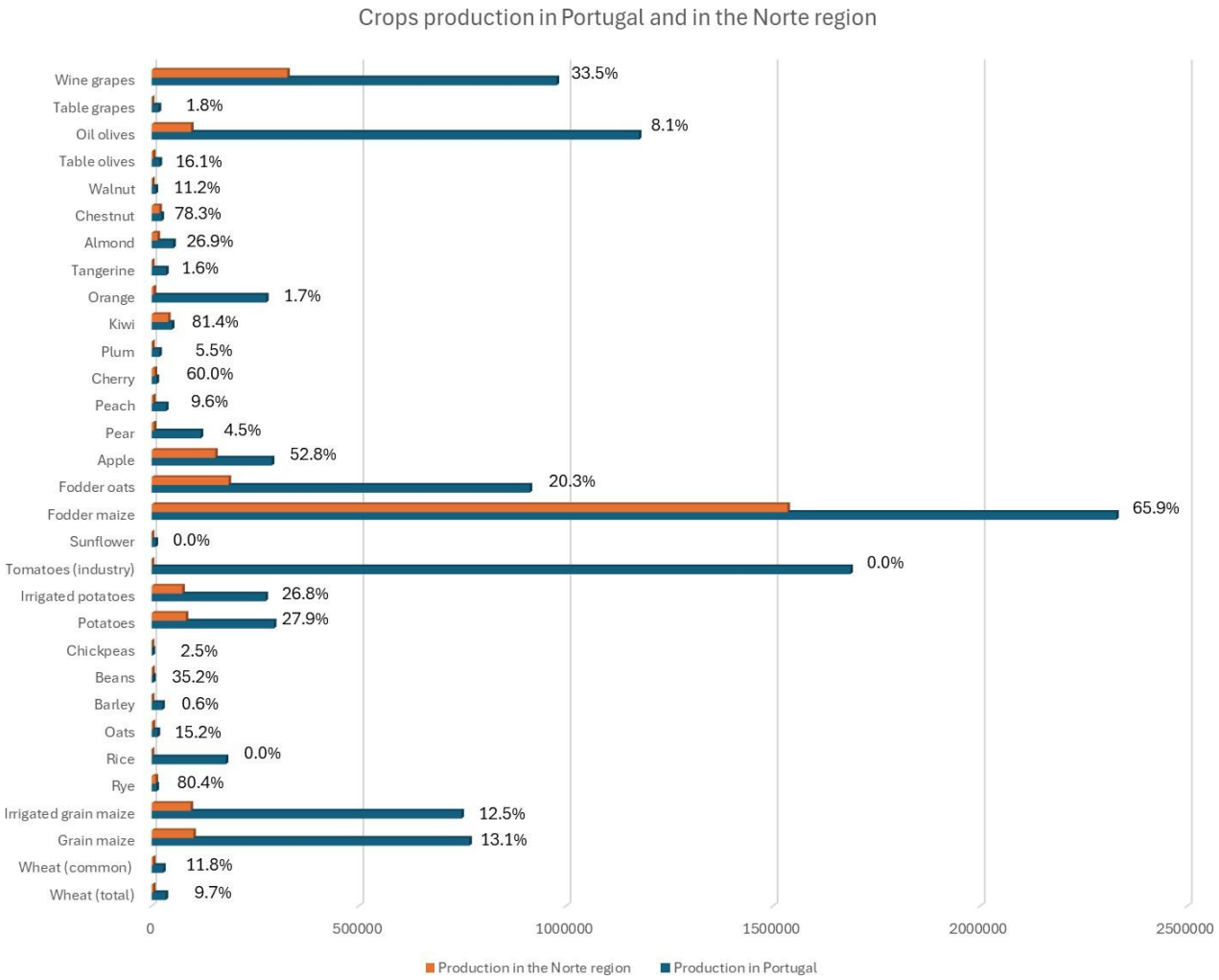

Figure 2 Main agricultural crops production (in tons) in continental Portugal and corresponding production in Norte (with the percentage of production in the Norte region in relation to the national level). (INE, 2024a)

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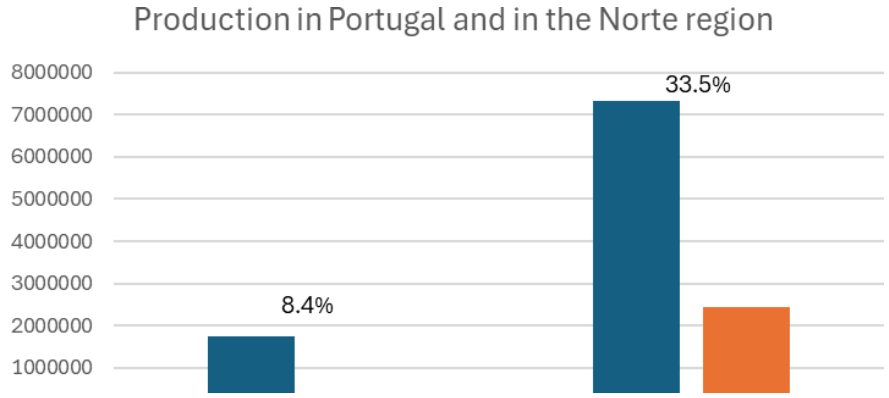

Figure 3 Main agricultural crops production (in hectolitres) in continental Portugal and corresponding production in Norte (with the percentage of production in the Norte region in relation to the national level) (continuation). (INE, 2024a)

Primary animal production

Animal products statistics are presented in Table 1 for 2023 in Portugal. Direct production data is not available per region (NUTS II) but may be inferred from total effective heads for each animal species per region (Table 2). Norte has 20% of cattle heads and 25% of goats (Table 2).

Table 1 Meat, milk, cheese, butter, honey, wax, and wool production in Portugal in 2023 (provisional results). (INE, 2024a)

Products	*Unit*	*Production*
1 - Meat (net weight)	t	903822
Cattle	t	98424
Sheep	t	12372
Goats	t	1098
Pigs	t	356455
Meat	t	231696
Bacon	t	124759
Horses	t	21
Poultry	t	420978
Chicken	t	336524
Turkey	t	50080
Duck	t	12747
Other meats (game, rabbit, pigeon, etc.)	t	14475
2 - Lard	t	39210
3 - Offal (except poultry)	t	54946
4- Milk	1000 L	1996212
Cow	1000 L	1901 001
Sheep	1000 L	67743
Goat	1000 L	27468
5 - Cheese	t	86466
Cow	t	63946

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Sheep	t	11290
Goat	t	3908
Mixed	t	7321
6 - Cow's butter	t	31583
7 - Chicken eggs (total)	t	152426
for incubation	t	21713
8 - Honey	t	8915
9 - Wax	t	240
10 - Wool		6218

Table 2 – Total headcount in Portugal and in Norte, in 2023, per animal species. (INE, 2024a)

Species	*Total headcount in Portugal (1 000 heads)*	*Headcount in the Norte region (1 000 heads)*	*% Norte region / Portugal*
Cattle	1528	300	20%
Pigs	2 181	63	3%
Sheep	2217	267	12%
Goats	336	83	25%
Poultry — all species	239458	15296	6%
Chickens	224007	15296	7%

Cattle in this region is particularly important for milk production. Most milk cooperatives are located in the Norte region. Agros is a union of cooperatives, representing 44 cooperatives and approximately 750 milk producers (Agros, 2025), all in the Norte region (Figure 4). Nonetheless meat production is also relevant, in particular in the context of native breeds: Arouquesa, Barrosã, Cachena, Maronesa, Mirandesa and Minhota are all bovine breeds from the Norte region (FERA, n.d.).

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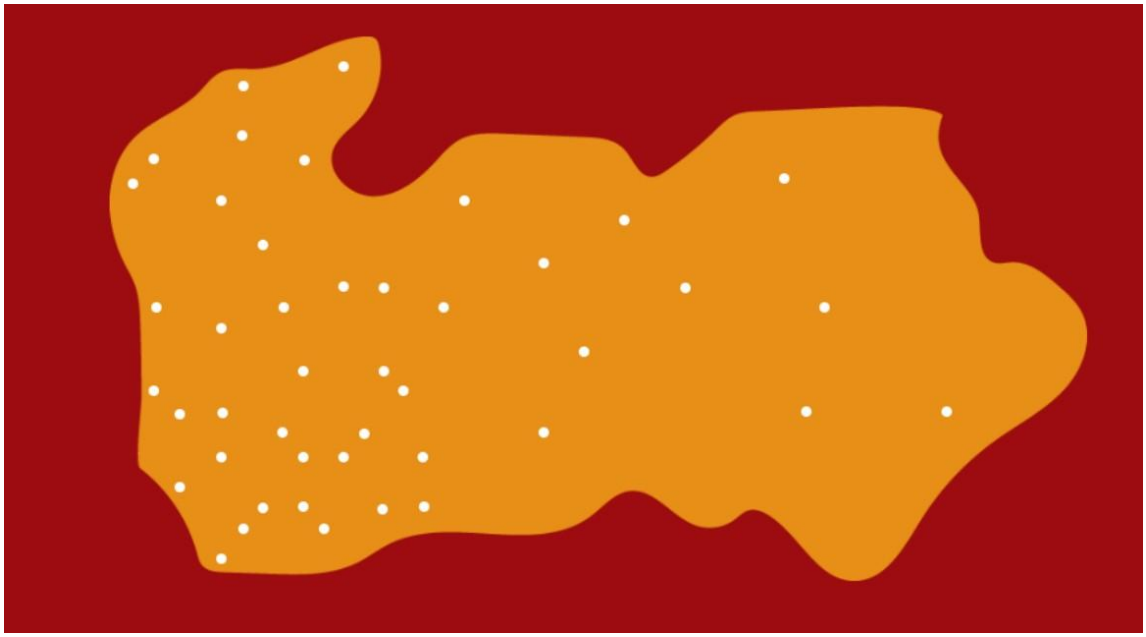

Figure 4 Map of Agros' associated milk production cooperatives, all in Norte (Agros, 2025). In the original map, each dot shows the name of the cooperative

Fisheries and aquaculture

Discharges of fresh or chilled fish by Producer Organisations (POs), for Portugal and the Norte region, by main species, are presented in Table 4. Nominal captures by species are presented for Portugal and the Norte region in Table 5. Original data shows fish captures per all NUTS II. The Norte region is particularly prominent in sardines, blue whiting (verdinho), Atlantic mackerel (sarda), pout and seabass captures. The Norte region has 3 main fisheries discharge ports: Viana do Castelo, Póvoa de Varzim and Matosinhos.

With regards to aquaculture, Norte has a small significance with only 2.4% of total production, except for inland water production where it assumes the whole production (Table 6). Although reduced, Portugal has shown a stable freshwater aquaculture production of trout (Portugal Global, 2024). The north coast of Portugal is, however, attracting interest from investors for large-scale salmon production (Portugal Global, 2024).

Table 3 Discharges of fresh or chilled fish by Producer Organisations (POs), for Portugal, continental Portugal and Norte, by main species, in 2022 and 2023. (INE, 2024b)

Species		*Portugal [t]*	*Continental Portugal [t]*	*Norte [t]*	*% Norte/Portugal*
Total	2022	91 760	79 849	14 649	16%
	2023	101 962	90 859	15 533	15%
Sardine	2022	24 087	24 072	6 933	29%
	2023	24 735	24 726	6 733	27%
Mackerel	2022	16 143	15 957	260	2%
	2023	15 086	15 048	51	0%

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Horse mackerel	2022	16 116	15 719	925	6%
	2023	13 656	13 295	755	6%
Blue whiting	2022	1 607	1 607	625	39%
	2023	1 688	1 688	673	40%
Atlantic mackerel (sarda)	2022	481	481	93	19%
	2023	475	475	168	35%
Others	2022	33 326	22 013	5 814	17%
	2023	46 322	35 627	7 152	15%

Table 4 Nominal catches, for Portugal and Norte, by species, in weight and value, in 2022 and 2023. (INE, 2024b)

	Norte		*Portugal*		*% Norte/Portugal*	
	t	kEuros	t	kEuros	Weight	Value
Total 2022	17 177	45 032	121 038	334 987	14%	13%
Total 2023	18 070	47 980	131 262	339215	14%	14%
Brackish and fresh water	27	836	69	1 107	39%	76%
Marine fish	14 217	28 399	111 174	219 741	13%	13%
Tuna and similar	55	250	9 306	26 520	1%	1%
Beetle	17	71	421	2 084	4%	3%
Horse mackerel	807	1 168	15 958	22 992	5%	5%
Blue jack mackerel	5	5	2 513	2 623	0%	0%
Mackerel	90	70	32 222	15 765	0%	0%
Conger eel	307	669	920	2652	33%	25%
Pout	406	1 106	908	2 291	45%	48%
Sole and flounder	144	1 343	624	7 102	23%	19%
Swordfish	1	5	102	539	1%	1%
Black scabbardfish	82	370	4 259	17 659	2%	2%
Hake	187	674	1 409	5 154	13%	13%
Skate	243	482	1 506	3 680	16%	13%
Seabass	162	1 456	546	7 443	30%	20%
Atlantic mackerel	174	143	684	1000	25%	14%
Sardine	6 771	4 836	25 092	26 816	27%	18%
Monkfish	20	114	611	3 816	3%	3%
Blue whiting	726	682	1 983	1 507	37%	45%
Miscellaneous	4 019	14 954	12 109	70 096	33%	21%
Crustaceans	166	765	1 827	21 310	9%	4%
Prawns	0	0	755	8 815	0%	0%
Lobsters	3	54	41	1 296	8%	4%
Norway lobster	0	0	98	2 910	0%	0%
Miscellaneous	162	712	933	8 288	17%	9%
Molluscs	3 278	16 124	17 755	94 802	18%	17%
Clams		3	2 190	8 505		0%
Cuttlefish	20	111	1 550	9 068	1%	1%
Squid	15	131	1 029	9 897	1%	1%

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Octopus	1 296	8 955	6 256	48 649	21%	18%
Miscellaneous	1 946	6 924	6 729	18 683	29%	37%
Miscellaneous aquatic species	383	1 855	437	2 255	88%	82%

Table 5 Aquaculture production in 2022 in Portugal, continental Portugal and Norte, for different waters and production types.(INE, 2024b)

		Portugal [t]	Continental Portugal [t]	Norte [t]	% Norte/ Portugal
Total		16 116	14 126	394	2.4%
Inland waters	Total	264	264	263	99.9%
	Extensive production	0	0	0	-
	Intensive production	264	264	263	99.9%
	Semi-intensive production	0	0	0	-
Transition and marine waters	Total	15 852	13 862	131	0.8%
	Extensive production	7 140	7 140	25	0.4%
	Intensive production	5 563	3 573	106	1.9%
	Semi-intensive production	3 149	3 149	0	0.0%

Food and Feed Industries

Food and feed production quantities data is not directly available per NUTS II, but may be inferred from number of enterprises and turnover per NUTS II.

The Norte region has 30% of the food companies in the country and 38% of the beverage companies. With respect to turnover, the Norte region represents 20% of the food industries turnover in the country and 43% of the beverage industries turnover.
From the analysis of data from INE (2024a), it can be observed that the most prevalent food, feed and beverage subsectors in the Norte region are:

- Dairy: only 15% of the dairy companies but 39% of the turnover.
- Beverages: 38% of the companies and 43% of the turnover.
- Cereals, pulses, starches: 27% of the companies and 46% of the turnover.
- Bakery and other flour products: 32% of the companies and 32% of the turnover

Furthermore, the Norte region detained almost one fourth of the enterprises and persons employed in 2023 in this subsector. (INE, 2024b)

Data on animal feeding stuffs production quantities is not available per NUTS II in the national agricultural statistics. However, from indirect data presented for NUTS II (number of companies, turnover, total expenditure and GVA), estimations can be made. The Norte region

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has around 10% of the number of feed producers and ≤12% of the countries' feed production turnover. The General Directorate for Food and Veterinary (DGAV)'s list of manufacturers of animal feedstuffs shows 204 plants with approval numbers (DGAV, 2024), classified as:

- Manufacturers of Animal Feed Additives
- Manufacturers of premixes of additives intended for animal feed
- Self-producers of compound feedstuffs
- Compound feed manufacturers

The number of companies is slightly lower, as some companies have two or more plants, and some plants produce more than one type of feed products. Of those feedstuffs' companies, only 15 seem to be located in the Norte region. This data supports the relatively small representativity of feed producers in the Norte region when compared to other NUTS II.

Many feedstuffs' producers deal with animal byproducts. As per Regulation 183/2005, these operators are registered in an information system with DGAV (SIPACE). In addition to those operators accounted for in production of feedstuffs, there are other operators that deal with animal byproducts, but which do not produce feedstuffs. These players may be of importance in terms of circular economy, as they add value to food byproducts. Some of these players are different companies (12 to be precise) but belong to larger groups that have feedstuff production capacities.

Plastics and rubber industry

The economic activity with the highest turnover in the northern region is 'Wholesale and retail trade; repair of motor vehicles and motorcycles', followed by manufacturing and construction. In terms of manufacturing, the industries with the highest turnover in the northern region are (Figure 5):

- Manufacture of basic metals, except machinery and equipment;
- Food industries;
- Manufacture of wearing apparel;
- Manufacture of motor vehicles, trailers, semi-trailers and parts of motor vehicles;
- Manufacture of rubber and plastic product.

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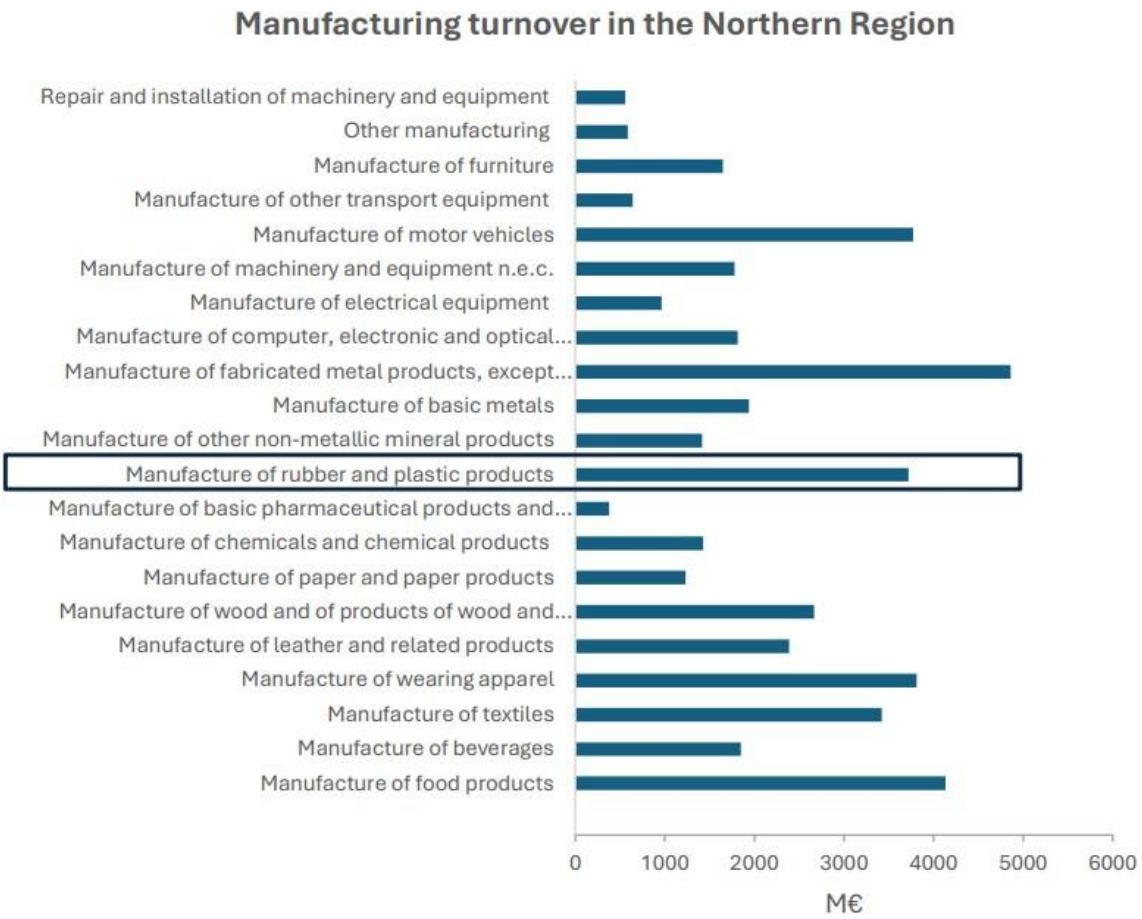

Figure 5 Manufacturing turnover in the northern region (INE, 2023d)

The rubber and plastics industry accounts for about 8.3 % of the manufacturing industry in the Norte Region. It is represented by economic activity code 22, which includes the sub-sectors of rubber and plastic products, as described in Table 6.

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Table 6 Codes of economic activities for the rubber and plastics industries (INE, 2007)

22 Manufacture of rubber and plastic products	*221 Manufacture of rubber products*	*22111 Manufacture of rubber tyres and tubes;*
		22112 Retreading and rebuilding of rubber tyres;
		22191 Manufacture of rubber components for footwear
		22192 Manufacture of other rubber products
	222 Manufacture of plastics products	*22210 Manufacture of plastic plates, sheets, tubes and profiles*
		22220 Manufacture of plastic packing goods
		22230 Manufacture of builders' ware of plastic
		22291 Manufacture of plastic components for footwear
		22292 Manufacture of other plastic products

It is important to emphasise that other industries may produce plastic and rubber articles and not be identified with the NACE 22, but for the purposes of this analysis we will start with the NACE described, with the proviso that other economic activities can be analysed later if necessary.

Manufacture of rubber and plastic products

Most enterprises operating in this sector are in the Norte region, with a total of 533 enterprises, representing almost 50 per cent of the national total, as shown in Figure 6.

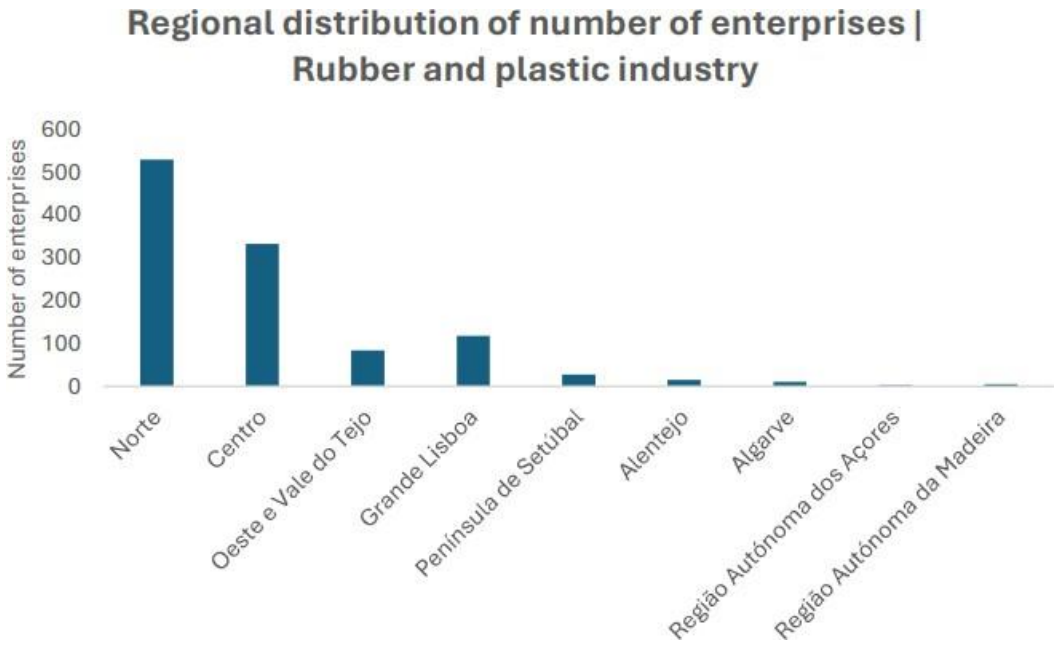

Figure 6 Number of enterprises in the rubber and plastics industry by region (INE, 2023e)

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In terms of sub-sectors, the plastics industry had the largest number of enterprises (434) compared with the rubber industry (96). In terms of gross value added (GVA), the difference is not very significant, although it is slightly higher in the case of plastics (around EUR 555 million GVA in the rubber sector and around EUR 594 million in the plastics sector) (Figure 7).

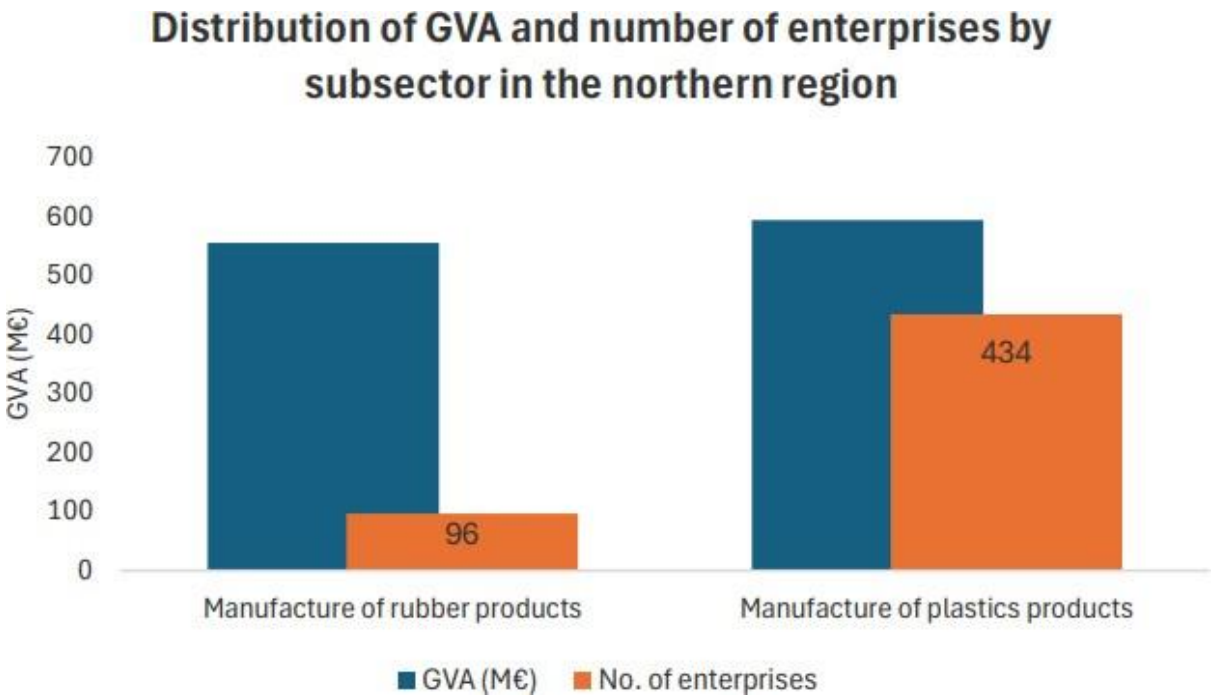

Figure 7 Gross value added and number of enterprises by plastics and rubber industry subsector (INE, 2023e)

Manufacture of rubber products

An analysis of the rubber sector by intermunicipalities in the northern region shows that the largest number of enterprises is in the metropolitan area of Porto. However, in terms of GVA, the region of Ave has the most significant figure (Figure 8).

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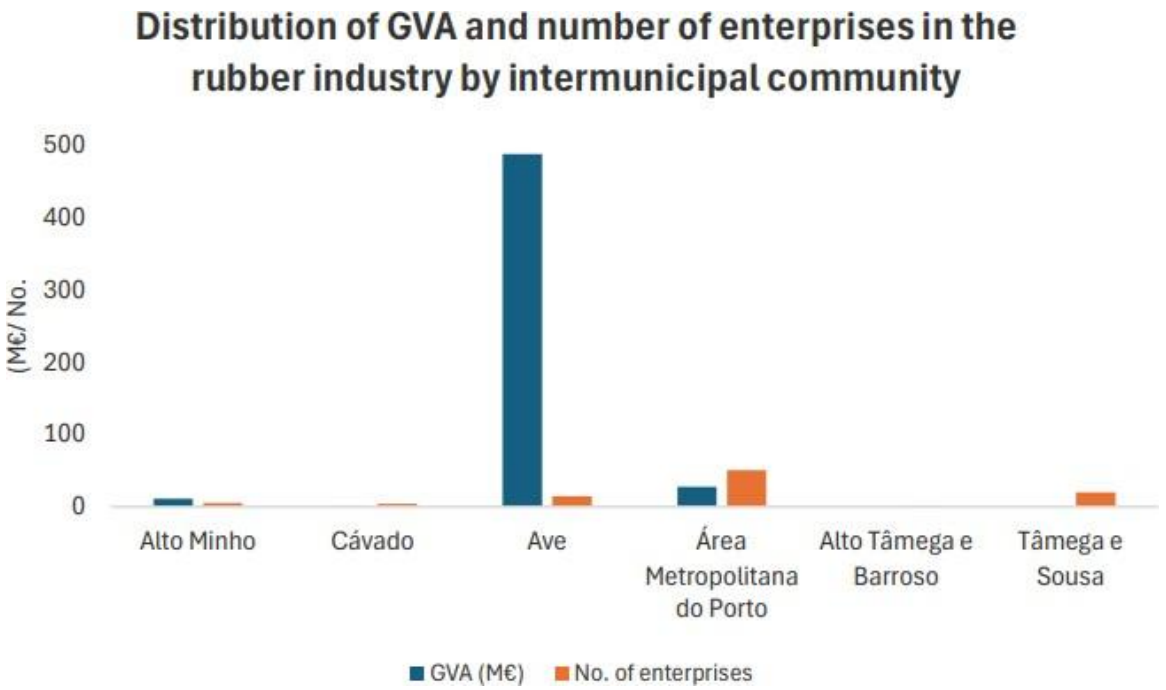

Figure 8 Gross value added and number of enterprises in the rubber industry by municipality in the Northern Region (INE, 2023e)

Among the sub-sectors of the rubber industry, the largest number of enterprises operate in the 'Manufacture of other rubber products', mainly in the Oporto metropolitan area and the Ave region. In the Tâmega e Sousa region, a significant number of enterprises operate in the manufacture of rubber components for footwear (Figure 9).

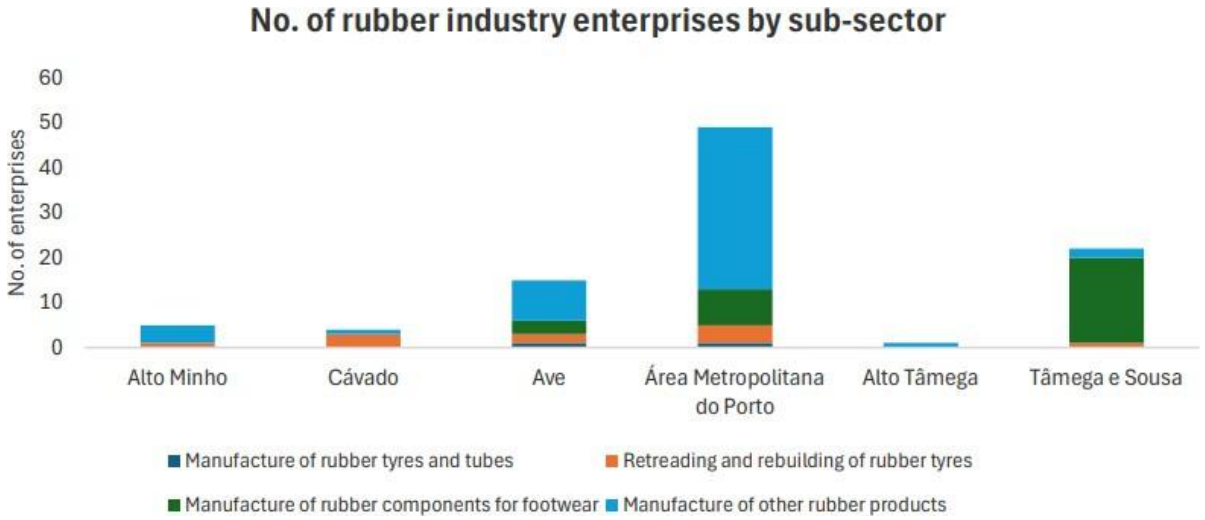

Figure 9 No. of enterprises by subsector of the rubber industry and by intermunicipal community in the northern region (INE, 2023e)

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An analysis by municipality shows that, in terms of the number of enterprises, most are in Felgueiras, a municipality with a strong footwear industry in the Tâmega e Sousa region (Figure 10).

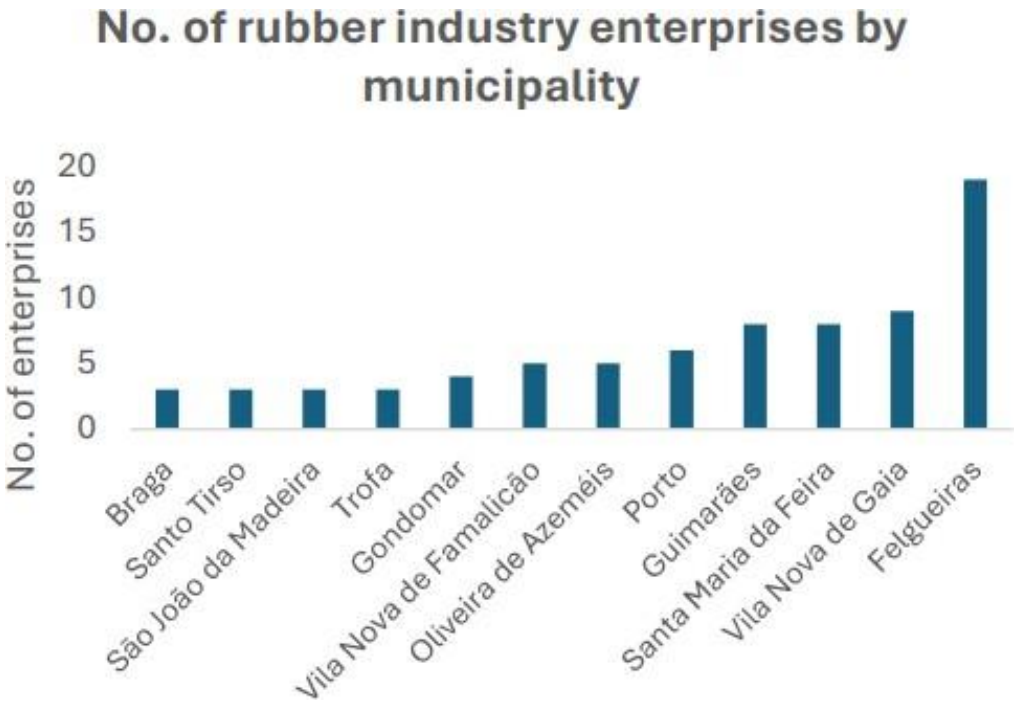

Figure 10 Municipalities in the Northern Region with the highest number of enterprises in the rubber industry (INE, 2023e)

In terms of exports, Vila Nova de Famalicão, located in the intermunicipal municipality of Ave, is the municipality with the highest figure. This is due to the presence of Continental, a multinational tyre manufacturer (Figure 11).

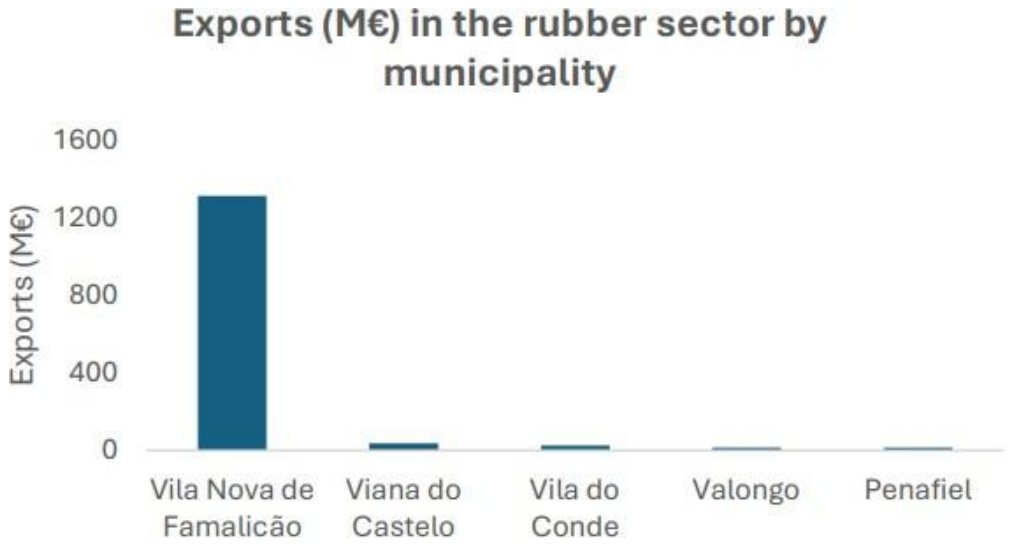

Figure 11 – The most exporting municipalities in the northern region in terms of the rubber industry (INE, 2023b)

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Manufacture of plastics products

With regard to the plastics sector, it is in the Porto Metropolitan Area that GVA and the number of companies are significantly higher, followed by the Ave, Cávado and Alto Minho regions (Figure 12).

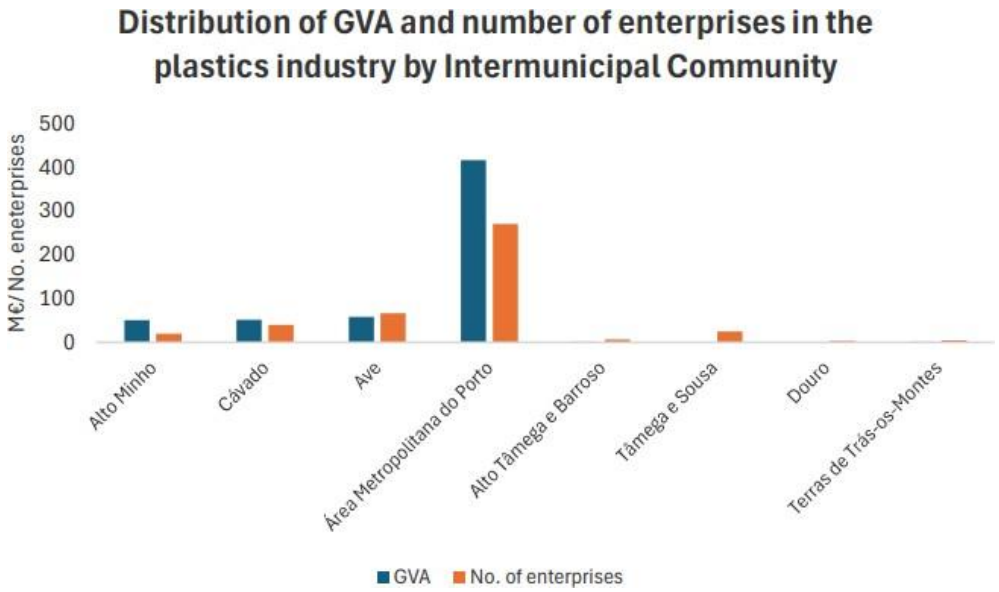

Figure 12 Gross value added and number of enterprises in the plastics industry by intermunicipal community in the northern region (INE, 2023e)

In terms of sub-sectors, the largest number of enterprises were active in the manufacture of other and unspecified plastic products, mainly in the Oporto metropolitan area (Figure 13).

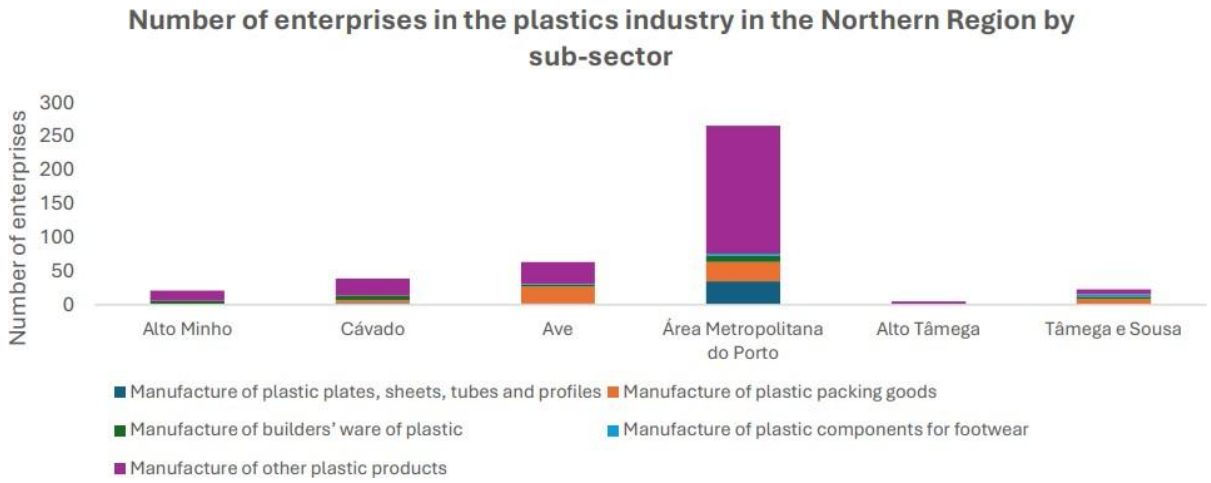

Figure 13 No. of enterprises by subsector of the plastic industry and by intermunicipal community in the northern region (INE, 2023e)

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When analysing the number of enterprises by municipality, the highest number is found in Oliveira de Azeméis, followed by Guimarães and Vila Nova de Gaia (Figure 14).

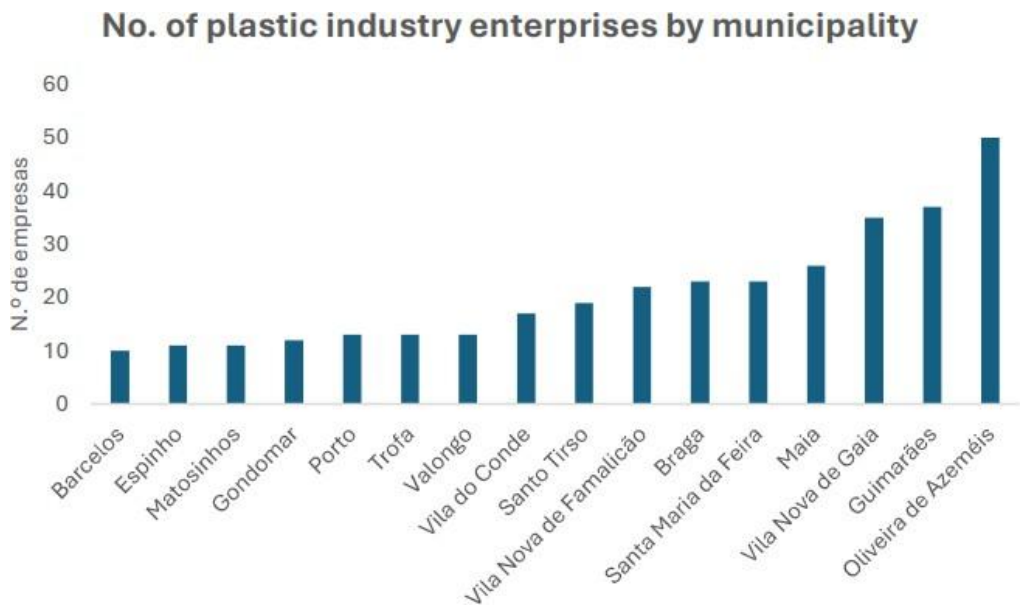

Figure 14 Municipalities in the Northern Region with the highest number of enterprises in the plastic industry (INE, 2023e)

In terms of exports, Santo Tirso is the municipality with the highest export profile, followed by Vila Nova de Gaia, Porto and Maia, all in the Porto metropolitan area. Vila Nova de Famalicão also has a high level of exports (Ave region), as does Arcos de Valdevez in the Alto Minho region (Figure 15).

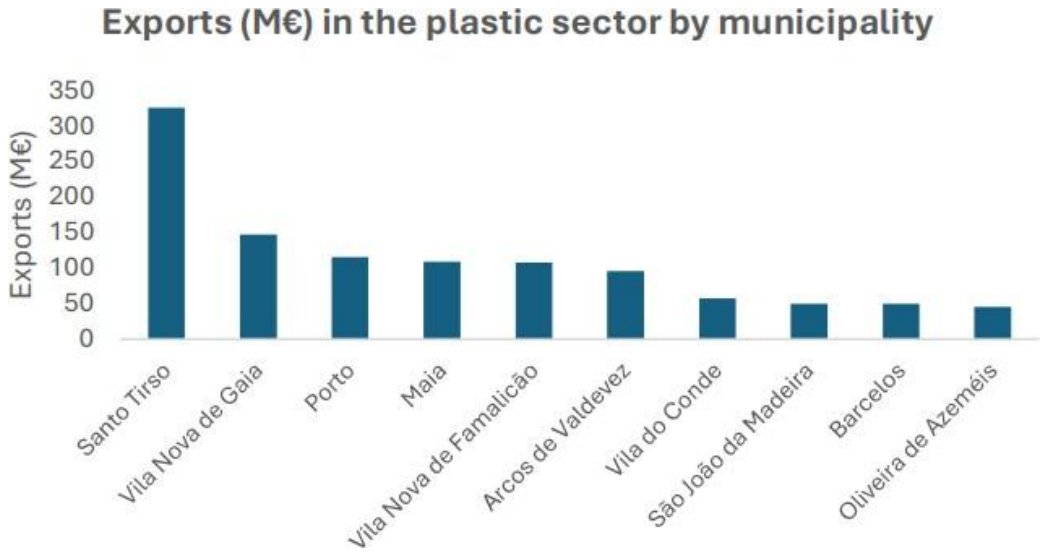

Figure 15 The most exporting municipalities in the northern region in terms of the plastic industry (INE, 2023b)

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In summary

Based on the analysis of the diagnosis of the plastics and rubber sector in the Norte region, here are some of the main conclusions:

- The Norte region has the highest number of enterprises in the plastics and rubber industry in Portugal.
- When comparing the rubber and plastics industries, the number of enterprises in the plastics industry is significantly higher (434 vs. 96), but in terms of gross value added (GVA) the difference is not very significant.
- With regard to the rubber industry, the highest number of enterprises is found in the Metropolitan Area of Porto (AMP), but in terms of GVA and exports, the figure is higher in the region of Ave, due to the presence of the tyre manufacturing company Continental, located in Vila Nova de Famalicão.
- The municipality with the highest number of rubber industry enterprises is Felgueiras, in the Tâmega e Sousa region, due to the footwear cluster that exists in the region.
- Regarding the plastics industry, most enterprises are located in the AMP, followed by the regions of Ave and Cávado. In terms of GVA, the value is most significant in the AMP.
- The municipalities with the highest number of enterprises in the plastics industry are Oliveira de Azeméis, followed by Guimarães, Vila Nova de Gaia and Maia. The municipality with the highest export profile in the region is Santo Tirso, followed by Vila Nova de Gaia, Porto and Maia.
- The regions of Terras de Trás-os-Montes, Douro and Alto Tâmega e Barroso are not relevant for the rubber and plastics industry. Tâmega e Sousa doesn't have much industry either, but due to the footwear cluster in the region, it would be relevant to include this region in the analysis of rubber industry.

It is important to stress that the plastics and rubber industry can produce materials for various segments - construction, automotive, food, agriculture, decoration, clothing, hospital equipment, household appliances. Although the scope can be very wide, no specific segment will be defined at this stage. Later, the need to study a more specific segment can be assessed.

1.3. Indicators

The indicators for the monitoring framework of Circular Economy are not readily available at regional level in Portugal, except for one indicator (“Recycling rate of municipal waste”). Thus, the National Institute for Statistics was contacted to assess the possibility to collect the data at regional level. For progress monitoring and evaluation of circular measures for the region we used EUROSTAT for socio-economic indicators and the CCRI Self-Assessment tool. For the monitoring of circular measures for CSS2 and CSS4, we propose the following specific indicators in figure x. Regarding the Sustainable Development Goals (SDGs), the

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selected indicators of sustainable development relating mainly to economic growth and circular economy in Portugal are presented in **Annex I**.

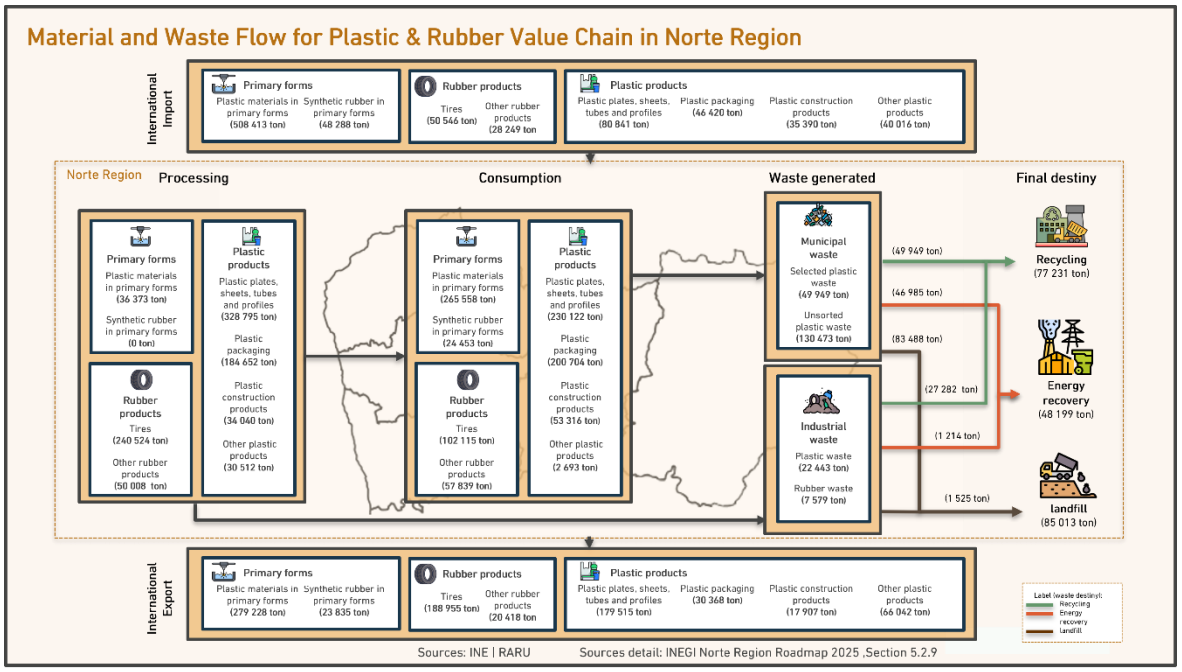

Figure 16 Norte Region consolidated value chain for CSS4. Plastics & Rubber that showcases main material and waste streams. Sources: INE, European Commission, RARU. Adapted by INEGI – Norte Region Roadmap 2025

The indicators for the monitoring framework of Circular Economy are not readily available at regional level in Portugal, except for one indicator ("Recycling rate of municipal waste"). Thus, the National Institute for Statistics was contacted to assess the possibility to collect the data at regional level. For progress monitoring and evaluation of circular measures for the region we used EUROSTAT for socio-economic indicators and the CCRI Self-Assessment tool. For the monitoring of circular measures for CSS2 and CSS4, we propose the following specific indicators in figure x. Regarding the Sustainable Development Goals (SDGs), the selected indicators of sustainable development relating mainly to economic growth and circular economy in Portugal are presented in **Annex I**.

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Pillars of Transition	Output indicators	Outcome indicators	Impact indicators
Sustainable Packaging Design	• Number of pilot projects launched to test alternative materials • Number of workshops held on eco-design • Number of standards or certifications developed for circular packaging	• Percentage of packaging produced with alternative materials (biodegradable, compostable, reusable) • Number of companies adopting mono-material packaging • Reduction of virgin plastic used (tons)	• Reduction of CO_2 emissions associated with packaging production (via LCA) • Overall reduction in packaging waste in the region (%) • Increase in recyclability rate of packaging materials (%)
Collaborative Solutions for Key Industry Sectors	• Number of companies per industrial sector of both CSS • Number of collaboration agreements signed in each key industry sectors • Number of digital platforms created for by-product exchange.	• Quantity of waste diverted for collaborative use (tons) • Number of new circular business models implemented	• Reduction in raw material extraction (via LCA) • Increase in regional circularity rate (%)
Industrial Symbiosis	• Number of industrial symbiosis initiatives identified and implemented • Number of companies that incorporate waste into their production process • Number of eco-parks under development	• Amount of resources reused between industries (ton) • Energy recovered through process integration (MWh)	• Reduction of GHG emissions by replacing virgin inputs (ton CO_2 eq.) • Improvement in overall energy efficiency of the industrial symbiosis (%) • Reduction in industrial waste generation (%)

Pillars of Transition	Output indicators	Outcome indicators	Impact indicators
New or Improved Recycling Systems	• Number of strategic plans developed • Number of new recycling facilities installed per sub-region • Number of bio-waste treatment facilities	• Increase in regional plastic recycling rate (%) • Amount of waste treated in recycling facilities (ton) • Amount of compost produced (ton)	• Reduction of waste sent to landfill (ton) • Reduction of GHG emissions associated with disposal (ton CO_2 eq.) • Agricultural area that used organic fertilizers (m^2)
Recycling Solutions for Non-PET Plastics	• Number of pilot projects launched for non-PET plastic recycling • Number of partnerships established with recyclers • Number of innovative recycling technologies tested	• Amount of non-PET plastics diverted from landfill (ton) • Percentage increase in recycling rate for non-PET plastics (%)	• Reduction in CO_2 emissions from avoided incineration or landfill (ton CO_2 eq.). • Increase in recycling efficiency for non-PET plastics (%)
Improvement of Waste Collection Processes	• Number of smart collection points installed • Number of awareness campaigns conducted	• Reduction in contamination levels in recyclables (%) • Increase in regional selective waste collection (%) • Percentage of selective waste collection by sub-region (%)	• Reduction of waste sent to landfill (ton)

Figure 17 Roadmap specific indicators to monitor the identified Circular Systemic Solutions in the Norte Region (Source: CCRI Self-Assessment Tool; adapted from INEGI Roadmap for the Norte Region 2025)

1.4 List of projects implemented in the circular economy area

In recent years, several projects have been and are being funded to promote circular economy in both the food and feed and the plastics and rubber sectors. Here is a non-exhaustive list of projects implemented in the Norte region or at national level by CSS.

1.4.1 List of projects in the food and feed sector

- ANIMAL4AQUA | ERDF | 2016 - 2019
- BioTecNorte | ERDF | 2016 - 2020
- DRECHEVALOR | COMPETE | 2009 - 2010
- GOEFFLUENTS | PDR 2020 | 2017 - 2020
- INSEAFOOD | Portugal 2020
- MICOBIOEXTRACT | ERDF | 2018 - 2022
- MOBFOOD | ERDF | 2017 -2021
- MULTIBIOREFINERY | ERDF | 2017 - 2020
- SPAWNFOAM | ERDF
- SPRAYSAFE | ERDF | 2019 - 2022
- ValorNatural | PDR 2020
- ValorIntegrador | COMPETE | 2014 - 2015
- YPACK10 |

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1.4.2 List of projects in the plastics and rubber sector

- Sustainable Plastics – Green Agenda for Business Innovation under the Recovery and Resilience Plan | ongoing
- Embalagem do Futuro | Recovery and Resilience Plan | 01/01/2022 - 31/12/2025
- BluePoint - Blue Circular Economy of Marine Plastics | Interreg Atlantic Area | 01/11/2023 - 30/04/2026
- SMART PACK - Smart & Eco-efficient Flexible Films | Funding of AICEP | until 2027
- Strengthening the Integrated Approach of Holistic Impact Assessments for Safe and Sustainable by Design Plastic Value Chain | HORIZON-CL4-2023-RESILIENCE-01| 1 January 2024 – 30 June 2027
- Better Plastics: Plastics in a Circular Economy – Mobilising project co-financed by COMPETE 2020 | 2021 – 2023
- 3R Connect - Interconnected Innovation Ecosystems| HORIZON EUROPE | 01/09/2022 -31/08/2024
- INOV.AM – Mobilising innovation in additive manufacturing
- Eco Sustainable Rail | COMPETE 2020 | POCI-01-0247-FEDER-017972 | ended 30 December 2019
- 2GLam - Development of 2nd generation laminates | COMPETE | 01/01/2013 –
- 30/06/2015
- MasterOpak - Development of a high opacity polyethylene masterbatch | COMPETE | Project no. POCI-01-0247-FEDER-017820 | 01/12/2016 - 30/11/2019
- FWFI - New Food Packaging from Nature | COMPETE | Project no. POCI-01-0247-FEDER-048235 | 01/02/2021 - 30/06/2023
- AGRO TEE - Agro Tires Engineered for Efficiency | COMPETE 2020 | 01/07/2017 - 30/06/2019

1.5 Analysis of barriers to implement a circular economy

CCDR-Norte and INL organized two workshops for each CSS with stakeholders (information in the next chapter) to be able to assess the barriers perceived by the participants to implement circular economy in their sectors. These workshops were organized in June and July 2024.

Methodology:

Using the world café methodology and surveys, the stakeholders were asked to ponder on four categories of challenges: 1. Legal Framework; 2. Innovation, product design and the value chain; 3. Infrastructure, investment, entrepreneurship; 4. Social inclusion, awareness and knowledge.

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In the first workshop, the barriers to implementing a circular economy plan for both CSSs in the Norte region were identified for each category of challenges. In the second workshop, stakeholders were asked to rank the challenges identified previously in order of importance and priority for action. For some groups of thematic challenges, new challenges were also identified at the second workshop.

The barriers and challenges for each CSS are presented below by ranking within each challenge category.

1.5.1 Barriers identified for CSS2 – Food and Feed

Challenge 1: Legal framework

- Lack of advice on regulatory aspects - there is a need to create support infrastructures for regulatory advice. There are costs associated with introducing new foods, due to regulation, but the benefits are only felt in 2-3 years. It would be important to have the support from CCDR-N to put pressure on the national government.
- Declassification of waste - many products may not be considered waste, but there is misinformation about what is a product or by-product. Legislation doesn't help in this area.
- Barriers to the use of materials depending on their origin – there is a need for better synergies between the reuse of urban and agricultural waste as there are barriers to the use of materials depending on their origin.
- Increase and enable the introduction of methods that guarantee the end of waste status for biomaterials/waste.
- It is important to legalise the use of materials for monitoring.
- Use of animal by-products – differentiate when they can effectively become waste and when they can still be used for processing. Clarify how organisations that have waste can acquire certifications.
- It's important to emphasise the role of CoLABs (Collaborative Laboratories) in declassifying waste into by-products. CoLABs are authorised by the Portuguese Environment Agency (APA) to help companies with this.
- Tax incentives for donations need to be better disseminated.

Challenge 2: Innovation, product design and the value chain

- Lack of resources to innovate - SMEs with only one person handling many of the organisation's tasks may not be able to innovate.
- Lack of motivation on the part of companies to invest in local/sustainable products.

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- The price factor associated with innovation – there needs to be a shift in paradigm within traditional companies focussed solely on production, with no room for R&D.
- Difficulty in modifying processes based on innovation.
- Traceability within value chains.
- Use of waste for other purposes, such as water treatment or soil treatment.
- Mapping, analysing and understanding the metabolism of cities/regions in order to increase circularity and innovation (crossing of ideas and opportunities).
- Lack of disruptive thinking and the inertia to change.

Challenge 3: Infrastructure, investment, entrepreneurship

- Scale and continuous availability - small companies may not be able to provide the scale and availability of resources to be incorporated into other processes.
- Logistics - supply of circular raw materials, disposal/processing of waste.
- Production seasonality.
- Valorisation of the careers of technicians and researchers.
- Lack of talent - young people don't seem to be attracted to the agri-food sector.
- Lack of resources.
- Infrastructure for gathering waste from various industries.

Challenge 4: Social inclusion, awareness and knowledge

- Lack of consumer literacy - poor consumer awareness of food products made with by-products. Example: beer made from bread waste, or banana bread. There is a need for consumers and future consumers (children and young people) to be made aware of Circular Economy. Waste is seen as lower quality, but it's not, it's just part of the product that isn't used.
- SMEs resistance to innovation - SMEs are used to a linear economy; they don't want to experiment because it represents an additional investment. Companies with policies that integrate innovation can show their success stories in circular economy to smaller companies with fewer resources. There is a need to train companies in circular economy.
- Lack of information among SMEs regarding support for innovation.
- Lack of support to check viability – there is a need for knowledge on how to create business models and feasibility studies. This is especially difficult given that the price of raw materials fluctuates a lot.

1.5.2 Barriers identified for CSS4 – Plastics and Rubber

Challenge 1: Legal framework

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- 100% recyclable packaging - promote the production of 100% recyclable packaging.
- National Strategy for the Circular Economy - consider proposing a national strategy, with stability, that doesn't change with government cycles (4 years), that is aligned with all stakeholders and with the Action Plan for Circular Economy; that is concerted and results in integrated solutions; that integrates waste management, so that materials can be recycled with quality and avoiding a diversion to landfill.
- Incorporating recycled materials into the production system - consider making it compulsory to use recycled materials, across all types of products, whenever appropriate, and there should be supervision to avoid issues associated with greenwashing.
- Energy valorization as opposed to landfill - allow incineration and energy valorization. Invest in energy valorization.
- Management entities for packaging plastics, but also for non-packaging plastics - packaging plastics have associated management entities, but non-packaging plastics are more difficult to organise throughout their life cycle.
- Raising awareness of recycling in society.
- Problems/constraints - compliance with regulations prevents further recovery or reuse. Too much legislation. Need to raise government's awareness on these issues, so that the legislation developed has practical applicability.
- Appropriate technologies for the circularity of specific materials
- Consumer literacy, particularly on the PPP - the Portuguese Pact for Plastics (PPP) is an initiative that brings together the ambition of the value chain to accelerate the transition to a circular economy for plastics in Portugal – recycling, reskilling, reusing, no waste. This initiative brings together companies from different sectors, government entities, NGOs, associations and universities around this common vision – a circular economy for plastics in Portugal.
- Circularity measurement.

Challenge 2: Innovation, product design and the value chain

- Quality of recycled materials - Promote recyclable materials, quality collection, materials with long-term recyclability.
- Eco-design – Importance of promoting eco-design and single-material products (applicable to both packaging and durable products), e.g. bottle design.
- Material passport – a desired reality that emphases the importance of traceability in the value chain. The participation of a variety of representatives from different sources in the plastics (of different types) value chain is key.
- Energy recovery - enabling energy recovery from waste.
- Specificities for the automotive and food industries – these industries have a lot of specificities that need to be considered when defining strategies.
- Sustainable alternatives to plastic - a life cycle analysis of the solutions should be carried out so that the best decisions can be made, keeping the consumer informed.

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- End-of-life of bioplastics - the end-of-life must be considered and weighed, taking into account the existence (or not) of solutions for its treatment - the spectrum of synthetic PET is similar to that of bio-PET, which makes it difficult to separate the different materials in recyclers, causing constraints on recycling.
- Very seasonal agricultural sector - if there is no product to pack, there is no need for boxes; large retailers are opting to rent out vegetable packaging, which is a good practice.
- Approach to Microplastics and Waste: Optimising Production and Recovery in the Plastics Industry - Styrofoam used as a float without protection gives rise to microplastics. Production purges are a complex issue for the plastics industry, as they usually end up in landfill; mixed purges should be avoided by optimising production so that purges of a single polymer are carried out. Different polymers for identical bottles. Solutions for valorising the waste produced.
- Extended Producer Responsibility (EPR) - producer responsibility after the product's useful life.

Challenge 3: Infrastructure, investment, entrepreneurship

- Recyclable polymers - promoting and regulating PET with long-term recyclability.
- Sending waste from the plastic industry to landfill - avoiding diversion to landfill and the associated costs of sending material to landfill, paying for waste disposal, containers and transport, and enabling energy recovery.
- Recycling Industry Cluster - consider promoting contacts with companies that want to use recycled materials, among other issues, for example, the lack of capacity of the rigid plastics recycling industry to absorb more material, due to difficulties in selling out the recycled material.
- Water consumption - treatment of the water required for the process for reuse.
- Market prices - the current price of virgin raw materials is low compared to the price of recycled raw materials; additionally, there is the fluctuating cost-per-tonne.
- EPR

Challenge 4: Social inclusion, awareness and knowledge

- Raise government officials' awareness of these issues, so that the legislation developed has practical applicability.
- Quality of products with recycled materials - promote the dissemination and certification of these products. Waste is seen as lower quality, but it isn't, it's just a part of the product that isn't used. It is difficult to persuade people that products made from recycled materials are of high quality and perform well.

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- Promote use of recycled materials - involve companies that use recycled materials. Regarding waste management, an aligned and concerted strategy must be found so that materials can be recycled with quality and diverted from landfills.
- Recyclability of developed products – know and inform.
- Raise awareness of Circular Economy - informing consumers and future consumers (children, young people).
- Promote links with academia - studying the subject of additives, as many are problematic; The need to study solutions for the valorisation of materials, both technical and complex; The behaviour of recycled raw materials.
- Raise other players' awareness.

1.6 Stakeholder and Supply Value Chain Analysis

Two associations for each one of the CSSs have been identified and engaged to work on the project in close partnership for the realisation of the replication strategy for the Norte region: PortugalFoods for CSS2 and Smart Waste Portugal for CSS4. These associations are active players in the engagement of stakeholders in their respective sectors. Each of them has more than 150 associates nationwide, from both the private and public sector, namely: academia, companies, and municipalities and governmental agencies.

There have been some attempts to map the value chain of the plastics sector. Below are some of the references that have tried to realise this work (Figure 18).

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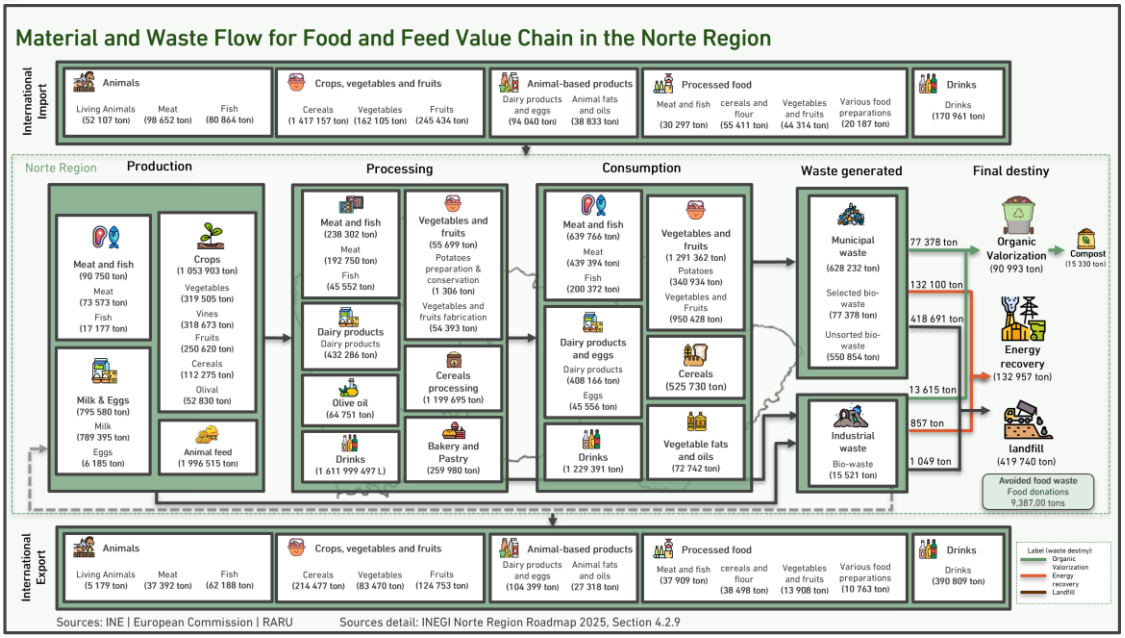

Figure 18 Norte Region consolidated value chain for CSS2. Food & Feed that showcases main material and waste streams. Sources: INE, European Commission, RARU. Adapted by INEGI – Norte Region Roadmap 2025

Regarding stakeholder engagement at various levels of the supply value chain, the following activities have been organised: four workshops (two per CSS) and one seminar for CSS4 (Table 7), and one seminar for CSS2 is being organised. The agenda for both seminars is available on **Annex 2.**

Table 7 - Activities carried out in 2024 and respective stakeholder engagement.

Activities	Number of Participants	Industry	Academia and Research Centres	Public Institutions/ Governmental Agencies
1st workshop CSS2	9	6	3	0
2nd workshop CSS2	8	4	4	0
1st workshop CSS4	13	10	1	1
2nd workshop CSS4	14	10	2	1
CSS4 Seminar	45	23	4	3

Workshops	Number of Registrants	Industry	Other companies	Academia and Research Centres	Public Institutions/ Governmental Agencies	NGO	Others
CSS2	91	6,6%	14,3%	22,0%	23,1%	14,3%	19,8%
CSS2&CSS4	74			30%			

Universities and Research Centres

Several Portuguese Universities and Polytechnic Institutes are in the Norte region:

- Universidade do Minho (UM)

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- Universidade do Porto (UP)
- Universidade de Trás-os-Montes e Alto Douro (UTAD)
- Universidade Católica Portuguesa (UCP)
- Instituto Politécnico de Bragança (IPC)
- Instituto Politécnico do Cávado e do Ave (IPCA)
- Instituto Politécnico do Porto (IPP)
- Instituto Politécnico de Viana do Castelo (IPVC)

Most, if not all, of these institutions have worked on circular economy projects in the agrifood and feed areas, and/or plastics and rubber.
Furthermore, several training courses provided by Portuguese academic, industrial and quality institutions (both in and out of the Norte region), directly or indirectly related to circular economy, have been identified.

Waste management stakeholders

- Urban Waste Treatment

An Urban Waste Management System (Sistema de Gestão de Resíduos Urbanos - SGRU) is a structure prepared to carry out the operations inherent to the management of urban waste. For the integrated management of urban waste and the pursuit of the priorities that have been defined in the legislation, two types of entities have been envisaged: municipalities or associations of municipalities, where the management of the system can be concessioned to any company, and multi-municipal entities, whose systems are managed by concessionary companies. (APA, n.d.)
There are twenty-three SGRUs covering the whole of mainland Portugal, and in the Norte region there are eight SGRUs: Ambisousa, Braval, Lipor, Resíduos do Nordeste, Resinorte, Resulima, Suldouro, and Valorminho. Each of these systems has the infrastructure to ensure a suitable final destination for the waste produced in its area.
These entities ensure the selective collection of the following waste fractions:

- paper/cardboard (packaging and non-packaging) and metal, plastic and glass packaging;
- used cooking oil.

Selective collection is planned for bio-waste (being implemented throughout the country from the beginning of 2024) and textiles, furniture waste and other bulky waste and hazardous waste (estimated for 2025).
Lipor has proven have an active interest in circular economy practices and thus has participated in both workshops for CSS4 and the first workshop for CSS2.
The next step will be to conduct a survey among the SGRUs to assess the waste management practices throughout the Norte region, collect data on some specific indicators and go into detail on the challenges that are identified by these stakeholders.

Non-urban Waste Treatment

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On the other hand, waste that typically results from economic activities is the responsibility of the initial producer of the waste, or its holder if it is impossible to determine the producer of the waste.
Currently only three waste management operators licensed to treat non-urban waste companies in the Norte region (for the concerned sectors) have been identified for the Frontsh1p project, namely: RDUZ, PreZero Portugal, and Veolia. A representative from Veolia has already been engaged and participated in CSS4 workshops and as speaker in a seminar held on December 18th, 2024.
The next step will be to engage other operators and discuss some challenges that have been brought up, such as: scaling up to meet the targets proposed by the EU, take into account the need to separate different types of plastic packaging and how to do this in order to be able to upcycle it later on, among others.

Municipalities
Certain municipalities have already been identified as early-adopters for circular economy and/or green transition practices, such as: Braga, Guimarães, Maia, Porto, and Viana do Castelo. A survey is going to be conducted to assess: (1) the solutions/good practices being implemented in Norte region's municipalities, (2) the challenges and barriers municipalities face, (3) and what is being done concerning citizen awareness.

Citizens
Citizen involvement was carried out in two moments through events to disseminate the project and the CEAP that is being developed in the Norte region:

> Greenfest, Porto, June 28th, 2024: participation in this event took the form of an informative talk on how stakeholders in the Norte region can contribute to developing a Roadmap for Circular Economy, tailored to their identified needs and opportunities.
>
> European Researchers Night, Braga, September 27th, 2024: the aim of taking part in this event was to engage with the public, particularly young students, in activities that on the one hand questioned them about their knowledge on circular economy, and on the other told them about the project and what can be implemented in these areas.

Overview on other important stakeholders
Several food and feed clusters exist in Portugal, recognised by IAPMEI, some of which located in the Norte region. (IAPMEI, 2020)

Portugal has 35 collaborative laboratories accredited by Foundation for Science and Technology (Fundação para a Ciência e Tecnologia - FCT, of which several are directly or indirectly related to the food and feed sectors, and plastic and rubber sectors, and most of them working in the framework of circular economy, located in Norte. (APA, 2023a)

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Interface Centres recognised by the National Agency for Innovation - ANI under the terms of Order no. 8563/2019, of 27th September related to food or feed and located in Norte. Collaborative laboratories accredited by FCT and Interface Centres recognised by ANI are particularly relevant to the country's circular economy. These institutions are authorised to issue a validation declaration for byproducts, to be submitted to the National Environmental Agency (APA – Agência Portuguesa do Ambiente). (APA, 2023b)

Several industrial and agricultural associations exist in Portugal in the food and feed industry, and food retail. Although not specific to the Norte region, all of them involve important players from this region.

Dialogue Council

The assessment on which stakeholders might belong to this committee begun in the early months of working in this project, particularly during meetings with the two associations that have been closely working on the project and that would probably integrate the dialogue council. Throughout the project, and considering the specifications of the sectors in the region, it was considered that the constitution of an official dialogue council (i.e. with legal basis and/or funding) was not feasible. However, a restricted group, including the aforementioned associations, APA and a research centre, which will be presented further on, have become a steering/monitoring committee with the aim of jointly developing and validating the action plans and roadmap that will be presented.

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STAGE II. RESOURCES MISSIONS AND CSSs

2. Stage II: Resources & Missions Selection

In the Norte Region, more than 90 per cent of the territory is occupied by agriculture and forestry and about 82 % of the agricultural production systems that are used are highly susceptible to climate change and consequently the impacts will have a large territorial dimension. The distribution of agricultural species by NUTSIII is not homogeneous, with a

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greater expression in the NUTS Terras de Trás-os-Montes (44%) and Douro (37%), followed by Cávado and Tâmega e Sousa and smallest agricultural area is in the NUTS Alto Minho (19%), (CCDRN, 2021).

The Norte is also one of the most industrialised regions in the country, so, the plastics and rubber sector was defined as a relevant sector with hight impact on this region (CCDRN, 2021).

In line with the analysis in Stage 1 for the replication strategy, to be integrated in the Norte region, the main related sectors are agri-food activities and industries and also plastics and rubber industries.

2.1 CSS Definition

Taking into account to the selection of resources and the Frontsh1p project specifications, the Norte replication plan involves Circular Systemic Solution 2 (CSS2), referring to the valorization of food and feed waste, that will be addressed by the Norte Region in the framework of the Frontsh1p project, and Circular Systemic Solution 4 (CSS4), concerning the valorization of plastics and rubber waste, as a sector also linked to the agrifood and feed industry and also because it is a sector highly represented in the Norte region industry.

CSS2_Food&Feed

Norte has 30% of the food companies in the country and 38% of the beverage companies. With respect to turnover, Norte has 20% of the food industries turnover in the country and 43% of the beverage industries turnover. From the analysis of data, it can be observed that important food, feed and beverage subsectors in Norte are:

- Dairy: only 15% of the dairy companies but 39% of the turnover.
- Beverages: 38% of the companies and 43% of the turnover.
- Cereals, pulses, starches: 27% of the companies and 46% of the turnover.
- Bakery and other flour products: 32% of the companies and 32% of the turnover.

Some important industrial players in the dairy, beverages, cereals and pulses, and bakery and other flour products subsectors in Norte are shown in next figures.

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Figure 19 Key industrial players in the dairy sector in Norte, with main brands and location. List is not exhaustive.

Figure 20 Key industrial players in the beverages sector in Norte, with main brands and location. List is not exhaustive.

Figure 21 Key industrial players in the cereals and pulses sector in Norte, with main brands and location. List not exhaustive.

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Figure 22 Key industrial players in the bakery and other flour products sector in Norte, with main brands and location. List not exhaustive.

Figure 23 - Key industrial players in fishing manufacturing industry in Norte, with main brands and location. List not exhaustive.

Data on animal feeding stuffs production quantities is not available per NUTS II in the national agricultural statistics. However, from indirect data presented for NUTS II (number of companies, turnover, total expenditure and GVA) estimations can be made. When data for Norte is not available, maximum values may be estimated from data for other NUTS II. Norte has 10% of the number of feed producers and ≤12% of the countries' feed production turnover.

The list of manufacturers of animal feedstuffs shows 204 plants with approval numbers (original list from [DGAV, 2024]), classified as:

- Manufacturers of Animal Feed Additives
- Manufacturers of premixes of additives intended for animal feed
- Self-producers of compound feedstuffs
- Compound feed manufacturers

The number of companies is slightly lower, as some companies have two or more plants, and some plants produce more than one type of feed products. Of those feedstuffs' companies,

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only 15 seem to be located in Norte. This data supports the relatively small significance of feed producers in Norte when compared to other NUTS II.

Many feedstuffs' producers deal with animal byproducts. As per Regulation 183/2005, these operators are registered in an information system with DGAV (SIPACE). In addition to those operators accounted for in production of feedstuffs, there are other operators that deal with animal byproducts, but which do not produce feedstuffs. These players may be of importance in terms of circular economy, as they add value to food byproducts. Some of these players are different companies but belong to larger groups that have feedstuff production capacities. The ones identified in SIPACE that were not registered in [DGAV, 2024], located in Norte.

The agrifood and feed sectors are supported by different players, such as clusters, colabs, academic institutions and research institutes, interface institutes and industrial associations.

Clusters

Several food and feed clusters exist in Portugal, recognised by IAPMEI, some of which located in Norte [IAPMEI, 2020] (Figures 24, 25, and 26).

Figure 24 Mission, objectives and data of the Vine and Wine Cluster [IAPMEI, nd-a].

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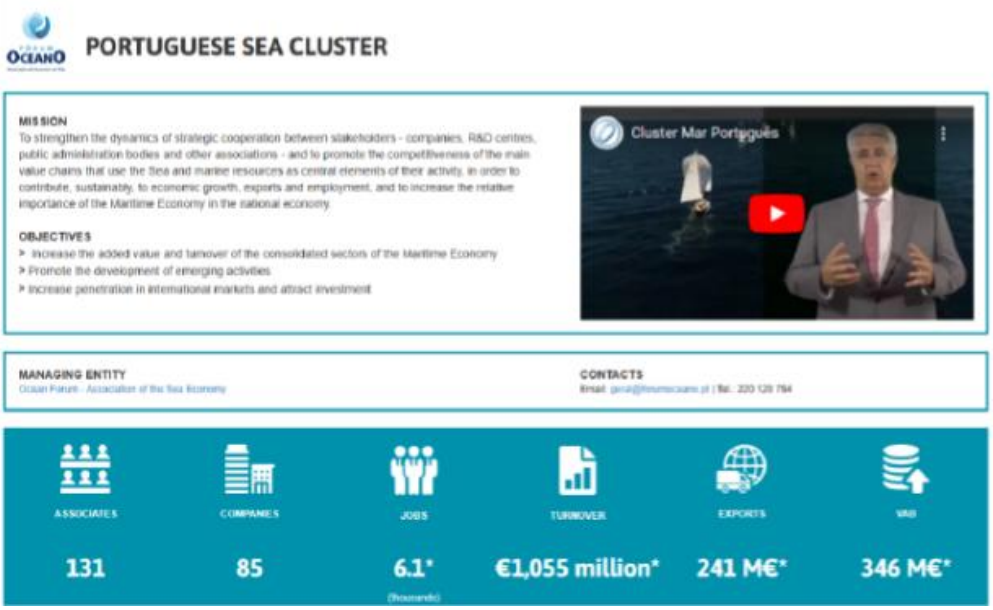

Figure 25 Mission, objectives and data of the Portuguese Sea Cluster [IAPMEI, nd-b].

Figure 26 Mission, objectives and data of the Portuguese Agrofood Cluster [IAPMEI, nd-c].

Interface Centres recognised by National Innovation Agency (ANI) under the terms of Order no. 8563/2019, of 27th September related to food or feed and located in Norte are shown in Figure 27 below.

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	Interface centre	Location
	Waste Recovery Centre	Guimarães, Região Norte
	International Iberian Nanotechnology Laboratory	Braga, Região Norte
	Innovation Centre for Polymer Engineering – one of their areas is packaging, relevant to the food industry.	Guimarães, Região Norte

Figure 27 Interface Centres recognised by ANI in Norte [APA, 2023a].

Collaborative laboratories accredited by FCT and Interface Centres recognised by ANI are particularly relevant to the country's circular economy. These institutions are authorised to issue a validation declaration for byproducts, to be submitted to the National Environmental Agency (APA – Agência Portuguesa do Ambiente) (see [APA, 2023b].

Most, if not all, of these institutions have worked on circular economy projects in the agrifood and feed areas.

Portugal has 35 collaborative laboratories accredited by Fundação para a Ciência e Tecnologia (FCT), of which several are directly or indirectly related to the food and feed sectors, located in Norte [APA, 2023a].

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Colab	How it relates to food or feed	HQ Location	Reference
MORE CoLAB – Montanhas de Investigação	**Bio-based Products and Processes** Valorisation of by-products from agro-industrial and forestry activities, development of natural ingredients for different industrial sectors and branding in the food sector.	Bragança	Morecolab, nd
CoLAB Vines and Wines – Vinha e Vinhos Portugueses, competitividade e sustentabilidade	Led by ADVID, this colab: – Supports the ambition expressed by the sector to increase the export value of Portuguese wines. – Ensures that the Portuguese wine system becomes more efficient, resilient and flexible in order to respond to climate, demographic and economic challenges.	Vila Real	Colabvinesnadwines, 2020
Bioref CoLAB – Laboratório Colaborativo para as Biorrefinarias	Although more in line with the biomass sector (forest), it may work with food and feed byproducts and wastes.	São Mamede de Infesta	Bioref-colab, 2025
CoLab4Food – Laboratório Colaborativo para Inovação na Indústria Alimentar	Colab4Food aims to promote innovation and development (R&D) and knowledge and technology transfer in the agri-food sector through close collaboration between academia and business. Colab4Food also aims to promote the circular economy and food sustainability through by-products valorisation, food waste reduction and new business models.	Vila do Conde	Colab4food, nd
Blue Bioeconomy CoLAB	This colab aims to galvanize and support the three main blue bioeconomy sectors with the highest potential: • Living Marine Resources • Marine Biotechnology • and Sustainable Aquaculture	Matosinhos	B2E, nd

Figure 28 List of collaborative laboratories accredited by FCT, located in Norte, directly or indirectly related to the food and feed sectors [APA, 2023a].

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Several industrial and agricultural associations exist in Portugal in the food and feed industry, and food retail. Although not specific to Region Norte, all of them involve important players from this region.

Figure 29 Agricultural associations from Portugal

In mainland Portugal, 37.71% of municipal waste in 2023 was biowaste: 46.69% biowaste from municipal waste from undifferentiated collection and only 8.17% biowaste from municipal waste from selective collection [APA, 2024]. Of the total biowaste, 27.81% was food waste, 9.01% garden waste and 0.89% other putrescible waste, making up 37.71% of the total municipal waste [APA, 2024]. 8% of urban waste in mainland Portugal in 2023 had composting or anaerobic digestion as its final destination, which confirms the low recovery of biological nutrients in food by-products reported by the Ellen MacArthur Foundation.

In Portugal, the Biomethane Action Plan 2024-2040 was published in Diário da República in March 2024 [Resolução do Conselho de Ministros nº 41/2024]. The Plan argues that the biomethane market should focus on five strategic sectors: urban waste, wastewater, livestock and agro-industry (Figure 8), referring to projects already approved in the agricultural and agro-industrial sector. The potential for using these materials to produce biogas depends on various factors such as the concentration of volatile solids and their biodegradability as an organic substrate: generally, the higher the volatile solids content, the greater the potential for biogas production [Resolução do Conselho de Ministros nº 41/2024].

The excessive presence of nutrients, together with a high nitrogen/carbon ratio, can be an inhibiting factor for the process, affecting its stability and reducing biogas production [Resolução do Conselho de Ministros nº 41/2024]. All these anaerobic digestion feed streams for biomethane production exist in Região Norte:

- Urban waste
- Wastewater
- Livestock effluent - The four municipalities with the highest number of cattle in intensive farming are in Região Norte: Barcelos, Vila do Conde, Póvoa de Varzim and Vila Nova de Famalicão.

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- Agro-industrial effluents - of those considered in the Biomethane Action Plan, Região Norte generates grape and olive pomace, olive oil mill wastewater1 and fruit pulp.
- Agricultural waste - of those considered in the Biomethane Action Plan, Região Norte generates corn residual materials.

The analysis carried out in National Strategy for Agricultural and Agroindustrial Effluents (ENEAPAI) concluded that the biomethane market in Portugal depends mainly on the recovery of agricultural waste and manure and slurry from the livestock sector, which together account for around two thirds of the technical biomethane potential [ENEAPAI 2030].

Taking into account the linearity of the current agrifood system and the need to transition to a more circular economy, respectful of planetary limits and, at the same time, capable of fairly ensuring the essentials for the entire population, a diagnosis was made of Região Norte of Portugal. The diagnosis covered characteristics of the agrifood systems, characteristics of the Region, a SWOT analysis and identification of priority areas for action, in order to draw up an Action Plan for the transition to a circular economy for the agrifood sector. This transition is imperative for the sustainability of systems, companies and human life. It is partially regulated by various instruments at European and national level.

The number of dairy cows in 2019 in Entre-Douro-e-Minho was 34% of Portugal's total (calculated from data from INE [2021a]). he list of existing certified agricultural cooperatives in Região Norte is about 63 organizations, and about 11 the list of producer organizations recognized by the regional authority, DRAP-Norte, to Olive oil, Fruits and vegetables, Cereals, oilseeds and protein crops, including corn, Nuts and Dairy. In addition to fruit and vegetable cooperatives, Região Norte has a number of 7 warehouses and first processing plants.

The stakeholders identified as the most relevant were involved in this project, even though some are not based in the northern region, they were included due to their national relevance.

Primary production

The number of dairy cows in 2019 in Entre-Douro-e-Minho was 34% of Portugal's total (calculated from data from INE [2021a]).

The list of existing certified agricultural cooperatives in Região Norte is shown in Table 8. The list of producer organizations recognized by DRAP-Norte, excluding some cooperatives already shown in Table 8, is shown in Table 9.

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Table 8 List of certified agricultural cooperatives in Região Norte [CCDR-N, 2024a].

Delegation: Trás-os-Montes
Cooperativa Agrícola de Boticas (CAPOLIB) - Boticas
Cooperativa de Ovinos Mirandeses (CHURRACOOP) - Miranda do Douro
Cooperativa de Apicultores do Alto Tâmega (MONTIMEL) -Chaves
Cooperativa dos Produtores de Cabrito de Raça Serrana (CAPRISERRA) - Mirandela
Cooperativa Agrícola Norte Transmontano - Chaves
Cooperativa Agrícola Norteleite - Chaves
Cooperativa dos Produtores de Leite de Cabra Serrana (LEICRAS) - Mirandela
Cooperativa Agrícola de Valpaços (COOPAÇOS) - Valpaços
Cooperativa de Produtores de Cabrito Bravio (ABRAVIA) - Vila Pouca de Aguiar
Cooperativa Agrícola de Vila Pouca de Aguiar - Vila Pouca de Aguiar
Cooperativa Agrícola dos Produtores de Suínos de Raça Bísara de Paredes do Rio (COOPEBISARO) - Montalegre
Delegation: Ave
Adega Cooperativa de Guimarães - Guimarães
Cooperativa dos Agricultores dos Concelhos de Santo Tirso e Trofa - Santo Tirso
Cooperativa Agrícola dos Agricultores de Vieira do Minho - Vieira do Minho
Cooperativa Agrícola de Rações (RACOOP) - Vila Nova de Famalicão
Cooperativa Agrícola de Vila Nova de Famalicão (FRUTIVINHOS) - Vila Nova de Famalicão
União das Adegas Cooperativas da Região dos Vinhos Verdes (VERCOOP) - Santo Tirso
Adega Cooperativa de Santo Tirso e Trofa - Santo Tirso
Delegation: Cávado
Adega Cooperativa de Barcelos - Barcelos
Cooperativa Agrícola de Barcelos - Barcelos
Cooperativa Agrícola de Esposende - Esposende
Cooperativa Agrícola e Leiteira do Concelho da Povoa de Varzim - Póvoa de Varzim
Cooperativa dos Produtores de Leite (LEICARCOOP) - Póvoa de Varzim
Cooperativa Agrícola de Vila do Conde - Vila do Conde
Cooperativa Agrícola de Vila Verde (CAVIVER) - Vila Verde
Delegation: Douro
Adega Cooperativa de Favaios - Alijó
Cooperativa Agrícola (Coopafreixo) - Freixo de Espada à Cinta
Adega Cooperativa de Murça - Murça
Cooperativa Agrícola de Penela da Beira - Penedono

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Centro de Aproveitamento de Subprodutos da Vinificação da Região Demarcada do Douro (SUBVIDOURO) - Peso da Régua
Cooperativa Agrícola de Tabuaço (COOPTAB) - Tabuaço
Cooperativa dos Produtores de Carne de Ovinos Terra Quente (OVITEQ) - Torre de Moncorvo Cooperativa dos Produtores de Leite de Ovinos da Terra Quente (QUEITEQ) - Torre de Moncorvo
Organização de Produtores Agrícolas do Varosa - Tarouca
Cooperativa Prod. de Amêndoa de Torre de Moncorvo (AMÊNDOACOOP) - Torre de Moncorvo
Cooperativa Agrícola dos Produtores Amêndoa de Trás-Os-Montes e Alto Douro (CAPATMAD)
Vila Nova de Foz Côa Cooperativa Agrícola dos Produtores dos Frutos Casca Rija (COAMÊNDOA) - Vila Nova de Foz Côa
Cooperativa de Viticultores e Olivicultores de Freixo de Numão - Vila Nova de Foz Côa
Adega Cooperativa de Freixo de Espada à Cinta - Bragança
Adega Cooperativa de Mesão Frio- Vila Real
Cooperativa Agrícola de Olivicultores de Murça - Vila Real
Cooperativa Agrícola de Távora - Vila Real
Caves Vale do Rodo - Peso da Régua
Delegation: Entre Douro e Vouga
Cooperativa Agrícola de Arouca - Arouca
Agrupamento de Produtores de Bovinos de Carne Arouquesa (CARNAROUQUESA) - Cinfães
Delegation: Minho Lima
Cooperativa Polivalente de Desenvolvimento Rural (VALDELIMA) - Arcos de Valdevez
Adega Cooperativa Regional de Monção - Monção
Adega Cooperativa de Ponte de Lima - Ponte de Lima
Delegation: Nordeste Transmontano
Cooperativa Agrícola de Sabodouro - Mogadouro
Cooperativa Agro-Pecuária Mirandesa - Miranda do Douro
Cooperativa dos Produtores de Mel da Terra Quente e Frutos Secos - Mirandela
Soutos os Cavaleiros - Macedo de Cavaleiros
Cooperativa Agrícola dos Olivicultores de Vila Flor e Ansiães - Vila Flôr
Adega Cooperativa do Rabaçal - Vinhais
Cooperativa Agrícola de Alfândega da Fé - Bragança
Delegation: Tâmega
Cooperativa Agrícola de Basto (COOPERBASTO) - Celorico de Basto

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Terras de Felgueiras, Caves de Felgueiras - Felgueiras
Cooperativa Agrícola de Rega da Lomba - Gondomar
Cooperativa Agrícola de Lousada (COPAGRI) - Lousada
Adega Cooperativa de Paredes - Paredes
Cooperativa Agrícola de Penafiel (COOPENAFIEL) - Penafiel

Table 9 List of Producer organizations recognized by DRAP-Norte, excluding some coops already presented in Table 1 [CCDR-N, 2024b].

Producer Organization	Legal nature	Sector
Olivicultores Valpaços	Cooperative	Olive oil
Kiwi Greensun	Public limited company	Fruits and vegetables
AGROS	Cooperative	Dairy
PROLEITE	Cooperative	Dairy
UCANORTE – União de Cooperativas Agrícolas	Cooperative union	Cereals, oilseeds and protein crops, including corn
Frutas Douro ao Minho	Public limited company	Fruits and vegetables
TOP – Taipina Organização Produtores	Private limited company	Fruits and vegetables
PAM OP	Private limited company	Fruits and vegetables
B-FRUIT	Public limited company	Fruits and vegetables
LCN	Cooperative	Nuts
Leite do Campo	Cooperative	Dairy

In addition to fruit and vegetable cooperatives, Região Norte has several warehouses and first processing plants, some of which shown in Figure 33.

Company/institution	Activity	Main products	Details	Location
Prosa – Produtos e Serviços Agrícolas[2]	Fruit and vegetable warehouse	Kiwi Peach Nectarine Cherry Chayote Lemon	Cold storage capacity 5 000 tons	Marco de Canavezes
KiwiGreenSun[3]	Kiwi warehouse	Kiwi	-	Guimarães
Indumape[4]	Portuguese fruit transformation	Apple Pear Elderberry	Concentrated apple, pear and elderberry juice	Warehouse in Armamar

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			Apple, pear and elderberry aromas	(factory in Pombal)
Régiefrutas[5]	Elderberry processing	Fresh mash and dried elderberries Frozen apples	Generate around 60-70 tons of stalks annually	Tarouca
Alcino Nunes & Irmão[6]	Chestnut's processing and commercializati on of other fruits	Chestnuts (fresh and frozen) Blackberries Figs Strawberries	5 000 toneladas/year of chestnuts	Bragança
AgroAguiar[7]	Processing, freezing and commercializati on of fruit	Chestnuts (peeled or roasted) Deep frozen raspberries, strawberries, blueberries, blackberries, redcurrants, blackcurrants, elderberries, cherries, sour cherries, black figs, plums, etc. Dried fruit		Vila Pouca de Aguiar

Figure 30 Examples of fruit and vegetable warehouses and first processing plants in Região Norte.

SWOT analysis

Based on the diagnosis made and on consultations with stakeholders in the sector in the region (workshop to develop a roadmap for accelerating the Circular Economy in Região Norte of Portugal, on 13/06/2024, promoted by CCDR-N and INL; seminar "Circular Economy in the agrifood sector in Região Norte: Valorization Challenges for Human and Animal Food", on 27/02/2025, co-organized by CCDR-N, INL and PortugalFoods; and other individual consultations with different stakeholders), a SWOT analysis was carried out on the agrifood system in the region. It should be noted that weaknesses, opportunities and threats are not necessarily exclusive to Região Norte.

STRENGTHS

- High number of companies in the agrifood sector: 30% of the number of companies and 20% of the turnover of national food industries in Região Norte.

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- Large and/or prominent companies in various agrifood sectors (e.g., dairy products, wine, beverages, cereals, meat, preserves, retail).
- Native and traditional agricultural crops (e.g., wine, chestnuts).
- Native animal breeds (e.g., Arouquesa, Barrosã, Cachena, Maronesa, Mirandesa and Minhota).
- Various PDO and PGI products in the region.
- Several cooperatives in the region, in various sectors.
- Circular products launched by companies in the region to make use of by-products (e.g., Vieira de Castro's Maria Vieira Moída cookie).
- SONAE MC's pink labels (labels indicating the approaching end of shelf life, with a reduction in the price of products) were pioneering and are an important tool in minimizing food waste in retail.
- SONAE MC's "I'm alone - Take me with you" initiative, which was launched in 2019 and has significantly reduced food waste of bananas, one of the products with the highest in-store losses [Almeida, 2020].
- Entrepreneurship ecosystem in the region, focused on topics such as the circular economy and sustainability, including some start-ups (e.g., AgroGrIN Tech) and initiatives such as the ECOTROPHELIA Prize, promoted in Portugal by PortugalFoods, which aims to develop eco-innovative and sustainable food products by higher education teams.
- Some recent examples of agri-food symbioses in the region (e.g., Tecmafoods; Simplyeast).
- Numerous technical-scientific partner institutions with research and circular economy projects in the region, including universities, polytechnic institutes and collaborative laboratories.
- Urban waste management infrastructures throughout the region, with some selective collection of organics and some organic recovery (albeit limited).
- LIPOR's circular economy projects in the food sector: EMBRULHA, DOSE CERTA, COMPOSTAGEM COMUNITÁRIA and CASEIRA, HORTA À PORTA.
- Urban vegetable gardens in various cities in the region: Porto (4 ha), Braga, etc.
- Some municipalities are promoting home and/or community composting. E.g., Vila Real, Guimarães, municipalities covered by LIPOR.
- Financial support from the EU, PRR, Norte2030 to help the transition to a more circular economy.

WEAKNESSES

- Low rate of recycling/recovery of organic waste.
- Large quantities of organic waste sent to landfills.
- Burning of some organic waste (e.g., pruning wood, stalks) in the fields, without any energy recovery.
- Agricultural dependence on synthetic fertilizers and plant protection products, despite Portugal being one of the Member States with the lowest consumption of synthetic fertilizers.

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- Significant consumption of pesticides in Portugal, in mass per agricultural area (no data specific for Região Norte).
- Low percentage of area under organic farming (far from the European target for 2030).
- Some surface waters in the region contaminated by organic, nutrient and chemical pollution.
- Some degraded soils.
- Geographical dispersion of agrifood production and its co-products/materials.
- Predominance of small companies, without investment capacity and/or with scale limitations for new circular businesses.
- Difficult terrain and long distances in some parts of the region.
- Great heterogeneity in population density.
- Very cheap or free water, with no metered consumption.
- Composting of many agrifood materials is limited by the lack of suitable co-materials at the producer, and by the restriction on transportation and use of these materials classified as waste.
- Lack of literacy among the general public when it comes to healthy and sustainable food.
- Lack of qualified professionals in companies in the areas of R&D&I and sustainability to accelerate and promote the transition to a more circular economy.

OPPORTUNITIES

- Agrifood (organic) materials are inherently circular.
- Increasing food sovereignty in the region.
- Healthy eating as the prevention of disease (and huge costs for society).
- Working on the Circular Economy in the agrifood sector in a comprehensive and integrated way (e.g., considering biodiversity protection and combating invasives, decarbonization, combating pollution, job creation, fostering conditions in the interior of the country, better water management, etc.).
- Main trends in food consumption include sustainability as a vector of choice: Innova Market Insights' Top 10 Trends for 2025 include Plant-Based Food and Climate Adaptation [PortugalFoods, 2025]; Top 10 trends for 2024 included Nurturing Nature; Plant-Based.
- The Rise of Applied Offerings, and Local goes Global [PortugalFoods, 2024].
- Growth in the market for organic, clean label and sustainable products.
- Opportunity to provide healthy and sustainable food in all schools in the region - healthy food per se, food and environmental education, disease prevention.
- Circular procurement (local, seasonal) and short commercial circuits by the public sector - e.g., school canteens – and IPSS.
- Quantifying food waste in public institutions, including schools - measuring and seeing are drivers for change.
- Reducing food waste at all stages of the chain, particularly in the primary sector and in collective catering.

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- Potential for the recovery of organic waste for energy (e.g., anaerobic digestion and biogas production), nutrients (e.g., composting) or other uses (e.g., dyes, enzymes, other high-value compounds).
- European and national targets encourage/oblige the transition to a circular economy.
- "Green water" conservation strategies, especially in the interior of the region.
- Reuse of water treated in wastewater treatment plants for selected agricultural irrigation.
- Positive communication of by-products and waste as something of value: changing the vocabulary.
- Streamline and make more transparent and traceable the processes for declassifying waste products.
- Speed up and facilitate the transportation and composting of organic materials in facilities other than those where they are generated.
- Use the exhaustion of landfills as leverage for the recovery of organic materials.
- Preserve and build fertile soils using organic matter and regenerative agricultural practices.
- Use agriculture to promote biodiversity (multicultures, stratified crops, preservation of insects, birds and amphibians, etc.).
- Changing the mindset: raising awareness and educating producers, and agricultural production schools and universities, about other cultivation methods and regenerative practices.

THREATS

- Climate change and (climate) desertification.
- Legislation preventing certain uses of by-products or agrifood waste, and inertia towards change.
- Demanding regulatory targets and very limited progress towards them in various aspects related to sustainability and the circular economy.
- Lack of clarity and traceability in waste declassification processes.
- Dispersion of agrifood players in terms of size and geography.
- Reluctance of competing players to collaborate.
- Logistical and environmental costs for potential industrial symbioses.
- Perishability of co-products, by-products and agrifood waste.
- Population desertification in the interior.
- Growing difficulty in hiring labour in all sectors, particularly agriculture.
- International competition for various food products.
- Unhealthy eating habits. Chronic non-communicable diseases are one of the most serious public health problems in Portugal, with inadequate eating habits being one of the main modifiable risk factors [Graça et al., 2020]. Poor diet has enormous costs for society, including early mortality, reduced quality of life, decreased productivity and high healthcare costs.

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- Increasing encouragement to reduce consumption of animal products, particularly meat (e.g., the EAT-Lancet diet [Eat Forum, n.d.]; China plans to reduce meat consumption by 50% [Table Debates, n.d.]), which is a threat to the meat sector.

CSS4_Plastics&Rubber

Manufacturing is one economic activity with the high turnover in the Norte region, wich includ the rubber and plastics industry that accounts for about 8.3 % of the manufacturing industry in these Region. It is represented by economic activity code 22, which includes the sub-sectors of rubber and plastic products. Most of national enterprises operating in this sector are located in the northern region, with a total of 533 enterprises, that represent almost 50 per cent of the national total.

When analysing the plastics and rubber sector, it's pertinent to look at waste production in order to find ways to achieve circularity. In the Norte region, a total of 100,787 tonnes of this type of waste was generated in 2023, according to APA data from the MIRR – Integrated Waste Registration Chart.

The total amount of waste generated by the selected European Waste Code (EWC) shows for the plastics and rubber sector, the highest contribution of End-of-life tyres (160103); Plastic packaging (150102); Composite packaging (120105) and Plastic and rubber (191204). Focusing on the NUTS III regions, the three most important wastes in the metropolitan area of Porto are plastic packaging (150102), plastics shavings and turnings (120105) and end-of-life tyres (160103). All these waste subgroups produce more than 10 000 tonnes, which coincide with the NUTSIII with the largest concentration of population and economic activities.

The stakeholders identified as the most relevant were involved in this project, even though some are not based in the northern region, they were included due to their national relevance.

Table 10 Stakeholders identified per value chain

Value chain	***Stakeholders***
Transversal association	Smart Waste Portugal Association
Industry associations	APIP, APICCAPS
Brands	Águas de Monchique, Superbock
Retailers	MC Sonae
Urban waste management systems	LIPOR, Braval, Suldouro, EGF, Resíduos do Nordeste
Waste management companies	Metais Jaime Dias, VEOLIA, Prezero, Grin, Rduz, Euro Separadora

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Polymer supply companies	AGI
Plastics manufacturing companies	Muroplas, RAMAG Plast, Intraplás, CEINOP, PROADEC Portugal, PLASTIRSO, Impact World, Silvex*, Codil, Artevasi, Ernesto S. Simão
Rubber manufacturing companies	Amorim Cork Solutions, Continental
Footwear manufacturing companies	Procalçado
Components for automative industry manufacturing companies	Simoldes, Faurecia, Sunviauto; TMG Automotive
Recycling companies	Ambitamega, Ecoibéria, R3Natura, Globipedestal, Extruplás, Gintegral, Micronipol*, Sirplaste*, Prodelix*, Verde Peculiar
Academia and Research Centres	INL, CeNTI, INEGI, University of Aveiro, University of Porto, University of Minho, UTAD, IPVC, IPB, CICECO, CVR, PIEP, CTCP, IPP
Regional institutions	CCDRn
National institutions	APA e DGAE
Management bodies of specific waste flows.	SPV, Novo Verde, Electrão, Valorpneu
Others	Renewing, Grupo Manuel Champalimaud, ZOR, OLIMEC

However, we are continuing to work on this issue.

This first aproaoch to the SWOT analysis will later be reviewed with the wider project team and validated by the identified stakeholders and future Dialogue Counsil at CTC.

Strenghts

- Strong economic dynamism in the plastics sector, especially in the automotive sector and the footwear sector, where plastic and rubber-based products are widely used;
- Strong industrial profile in the regions of Área Metropolitana do Porto, Ave, Cávado and Tâmega e Sousa, which can foster the creation of industrial symbioses;
- Presence of several universities and research centres with strong relations with companies in the region;
- Good level of infrastructure, particularly the motorway network, which connects the main cities in the region and the borders with Spain.

Weaknesses

- Weak rail network for transporting goods in the region;

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- Lack of collaboration between the different stakeholders in the value chain;
- A large amount of waste from the plastics industry is sent to landfill;
- Difficulty in recovering the purges resulting from the plastics industry's production process, especially in the case of mixed purges;
- Lack of dedicated collection and sorting infrastructures;
- Difficulty in sorting different types of plastics;
- Lack of capacity in the rigid plastics recycling industry to absorb more material, due to difficulties in disposing of recycled material;
- Different formulations of plastics in terms of additives will jeopardise the subsequent transformation of these products;
- While packaging plastics are managed by management bodies, the control of non-packaging plastics throughout their life cycle is more difficult;
- Lack of training and capacity building for employees on circular practices;
- Lack of interest from the producer community (fishing and aquaculture) in preventing the loss of plastics from fishing structures and nets into the environment;
- Difficulty in managing the flow of agricultural plastics.

Opportunities

- Promotion of innovation and the design of new products and monomaterial products;
- Design solutions for the recovery of technical and complex materials;
- Link companies with universities and research centres to leverage new opportunities for innovation in terms of products and processes;
- Investment in chemical recycling solutions that can help recycle some materials that are difficult to recycle mechanically;
- Mandatory incorporation of recycled materials by legislation, guaranteeing adequate supervision to avoid greenwashing practices;
- Implementation of taxes and/or financial incentives to promote recycling;
- Use of digitalisation in processes, such as the adoption of material passports to ensure product traceability throughout the value chain;
- Existence of funding at regional, national and international level to promote the circular economy.

Threats

- Low price of virgin raw materials compared to the price of recycled raw materials;
- Resistance to improving processes, equipment and infrastructure due to high investment;
- Lack of confidence in the performance and quality of products incorporating recycled materials;
- The use of bioplastics can make it difficult to sort materials, causing constraints on recycling;
- Production downturns in the European automotive sector could affect many companies in the plastics and rubber sector in the region.

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Considering the existing information, we continue to work with the stakeholders on applying the basic criteria to help select the main resource missions for the CTC defined by the tool, 4NO Filter:

- Resource area NOT developed
- not yet developed/not used (but should be from the point of view of the circularity of the territory/entity or simply the principles of the circular economy)
- Area of value-added chains NOT closed
- are or could be part of circular value-added chains (but are not yet part of them - because they may not yet exist)
- Area of NO adaptation to climate change
- their use could contribute to adapting the territory/entity to climate change (but they are not yet used)
- Area of NON-convergent activities
- they are not very similar to each other (including in terms of characteristics and potential for use).

A consensus was reached in which it would be advantageous to not only reach out to stakeholders that were already considered an example of best practices but also stakeholders that revealed intention of evolving and allow the project to give them tools for growth. This allowed us to identify rows in the value chain that are not tackled in the Norte Region.

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STAGE III. CHALLENGES

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3. Stage 3: Challenges

At this point, INEGI – Institute of Science and Innovation in Mechanical and Industrial Engineering, a Research and Technology Organisation (RTO), joined the partnership already in place with the two associations, PortugalFoods for CSS2 and Smart Waste Portugal for CSS4 (mentioned above), to contribute to the roadmap for the Norte Region. INEGI brings its expertise in research and technology-based innovation activities, technology transfer, consulting and technological services, oriented to the development of industry and economy in general. INEGI is non-profit, private and recognised as a public utility entity. As this entity manages to cover both sectors, it focused on the final part of the value chain (operators and waste value chain), with a specific focus on monitoring and indicators, and georeferencing of companies.

To be able to formulate the circular challenges from bottom up by different stakeholders' groups, reactive methods such as brainstorming during specific events and individual consultations with various stakeholders were used.

CCDR-N, in partnership with INL and PortugalFoods, organized a workshop dedicated to **CSS2 Food&Feed on June 25th, 2025** entitled **"Food Sovereignty and Circularity in Food Systems".** The aim of this workshop was to validate previously identified challenges and identify practical solutions for building sustainable and circular food systems. We used the Jamboard's sticky notes methodology to interact with stakeholders, cluster ideas, gather group feedback and co-create solutions. For this, we invited participantsto actively contribute by writing down their ideas on their own time during the session.The key aspects to set in place retained from this workshop were as follow:

- A sustained political commitment from local and regional authorities;
- A multidisciplinary strategic vision integrating environmental, economic, social, and territorial dimensions;
- Effective communication and knowledge exchange of proven good practices and transparent learning from less successful experiences;

Scaling initiatives via strategic public procurement to better link urban and rural contexts;Cross-sectoral education and training aimed at community, students, technical professionals and policymakers, to transform food-related behaviours and practices at community and institutional levels.

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Figure 31 Workshop on Food Sovereignty and Circularity in Food System in Porto (June 25th). Stakeholders in the Norte Region gathered for an afternoon of roundtable discussions and ideation on solutions for the circularity of the setor.

As for **CSS4 Plastics&Rubber**, an event entitled **"Circular Economy (CE) in the Plastics and Rubber Sector in Northern Portugal: Challenges, Solutions and Actions"** was co-organized on **July 15th** by CCDR-N, INL and Smart Waste Portugal. The event brought together key stakeholders from the manufacturing and recycling industries, sectoral associations, universities, and research centres from the plastics and rubber value chain. The workshop was divided into two parts:

- The first one was an exercise focused on validating and prioritising the sector's key challenges, which were identified in previous stakeholder consultations: Legal framework and politics (52%) was validated as the main barrier to adopt CE strategies, primarily due the lack of legislation demanding the incorporation of recycled materials into products, followed by Product innovation and value chain (24%), Infrastructure and investment (16%) and Social inclusion and awareness (8%).
- The second one was a brainstorming exercise on concrete measures, identified responsible stakeholders, and determined actionable solutions while assessing their resource needs.

In summary, the **key takeaways from this event for CSS4 Plastics&Rubber** were:

- The type of support that would help implement CE strategies in the plastics and rubber industry sector is an alignment of legal requirements with the sector's needs, followed by effective dialogue with actors.
- The most tangible solutions to replicate within the sector are effective recycling and management, followed by product traceability.
- The key coordinators for implementing CE actions in the region are the Portuguese Agency for the Environment (APA), as well as the government, Companies, and Municipalities.

Good practices for implementing CE solutions within the sector include industrial symbiosis and stakeholder cooperation.

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In addition to this workshop, throughout the project, stakeholders were asked to identify solutions to overcome the barriers initially identified for this sector. The informal discussions and additional interviews resulted in the solutions summarized in Tables XX and XX for the plastics and rubber sector, respectively. Although interesting and with potential, some of these solutions cannot be translated into actions in the plan of action as they are not feasible, for now at least.

Table 11 Solutions identified by the stakeholders for the plastics sector.

Legal and Regulatory Framework
Regulatory/legislative requirement to incorporate post-consumer plastics into product
Survey of the legal framework in other countries with higher recycling rates and verification of applications at national level
Simplify the process of declassifying plastic waste as a product by applying for End-of-Waste Status (EWS)
A platform for waste management and trade that offers tax benefits to compliant businesses.
Innovation, product design and the value chain
Mapping available materials to promote industrial symbiosis.
Increased availability of additives to improve the characteristics of recycled plastics.
Greater application of eco-design in product development.
Establishment of value chains that promote synergy in the circulation of materials between producers and consumers, facilitating the collection of waste for treatment and reintroduction into the process.
Product traceability to facilitate identification of the type of polymer.
Infrastructure, investment, entrepreneurship
Support for the implementation of new technologies through tax incentives.
Marketplace platforms/systems to promote industrial symbiosis.
Improvement of selective collection and sorting equipment for different types of plastics.
Development of stations dedicated to the recovery and recycling (chemical and mechanical) of materials.
Implementation of a regional program to tackle the recycling gap of non-PET plastics in the Norte Region.
Social inclusion, awareness and knowledge
Information on the potential for transforming waste into valuable materials, by raising awareness among the public.
Promoting closer ties between the business community and universities.
Environmental education initiatives in schools and awareness campaigns.
Raising public awareness about recycling processes.

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Table 12 Solutions identified by the stakeholders for the rubber sector.

Legal Framework
Simplification of industrial licensing and streamlining of the waste declassification process.
Publication of the national circular economy action plan (CEAP).
Ensure circularity in opinions/decisions by competent authorities / access to information / Systematisation and registration.
Personalised legal support for businesses.
Innovation, product design and the value chain
Coordination and cooperation across the value chain for mapping resources/waste.
Development and innovation of new products – associated strategies and business models.
Definition of standard methodologies and information requirements to be integrated into the digital product passport.
Infrastructure, investment, entrepreneurship
Investment in pilot units for pre-industrial validation.
Identification of specific waste management circuits.
Training, research and provision of infrastructure to develop new products and processes.
Social inclusion, awareness and knowledge
Creation of support centres for rubber sub-sectors.
Awareness raising in schools.
Partnerships between industries and universities, technology centres and laboratories.

Figure 31 Figure 31 Workshop on Circular Economy for the Plastics & Rubber: Challenges, Solutions and Actions held in CCDR-NORTE headquarters in Porto (July 15th).

Lastly, on **July 30th, 2025**, an event entitled "**Waste management and Circular Systemic Solutions**" was co-organized by CCDR-N, INL and INEGI, with the collaboration of PortugalFoods and Smart Waste Portugal, to engage stakeholders and build momentum for co-designing practical measures to improve sustainability in industrial and urban waste streams in the Norte Region of Portugal, tackling both CSS2 and CSS4. In a pre-event survey of 74 registrants, top barriers identified included: Inconsistent waste management (54.1%), Low consumer awareness (31.1%), Financial constraints (27%), Infrastructure gaps (25.7%), Limited technical knowledge (24.3%), and Market access challenges (16.2%). A roundtable discussion was held to with stakeholders from different industries, i.e. wine production,

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waste management, plastic recycling, academia/research center, and **five strategic opportunities** were identified:

- Cork stopper collection and valorisation (relevant to the wine sector);
- Synergies between waste producers and valorisation industries (e.g., biomass from wine production);
- Reimagining waste collection systems (e.g. more adaptive systems based on waste type and frequency);
- Promoting conscious consumption (e.g. to reduce unnecessary waste and pressure on urban infrastructure);
- Attracting Investment in Waste Valorisation (e.g. turning waste into resources and stimulating green jobs).

During the second part of the workshop participants formed five working groups, split by sector and waste type (industrial or urban), to come up with actionable strategies, such as:

Working Group	**Systemic Circular Solutions**
Group 1 | Industrial Waste – Food and Feed	• Creation of working groups for key sectors in food & feed focused on developing the Circular Economy. • Legislative simplification – Current legislation is overly complex and restrictive, hindering companies from integrating waste as by-products and implementing new business models.
Group 2 | Industrial Waste – Plastic and Rubber	• Development of solutions for non-PET plastics currently overlooked compared to PET. • Promotion of resource creation. • Development of solutions enabling energy recovery. • Improve waste segregation at source (citizens). • Amend legislation to benefit (via tax incentives) companies achieving a minimum level of recycled content. • Develop and boost investment in new recycling systems (e.g. chemical) for critical plastics. Explore private investment by value chain organisations. • Facilitate the process to end the status of Waste (waste declassification). • Invest in ecodesign, particularly in creating monomaterial products, addressing the current proliferation of mixed materials with recycling challenges.
Group 3 | Industrial Waste – Plastic and Rubber	• Apply taxes to users of virgin products. • Intelligent ecodesign avoiding multimaterial products, designed for reuse and/or recycling. • Establish an entity to connect regulatory bodies (e.g. APA) and industry. • Bring closer the entities developing legislation and industry through

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	a dedicated communication entity. • Streamline bureaucratic processes, as companies currently face delays in receiving necessary responses.
Group 4 | Municipal Waste – Food and Feed	• Promote consumer literacy regarding waste segregation. • Study logistics infrastructure for biowaste collection and identify optimisation opportunities. • Focus on ecodesign, eliminating mixed materials.
Group 5 | Municipal Waste – Plastic and Rubber	• Promote industrial symbiosis. • Implement incentives for entities integrating recycled materials and fines for those favouring virgin raw materials. • Ensure better quality municipal services for residents.

Figure 32 Last workshop of the Norte Region on the cross-cutting topic of "Waste management and Circular Systemic Solutions" for both the Food & Feed and the Plastics & Rubber sectors.

The agenda for these workshops is available on **Annex 2**.
An analysis on the participation in these workshops by participant typology is presented in table 13.

Table 13 Stakeholder engagement in the workshops and seminars

Workshops	Number of Registrants	Public Authorities	Industry/ Companies	Academy/ Research	NGO/ Associations	Civil Society/ Consumers
February 27th 2025	149	24.8%	29.5%	32.2%	8%	5.4%
June 25th 2025	91	24.7%	22.4%	22.5%	15.3%	14.1%
July 15th 2025	46	10.0%	66.7%	16.7%	6.7%	0
July 30th 2025	74	17.5%	54.0%	19.0%	6.3%	3.2%
October 14th 2025	111	19.8%	21.6%	41.4%	9.0%	8,1%

Circular Challenges:
The tables below describe the challenges identified in Norte Region for CSS2 and CSS4:

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Table 14 CSS2 Food and Feed Challenges

CSS 2 Food and Feed
Legal and Regulatory Framework
Systematic measurement and public reporting of food waste in school and institutional canteens.
Establish a stable, independent, and technically capable governance structure.
Condition and direct public funding.
Correct institutional dysfunctions.
Innovation, product design and the value chain
Create a regional network of proximity markets and short agrifood supply chains.
Integrate local, organic, and seasonal products in school and institutional canteens.
Stimulate partnerships between producers, consumers, and local entities for community-supported agriculture (CSA).
Promote regenerative agriculture and agroecology.
Increase the production and consumption of organic products.
Create (and maintain) regional land banks.
Promote the diversification of crops and species and its valorisation.
Sustainable management of agricultural water.
Prevention of food waste by redirecting all edible food to human consumption.
Infrastructure, investment, entrepreneurship
Support family farming.
Reactivate or replace local experimental stations.
Promote soil health and preservation.
Selective Collection and Valorisation of Biowaste.
Facilitation of Agrifood Symbiosis.
Promote practical cooperation between companies, research centres, and municipalities/CIMs/GALs to jointly develop replicable and economically sustainable circular solutions.
Social inclusion, awareness and knowledge
Boost food donation and redistribution networks.
Systematize and disseminate information on Sustainable and Territorialized Food Systems.
Create urban-rural intermunicipal communities.
Provide ongoing and practical training for farmers.
Encourage the consumption of “ugly” fruits and vegetables across all channels (retail, food services, social institutions).
Training programme in Circular Economy and Sustainability for technical staff in the Northern Region.
Education and awareness in school settings.
Capacity-building for food system actors.

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Production and sharing of practical knowledge.
Valuing the primary sector and local knowledge.
Institutional learning and long-term vision.

CSS4_Plastics&Rubber

Table 15 CSS4 Challenges in the plastics and rubber sector

CSS 4 Plastics and Rubber
Legal and Regulatory Framework
Preparation of a study to survey the legal framework of countries with the highest recycling rates and analysis of possible replicas at the national level.
Preparation of a study to analyse the impact of implementing specific regulatory and fiscal instruments, defining appropriate oversight mechanisms
Preparation of recommendations on simplifying waste declassification and licensing processes.
Preparation of specific recommendations on end-of-life management strategies for bioplastics and microplastics
Advocacy actions on the challenges of implementing environmental regulations
Holding information sessions on the relevant legal framework in the context of the circular economy
Creation of an office for personalised legal support to companies
Innovation, product design and the value chain
Preparation of a study mapping the materials available in the plastics and rubber sector to promote industrial symbiosis in the Norte region
Creation of new specific waste streams, namely composite and multi-material products
Creation of a working group to define standard methodologies and information requirements to be included in the digital product passport
Identification of existing eco-design tools for the development of new products
Creation of solutions that extend the useful life of materials (e.g. reuse, repair, refill, sharing)
Infrastructure, investment, entrepreneurship
Carrying out B2B networking activities on waste recovery
Establishment of consortia for the development of new solutions, such as additives, to improve the characteristics of recycled plastics
Establishment of consortia to increase the recyclability of PETmaterial
Investment in pilot units for the development of new circular products and processes for pre- industrial validation
Investment in equipment and improvement of selective collection and sorting processes for different types of plastic
Social inclusion, awareness and knowledge

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Development of awareness-raising actions on reducing consumption and on the potential for recovering waste in new products
Implementation of actions to raise awareness and encourage the use of platforms for waste management/trade
Creation of a repository of best practices in circular economy in the plastics and rubber sectors (e.g. agriculture, retail, automotive, etc.)
Development of training activities for professionals on the circular economy (eco-design practices, certification and reporting tools, etc.)

As previously stated, in the Norte Region, there is an overlap between the two sectors, and thus it made sense to conduct a cross-sectional analysis with proposals involving both CSSs. This analysis is presented below.

Table 16 Circular Challenges for both CSS2 and CSS4

CSS 2 & CSS 4
Legal Framework
Encourage Adoption of Sustainable Packaging through Policy and Market Incentives.
Innovation, product design and the value chain
Transitioning to Circular Packaging. Industrial Symbiosis for Circular Value Chains.
Infrastructure, investment, entrepreneurship
Optimisation of Regional Recycling Infrastructure. Implementation of Waste-to-Energy Solutions.
Social inclusion, awareness and knowledge
Working Groups for Collaborative Solutions Optimization of Urban and Rural Waste Collection. Enhanced Visibility for Circular Materials and access to comprehensive data on waste and material flows.

In addition to identifying circular challenges, these workshops, together with individual and small group interviews, also helped to pinpoint the solutions that will be presented in phase 4.

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Stage IV. Action Plan

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4. Circular Economy Action Plan for Norte Region - CircuPuncture Action Plan

4.1 Background

This section presents the Action Plan for the Circular Economy in the Food and feed and Plastics and rubber sectors in the Norte Region. Based on the diagnosis of the region and the stakeholders' consultation, it identifies the objectives, measures and actions, as well as those responsible for its implementation. As portrayed in the stage III, given the specificities of the region and the sectors, three action plans are developed: an Action Plan for CSS2, an Action Plan for CSS4 and an Action Plan with cross-sectional actions that tackle both CSS2 and CSS4.

General Objective

Promote the transition to a circular economy in the Food and feed and Plastics and rubber sectors in the north of Portugal by coordinating with the current regulatory framework, strengthening innovation, investment, training and governance, and increasing resource efficiency to create new business models and strengthen regional competitiveness.

Specific Objectives:

- Ensure a clear and simplified legal framework that supports companies and entities in adopting circular practices.
- Foster the development of new products, processes and business models through eco-design, circular supply chains and industrial symbiosis.
- Strengthen cooperation between stakeholders and support investments in technologies, infrastructure and entrepreneurial initiatives that accelerate circularity.
- Mobilise consumers and train professionals in more sustainable practices through awareness-raising, the dissemination of good practice and specialised training in the circular economy.
- Ensure the effective governance of the Action Plan through monitoring, continuous evaluation and the involvement of key stakeholders.

The measures and actions set out in these Action Plans are presented in the following sections. Also presented are suggestions for responsible entities, examples of funding sources, the target audience, action monitoring indicators and the time frame.

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Figure 33 Final event of the Norte Region. The final seminar took place at INL, Braga (Oct 14th) and mobilized over 100 stakeholders, including exhibitors showcasing circularity practices and models within their own professional activities

Lastly, on October 14th, CCDR-NORTE hosted the final seminar of the FRONTSH1P project at INL. The event entitled "From the Agri-food Sector to the Plastics Sector: Food Sovereignty and Circularity" marked the end of the project with the presentation of the action plans. It brought together representatives from public institutions (20%), businesses (22%), research institutions (41%), professional associations (9%) and civil society (8%). Discussions centred on the FRONTSH1P project's contributions to territorial sustainability and regeneration actions for the agri-food, feed, plastics, and rubber value chains. This was an opportunity to present the results to the relevant regional and national authorities. It was also a space to raise questions for future research and lead to new possibilities.

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4.2 Action Plan for CSS2

Legal and Regulatory Framework

Measures	Actions	Responsible Entities	Time frame
1. Sustainable and Territorialized Food Systems	Systematic measurement and public reporting of food waste in school and institutional canteens	Schools, ABAAE, Eco-School coordinators, school headmasters, kitchen staff	Medium-term
2. Governance, Policy and Funding	Establish a stable, independent, and technically capable governance structure: appoint a regional coordinator responsible for the implementation and monitoring of the plan and promote the development of simple yet concrete municipal and regional circular economy plans, adapting this action plan to local realities and integrating the most relevant indicators and target.	CCDR-N, municipalities, CIMs, GALs, Ministry of Agriculture, Ministry of Environment, Directorate-General for Local Authorities, producer associations and cooperatives, universities and research centres, Court of Auditors, oversight bodies	Short-term
	Condition and direct public funding: implement agile, accessible, and proportional financial mechanisms, including sustainability, replicability, and public resource efficiency as key criteria in the allocation of public funds.	CCDR-N, ANI, PEPAC, COMPETE	Short-term
	Correct institutional dysfunctions: map and eliminate overlapping competencies among entities and assign clear responsibilities proportional to the available funding.	CCDR-N, CIMs, GALs, municipalities, parish councils	Short-term Medium-term

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Innovation, product design and the value chain

Measures	Actions	Responsible Entities	Time frame
Sustainable and Territorialized Food Systems	Create a regional network of proximity markets and short agrifood supply chains: provide suitable spaces for local product distribution pop-up fresh markets and foster regular dialogue between supply and demand.	Municipalities, Intermunicipal Communities (CIMs), Local Action Groups (GALs) e producer associations	Short-term
	Integrate local, organic, and seasonal products in school and institutional canteens.	Municipalities, parish councils, schools, social institutions (IPSS), CCDR-N, nutritionists	Medium-term
	Stimulate partnerships between producers, consumers, and local entities for community-supported agriculture (CSA)	Municipalities, CIMs, GALs, producer associations, cooperatives	Short-term
Sustainable and Regenerative Agrifood Production	Promote regenerative agriculture and agroecology.	DGADR, Regional Agricultural Directorates, GALs, producers, cooperatives, agricultural training institutions	Medium-term Long-term
	Increase the production and consumption of organic products: expand organic farming areas by modifying PEPAC rules to allow annual applications (instead of 3-year cycles) and introduce partial inclusion of organic fruit and vegetables in public procurement.	DGADR, Ministry of Agriculture, CCDR-N, CIMs, GALs	Short-term Medium-term
	Create (and maintain) regional land banks using common lands and underutilized public lands, as well as partnerships with private landowners	Municipalities, CIMs, GALs	Short-term Medium-term
	Promote the diversification of crops and species, both in production and consumption: preserve and propagate autochthonous varieties in cooperation with local producers, the Portuguese Germplasm Bank, and municipal nurseries, while promoting R&D projects on the behaviour of native species and varieties.	NIAV, Germplasm Bank, Municipalities, GALs, agricultural institutions, cooperatives, farmers, universities, ICNF	Short-term Medium-term
	Sustainable management of agricultural water: improve water management through borehole monitoring, consumption metering, and proportional tariffs, as well as support reuse of treated wastewater for irrigation.	DGADR, Municipalities, CIMs, GALs, Regional Agricultural Directorates	Short-term
Circular Economy and Resource Management	Prevention of food waste by redirecting all edible food to human consumption.	APA, SGRUs, CCDR-N, APED, retailers, municipalities, IPSS	Short-term

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Infrastructure, investment, entrepreneurship

Measures	Actions	Responsible Entities	Time frame
Sustainable and Regenerative Agrifood Production	Support family farming: support and implement the Family Farming Statute, ensuring better living conditions, technical support, and institutional recognition and value the farming profession.	Ministry of Agriculture, DGADR, Regional Agricultural Directorates, Municipalities, CIMs, Employment Centres, IPSS	Short-term Medium-term Long-term
	Reactivate or replace local experimental stations.	CCDR-N, DGADR, Ministry of Agriculture, Agricultural Schools, Universities	Medium-term
	Promote soil health and preservation through promotion of good agricultural practices through training and recover of degraded areas through revegetation, nutrient and pH correction, and organic matter incorporation.	DGADR, CIMs, GALs, GPP, farmer support institutions, PEPAC, ICNF	Medium-term
Circular Economy and Resource Management	Selective Collection and Valorisation of Biowaste.	APA, SGRUs, research labs, municipalities, private waste operators, Smart Waste Portugal, universities, R&D centres	Short-term Medium-term
	Facilitation of Agrifood Symbiosis by using existing digital platforms to promote resource exchanges and identifying and activating regional biowaste streams with high circular valorisation potential.	CCDR-N, APA, Ministry of Environment, Ministry of Agriculture, municipalities, parish councils, CIMs, GALs, SGRUs, private waste managers, farmers, food industry	Short-term
Capacity Building, Innovation, and Circular Food Citizenship	Promote practical cooperation between companies, research centres, and municipalities/CIMs/GALs to jointly develop replicable and economically sustainable circular solutions.	CCDR-N, CIMs, GALs, universities, institutes, colabs	Short-term

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Social inclusion, awareness and knowledge

Measures	Actions	Responsible Entities	Time frame
Sustainable and Territorialized Food Systems	Boost food donation and redistribution networks.	Parish councils, municipalities, IPSS, redistribution institutions	Short-term
	Systematize and disseminate information on Sustainable and Territorialized Food Systems.	CCDR-N, circular city networks, schools, municipalities	Short-term
	Create urban-rural intermunicipal communities.	CCDR-N, CIMs	Medium-term
Sustainable and Regenerative Agrifood Production	Provide ongoing and practical training for farmers.	DGADR, Regional Agricultural Directorates, GALs, producers, cooperatives, agricultural training institutions	Medium-term Long-term
Circular Economy and Resource Management	Encourage the consumption of "ugly" fruits and vegetables across all channels (retail, food services, social institutions).	APA, SGRUs, CCDR-N, APED, retailers, municipalities, IPSS	Short-term
Capacity Building, Innovation, and Circular Food Citizenship	Training programme in Circular Economy and Sustainability for technical staff in the Northern Region.	CCDR-N	Short-term
	Education and awareness in school settings.	Ministry of Education, DGE, Regional Education Directorates, School Clusters, Agricultural Schools, Higher Education Institutions	Short-term Medium-term
	Capacity-building for food system actors through development of modular training programmes in (agrifood) circular economy.	Vocational training entities, universities, CCDR-N, CIMs, GALs	Short-term
	Production and sharing of practical knowledge, such as the results of the project, good practices and outcomes of funded projects, and organise an annual sustainability forum for all stakeholders from the Northern Region.	CCDR-N, funding bodies, municipalities, universities, CIMs, GALs	Short-term Medium-term Long-term
	Valuing the primary sector and local knowledge from the earliest levels of education, also by fostering intergenerational relationships between IPSS and local schools through knowledge sharing and practical workshops in agriculture, beekeeping, and cooking — for the benefit of both younger and older generations.	CCDR-N, IPSS, municipalities, parish councils, school clusters, community gardens, NGOs	Short-term Medium-term Long-term
Governance, Policy and Funding	Institutional learning and long-term vision: develop a public monitoring platform for the plan, with updated indicators, reports, and best practices, as well as hold annual stakeholder meetings to review progress, define next steps, scale what works, and correct what doesn't.	CCDR-N, advisory council	Short-term Medium-term Long-term

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4.3 Action Plan for CSS4

Legal and Regulatory Framework

Measures	Actions	Responsible Entities	Target audience	Time frame
1. Knowledge creation and policy recommendations to support decision-making	1.1 Preparation of a study to survey the legal framework of countries with the highest recycling rates and analysis of possible replicas at the national level.	APA; CCDR-N; Associations	APA; Government; Manufacturing industry; Waste management operators	Short-term
	1.2 Preparation of a study to analyse the impact of implementing specific regulatory and fiscal instruments, defining appropriate oversight mechanisms	APA; CCDR-N; Associations	APA; Government; Manufacturing industry; Waste Management operators	Medium-term
	1.3 Preparation of recommendations on simplifying waste declassification and licensing processes	Associations Licensing bodies	APA; Government; Licensing bodies; Companies	Short-term
	1.4 Preparation of specific recommendations on end-of-life management strategies for bioplastics and microplastics	Academia; recycling industry.	APA; Government	Short-term Medium-term
	1.5 Advocacy actions on the challenges of implementing environmental regulations	Associations	MEPs; APA; government	Short-term Medium-term
2. Strength of support and clarification for companies in applying the legal framework	2.1 Holding information sessions on the relevant legal framework in the context of the circular economy	APA; CCDR-N; Associations	Manufacturing industry; Universities; Research Centres; Companies	Short-term Medium-term
	2.2 Creation of an office for personalised legal support to companies	APA; CCDR-N; Associations	Companies	Short-term Medium-term

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Innovation, Product Design and Value Chain

Measures	Actions	Responsible Entities	Target audience	Time frame
3. Creation of knowledge and development of resources necessary for the implementation of circular strategies	3.1 Preparation of a study mapping the materials available in the plastics and rubber sector to promote industrial symbiosis in the Norte Region	CCDR-N; Associations	Manufacturing and Recycling Industry; Universities and Research Centres	Short-term
	3.2 Creation of new specific waste streams, namely composite and multi-material products	APA; Associations	Industry; Distribution; Retailers; PRO	Short-term
	3.3 Creation of a working group to define standard methodologies and information requirements to be included in the digital product passport	IAPMEI; Associations	Industry; Distribution; Retailers; PRO	Medium-term Long-term
4. Promotion of circularity through eco-design and repair and reuse solutions	4.1 Identification of existing eco-design tools for the development of new products	Companies; ENESII	Manufacturing industry	Medium-term Long-term
	4.2 Creation of solutions that extend the useful life of materials (e.g. reuse, repair, refill, sharing)	Municipalities; Companies; Recycling Companies	Industry; Consumers	Medium-term Long-term

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Infrastructure, investment, entrepreneurship

Measures	Actions	Responsible Entities	Target audience	Time frame
5. Strength of collaboration between different stakeholders through the establishment of consortia	5.1 Carrying out B2B networking activities on waste recovery	CCDR-N; Associations	Manufacturing industry;	Medium-term Long-term
	5.2 Establishment of consortia for the development of new solutions, such as additives, to improve the characteristics of recycled plastics	Universities; Research Centres; Industry	Industry	Medium-term Long-term
	5.3 Establishment of consortia to increase the recyclability of PET material	Universities; Research Centres; Industry	PRO; Universities; Research Centres; Companies	Medium-term Long-term
6. Increased investment in developing new Products, technologies and processes based on the circular economy.	6.1 Investment in pilot units for the development of new circular products and processes for pre-industrial validation	Academia; Research Centres and Companies	Industry	Medium-term Long-term
	6.2 Investment in equipment and improvement of selective collection and sorting processes for different types of plastic	Urban waste management Systems; Municipalities; Research Centres; Companies	Urban waste management systems; Municipalities; Consumers	Medium-term Long-term

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Social inclusion, awareness and knowledge

Measures	Actions	Responsible Entities	Funding	Target audience	Indicators	Time frame
7. Public engagement and behavioural change	7.1 Development of awareness-raising actions on reducing consumption and on the potential for recovering waste in new products	APA; Municipalities; Associations; Urban waste management system	Internal financial resources	Consumers; Companies	No. of municipalities where actions were carried out	2026-2030
8. Strength of the technical capacity of professionals in the plastics and rubber sectors	8.1 Implementation of actions to raise awareness and encourage the use of platforms for waste management/trade	ASWP; Other entities with waste management/trading platforms	Internal financial resources	Industry	No. of actions taken	2026-2030
	8.2 Creation of a repository of best practices in circular economy in the plastics and rubber sectors (e.g. agriculture, retail, automotive, etc.)	CCDR-N, Associations	Internal financial	Industry resources	Repository published No. of best practices included in the repository	2026-2030
	8.3 Development of training activities for professionals on the circular economy (eco-design practices, certification and reporting tools, etc.)	Associations, companies, training institutions, universities	Internal financial	Companies' resources	No. of training courses developed	2026-2030

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In addition to the other 4 categories of challenges, it was esteemed that a new one should be created to represent a category of challenges that address the governance.

Institutional

Measures	Actions	Responsible Entities	Funding	Target audience	Indicators	Time frame
9. Monitoring the implementation of the Action Plan	9.1 Definition of the governance model for the Action Plan	CCDR-N; Associations	Internal financial resources	CCDR-N; Associations; Monitoring Committee.	Governance model defined	2025
	9.2 Establishment of a committee to monitor the actions implemented under the Action Plan	CCDR-N; Associations	Internal financial resources	CCDR-N; Associations Companies	Monitoring Committee established	2026-2030
	9.3 Holding meetings to monitor the implementation of the Action Plan	Monitoring Committee	Internal financial resources	Monitoring Committee	No. of meetings held	2026-2030
10. Monitoring and Evaluation of the Action Plan	10.1 Creation and implementation of monitoring tool	Monitoring Committee	Internal financial resources	Monitoring Committee	Monitoring tool created and implemented	2026 - 2030
	10.2 External evaluation of the implementation of the Action Plan	Monitoring Committee	Internal financial resources	Monitoring Committee	External evaluation report published	2030

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4.4 Action Plan for cross-section collaboration

Legal and Regulatory Framework

Measures	Actions	Key Actors	Time frame
1. Efficient Regulatory Pathways for Waste Management	1.1 Map Regulatory Barriers and Bottlenecks: Conduct a thorough review of current waste management legislation, permitting processes, and administrative procedures.	Public administration Municipalities Research centres and universities	Short-term
	1.2 Develop Updated Guidelines and Simplified Procedures: Engage policymakers, municipalities, industries, and legal experts to design updated regulatory guidelines and streamlined procedures	Public administration Municipalities Research centres and universities	Short-term Medium-term
	1.3 Pilot and Implement Regulatory Reforms: Test new procedures in selected municipalities or sectors, monitor effectiveness, gather feedback from stakeholders, and scale successful approaches regionally.	Public administration Municipalities Research centres and universities	Long-term

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Innovation, product design and the value chain

Measures	Actions	Key Actors	Time frame
2. Transitioning to Circular Packaging	2.1 Launch Initiative and Define Priorities: Identify critical challenges, such as multi-material packaging, and set the basis for targeted eco-design strategies.	Industry Research centres and universities	Short-term
	2.2 Co-define Eco-Design Guidelines: Work with packaging producers, food and beverage industries, and research institutions to co-create regional eco-design guidelines. These focus on mono-material solutions, reduced material use, and full compatibility with recycling streams. Training and awareness sessions support early adoption.	Industry Research centres and universities	Medium-term Long-term
	2.3 Support Innovation and Pilot Alternative Materials: Foster R&D and collaborative pilots with universities, technology centres, and industrial partners to test biodegradable, compostable, or reusable packaging.	Industry Research centres and universities	Medium-term
	2.4. Adopt Standards and Scale Solutions: Turn guidelines and pilot results into regional standards and incentives	Industry Research centres and universities	Long-term
3. Industrial Symbiosis for Circular Value Chains	3.1 Map Industrial Flows and Identify Collaboration Opportunities: Engage industries, research centres, and municipal authorities to map residual streams, identify potential synergies, and prioritize high-impact exchange opportunities across plastics, rubber, and agro-food sectors	Industry, Waste operators Research center and universities	Short-term Medium-term
	3.2 Identify and Prioritize Synergies: Using mapping results, potential resource exchanges are analysed and prioritized based on impact and feasibility.	Industry, Waste operators Research center and universities	Short-term
	3.3 Establish Industrial Symbiosis Networks and Coordination Platforms: Create working groups or regional platforms to facilitate partnerships, define roles, and provide governance structures for pilot exchanges,	Industry, Waste operators Research center and universities	Medium-term
	3.4 Pilot, Monitor, and Scale Resource Exchange Programs: Implement pilot projects for selected industrial symbiosis opportunities, monitor results in terms of waste reduction, resource efficiency, and economic benefits, and develop strategies for scaling successful models across the region.	Industry, Waste operators Research center and universities	Medium-term Long-term

Infrastructure, investment, entrepreneurship

Measures	Actions	Key Actors	Time frame
4. Optimisation of Regional Recycling Infrastructure	4.1 Comprehensive Assessment of Existing Facilities and Material Flows: Analyse current recycling infrastructure and map material flows for plastics, rubber, and agro-food residues, identifying capacity gaps, technological limitations, and contamination issues to guide future improvements.	Municipalities Waste operators Research centres and universities	Short-term
	4.2 Strategic Planning and Stakeholder Coordination: Bring together municipalities, waste operators, industrial partners, and research centres to develop a coordinated plan for optimizing regional recycling infrastructure. Define investment priorities, governance structures, operational standards, and collaboration mechanisms to ensure that upgraded or new facilities are aligned with market demand, regulatory frameworks, and circular economy goals.	Municipalities Waste operators Research centres and universities	Short-term Medium-term
	4.3 Pilot Implementation and Scaling of Optimized Systems: Deploy pilot projects to test new or upgraded recycling technologies, monitor performance, and scale the most effective solutions across the region to maximize resource recovery and support circular practices.	Municipalities Waste operators Research centres and universities	Long-term
5. Implementation of Waste-to-Energy Solutions	5.1 Engage Stakeholders on Fast-Track Energy Recovery: Initiate dialogue with municipalities, waste operators, industrial actors, energy utilities, and research institutions to map residual flows and explore immediate opportunities for energy recovery from plastics, rubber, and agro-food waste.	Municipalities Waste operators Research centres and universities	Short-term
	5.2 Coordinate Regional Energy Valorisation Efforts: Set up working groups or a regional platform to define roles, responsibilities, regulatory compliance, and joint decision-making for implementing energy valorisation projects efficiently across different waste streams.	Municipalities Waste operators Research centres and universities	Short-term Medium-term
	5.3 Identify Priority Streams and Deploy Pilot Projects: Analyse residual streams, evaluate suitable technologies (anaerobic digestion, controlled incineration, pyrolysis), and plan pilot projects that can quickly reduce landfill disposal while generating renewable energy and supporting circular economy objectives.	Municipalities Waste operators Research centres and universities	Long-term

Social inclusion, awareness and knowledge

Measures	Actions	Key Actors	Time frame
6. Working Groups for Collaborative Solutions	6.1 Creation of Working Groups: Identify stakeholders for selected key areas, map interests & roles. Define governance & structure, including roles & responsibilities. Establish decision-making rules and setup working methodology	Industry Research centres and universities	Short-term
	6.2 Co-creation of Solutions: Prioritize challenges & opportunities, identifying key leverage points and defining priority focus areas for each working group. Implement design thinking or innovation sprints with stakeholders.	Industry Research centres and universities	Short-term
	6.3 Roadmap & Implementation Planning: Develop roadmap proposal, including KPIs & monitoring framework as well as responsibilities & funding sources.	Industry Research centres and universities	Medium-term
	6.4 Pilot Projects & Demonstrations: Launch small-scale pilots to test collaborative solutions. Measure impact and document learnings. Scale up promising solutions across the industry.	Industry Research centres and universities	Medium-term Long-term
7. Optimization of Urban and Rural Waste Collection	71. Convene Stakeholders and Launch Dialogue: Bring together municipalities, intermunicipal waste systems, waste operators, research centres, and community organizations to share knowledge on current collection challenges, validate available data, and initiate a coordinated discussion on priorities and opportunities across urban, semi-urban, and rural contexts.	Municipalities waste operators Society Research centres and universities	Short-term
	72. Define Collaborative Mechanisms: Establish working groups or a regional coordination forum to define roles, responsibilities, communication channels, and joint decision-making processes, ensuring that all stakeholders are aligned on objectives and approaches for improving selective waste collection.	Municipalities waste operators Society Research centres and universities	Short-term Medium-term
	7.3 Identify Priorities and Explore Solutions: Through workshops and consultations, stakeholders collectively identify key focus areas (e.g., bio-waste, plastics, rural vs. urban collection), explore possible technical and operational solutions, and outline criteria for pilot programs and future initiatives.	Municipalities waste operators Society Research centres and universities	Medium-term Long-term
8. Enhanced Visibility for	8.1 Launch Initiative and Map Data Practices: The coordinator initiates the program by reviewing current data collection methods. Municipalities, waste operators, and industrial partners are engaged to identify gaps and	Industry Research centres and universities	Short-term

Circular Materials	standardize practices for tracking material flows, recycling rates, and residual streams.		
	8.2 Develop Standardized Guidelines and Protocols: Based on the mapping, the coordinator works with stakeholders to establish clear, standardized methods and protocols for consistent and comparable data across the region	Industry Research centres and universities	Short-term
	8.3 Build Integrated Digital Platforms: Shared information systems are created to centralize data, visualize material flows, and provide real-time insights. These platforms support planning, monitoring, and reporting for all stakeholders.	Industry Research centres and universities	Medium-term
	8.4 Leverage Data for Decision-Making and Collaboration: Collected data is used to identify priorities, monitor the effectiveness of initiatives, inform policy, and foster collaboration among municipalities, industries, and research centres for targeted circular economy interventions.	Industry Research centres and universities	Medium-term

4.5 Progress monitoring and Evaluation

Monitoring is essential to ensure a successful transition to a more circular economy in the Norte region. The indicators and targets set out in Tables 17, 18 and 19 enable a more direct assessment of the actions that facilitate the monitoring of the plan's implementation.

Table 17 Indicators for the CSS2 Action Plan

Areas of intervention	Measures	Indicators
Legal and Regulatory framework	Sustainable and Territorialized Food Systems	- No. of public schools that quantify and annually publish food waste data - Quantified reduction (in kg and %) of food waste in public canteens - No. of public procurement contracts with explicit sustainability criteria
	Governance, Policy and Funding	- Existence of an advisory council with representatives from the Health, Nutrition, Education, Eco-Schools sectors, one or two school clusters, two or three municipalities (urban, semiurban, and rural), Agricultural Production, and Spatial Planning - No. of institutional protocols with joint targets signed - Indicators from other axes resulting from publicly funded projects
Innovation, Product Design and Value Chains	Sustainable and Territorialized Food Systems	- % of local products integrated into meals in public institutions - % of national products integrated into meals in public institutions - % of PDO/PGI/autochthonous breed products integrated into meals in public institutions - No. of meals with implemented sustainability criteria (specifying which criteria)
	Sustainable and Regenerative Agrifood Production	- No. of formally established and active bioregions - % increase in organic matter in soils (agrochemical monitoring) - Effective reduction in the use of synthetic fertilizers - No. of hectares with traditional crops and native breeds - % of agricultural water consumption metered and fairly priced - No. of active land banks and available area per municipality or Intermunicipal Community (CIM) - % of degraded soils – ESA soil condition indicators

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	Circular Economy and Resource Management	- Quantity of food waste avoided (redistributed for human consumption) - Area covered by operational selective biowaste collection - % of establishments (food services, retail, IPSS) implementing concrete and measurable practices for food waste quantification, publication, and reduction - Quantity of by-products revalorized for specific purposes (e.g., biogas, fertilizer, animal feed, etc.)
Infrastructure, investment, entrepreneurship	Sustainable and Regenerative Agrifood Production	- % of agricultural land under organic farming - No. of farmers covered by the Family Farming Statute - Number of experimental stations or technical centres reactivated or created, and number of technical staff in operation
	Circular Economy and Resource Management	- Quantity of selectively collected biowaste and % of total biowaste generated - Quantity of biowaste diverted from landfill per year - Quantity of biowaste composted through community, household, or collective composting systems (e.g., in partnership with farmers) - No. of industrial symbioses facilitated and volume of waste valorised
Social inclusion, awareness and knowledge	Capacity Building, Innovation, and Circular Food Citizenship	- No. of schools that incorporate circular food economy in their educational projects - No. of curricula updated in agricultural schools and universities to include circular and regenerative content - No. of professionals trained in circular food economy (disaggregated by role – technicians, decision-makers, cooks, etc. – and by municipality) - No. of projects with publicly available summaries of lessons learned - No. of local, regional, or national producers trained and who effectively responded to awarded public procurement tenders - Qualitative and quantitative assessment of food and circular literacy among the regional population (via surveys)
	Governance, Policy and Funding	- Existence of an active and functional regional coordination and monitoring structure - No. of projects with lessons learned systematized and reused in new projects

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Table 18 Indicators for the CSS4 Action Plan

Areas of intervention	Measures	Indicators
Legal and Regulatory framework	1. Knowledge creation and policy recommendations to support decision-making	- Study publication - Publication of recommendations - No. of advocacy actions
	2. Strength of support and clarification for companies in applying the legal framework	- No. of sessions - No. of companies supported
Innovation, Product Design and Value Chains	3. Creation of knowledge and development of resources necessary for the implementation of circular strategies	- Study publication - No. of new waste streams identified - No. of entities involved
	4. Promotion of circularity through eco-design and repair and reuse solutions	- No. of tools identified - Toolkit published - No. of solutions provided
Infrastructure, investment, entrepreneurship	5. Strength of collaboration between different stakeholders through the establishment of consortia	- No. of networking events held - No. of project applications submitted
	6. Increased investment in developing new products, technologies and processes based on the circular economy.	- Investment in pilot units (€) - Increase in selective collection rates in the Norte region (%)
Social inclusion, awareness and knowledge	7. Public engagement and behavioural change	- No. of municipalities where actions were carried out
Institutional	8. Definition of the governance model for the Action Plan	- Governance model defined - Monitoring Committee established - No. of meetings held
	9. Monitoring and Evaluation of the Action Plan	- Monitoring tool created and implemented - External evaluation report published

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Table 19 Indicators for the cross-sectional CSS2 and CSS4 Action Plan

Pillars of Transition	Output indicators	Outcome indicators	Impact indicators
Sustainable Packaging Design	• Number of pilot projects launched to test alternative materials • Number of workshops held on eco-design • Number of standards or certifications developed for circular packaging	• Percentage of packaging produced with alternative materials (biodegradable, compostable, reusable) • Number of companies adopting mono-material packaging • Reduction of virgin plastic used (tons)	• Reduction of CO_2 emissions associated with packaging production (via LCA) • Overall reduction in packaging waste in the region (%) • Increase in recyclability rate of packaging materials (%)
Collaborative Solutions for Key Industry Sectors	• Number of companies per industrial sector of both CSS • Number of collaboration agreements signed in each key industry sectors • Number of digital platforms created for by-product exchange.	• Quantity of waste diverted for collaborative use (tons) • Number of new circular business models implemented	• Reduction in raw material extraction (via LCA) • Increase in regional circularity rate (%)
Industrial Symbiosis	• Number of industrial symbiosis initiatives identified and implemented • Number of companies that incorporate waste into their production process • Number of eco-parks under development	• Amount of resources reused between industries (ton) • Energy recovered through process integration (MWh)	• Reduction of GHG emissions by replacing virgin inputs (ton CO_2 eq.) • Improvement in overall energy efficiency of the industrial symbiosis (%) • Reduction in industrial waste generation (%)
New or Improved Recycling Systems	• Number of strategic plans developed • Number of new recycling facilities installed per sub-region • Number of bio-waste treatment facilities	• Increase in regional plastic recycling rate (%) • Amount of waste treated in recycling facilities (ton) • Amount of compost produced (ton)	• Reduction of waste sent to landfill (ton) • Reduction of GHG emissions associated with disposal (ton CO_2 eq.) • Agricultural area that used organic fertilizers (m^2)
Recycling Solutions for Non-PET Plastics	• Number of pilot projects launched for non-PET plastic recycling • Number of partnerships established with recyclers • Number of innovative recycling technologies tested	• Amount of non-PET plastics diverted from landfill (ton) • Percentage increase in recycling rate for non-PET plastics (%)	• Reduction in CO_2 emissions from avoided incineration or landfill (ton CO_2 eq.). • Increase in recycling efficiency for non-PET plastics (%)
Improvement of Waste Collection Processes	• Number of smart collection points installed • Number of awareness campaigns conducted	• Reduction in contamination levels in recyclables (%) • Increase in regional selective waste collection (%) • Percentage of selective waste collection by sub-region (%)	• Reduction of waste sent to landfill (ton)
Energy Valorization	• Number of energy recovery facilities implemented • Number of agreements for energy valorization signed • Number of governance frameworks defined	• Energy recovered from waste (MWh) • Percentage of residual waste converted into energy (%)	• Increase of waste into energy generation (MWh) • Reduction of waste sent to landfill (ton)
Streamline Bureaucratic Processes	• Number of regulatory bottlenecks identified • Number of guidelines drafted	• Reduction in average time for circular project approvals (days) • Increase in number of circular projects initiated	• Increase in adoption rate of circular initiatives (%) • Improvement in regulatory efficiency index
Better Data and Enhanced Visibility	• Number of data platforms created • Number of stakeholders involved in standardization	• Number of databases created • Number of standardized indicators adopted	• Improvement in decision-making speed (%) • Increase in data reliability index • Increase in data availability on material flows (%)

Monitoring should be carried out annually by the Action Plan coordination group using the identified indicators. It should be noted that the implementation of actions may not have a short-term impact on the overall objectives identified.

The planned actions and indicators may also be reviewed annually by the Steering Committee, taking into account the existing regulatory, economic and social context, which may change during the implementation of the Action Plan.

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4.6 Communication Plan

The well-known quote by Antoine-Laurent de Lavoisier, "In Nature, nothing is created, nothing is lost, everything is transformed" serves as a mantra on the journey toward a more circular economy, advocating for a new life for the various materials that surround us.

The results obtained through the Action Plan for the Norte Region should serve the purpose of raising awareness, involving the business sector, the community, and academia, as well as aligning actions and defining common goals. To achieve the project's aims, the communication approach required should go beyond the mere dissemination of outputs and instead promote stakeholder mobilization.

The communication objectives of the FRONTSH1P Project will therefore focus on encouraging concrete actions and interaction from key players in both sectors, contributing to a greater understanding of the transformations needed to achieve circularity, and fostering research and development of projects aimed at making these value chains more circular.

Target groups

The communication plan will be aimed the target groups identified in the action plans proposed, namely companies and stakeholders working within the food & feed and plastics & rubber value chains, industry associations, researchers and universities. These groups are directly interested in the practical outcomes of the project, its industrial applications, and its impact on the value chains. Communication with this audience can therefore be more technical, focusing on data, indicators and opportunities for scaling up the developed solutions.

The involvement of municipalities is also crucial, particularly due to their role in managing urban waste and their relevance to certain industrial parks.

From a broader perspective, there is also a need to bring the results to the public. For this reason, communication should also be educational and aimed at raising awareness of the topic within public networks and communities.

Conveying the key messages

The communication of the FRONTSH1P Project's results should be based on a clear, mobilizing, and inspiring message that reflects the transformative vision the action plans aim to promote. This message should convey a cutting-edge and systemic approach, focused on circularity and territorial sustainability, challenging different audiences to rethink the current production and consumption paradigm within the sectors under study.

In this regard, communication should emphasize that the action plans are not merely technical outcomes of the project, but strategic tools for mobilizing businesses, academic institutions, and the scientific community around a common goal: to promote circular solutions and reduce the environmental impact of the food & feed and plastics & rubber sectors.

Therefore, it is essential to engage and inspire stakeholders to become active participants in this

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transition, taking on a leadership role in building more circular, efficient, and eco-friendly value chains. This is the most effective approach to ensure the project has a clear impact after the results are published, as it seeks to position the action plans as a seed for fostering future advancements toward the circularity of food & feeds and plastics & rubber.

Communication channels

With the aim of disseminating the keys messages and achieving the project's objectives, a set of communication channels has been identified that can serve as bridges between the knowledge generated in the action plans and the stakeholders of both sectors. These are compiled in Table 20.

Table 20 Communication channels that were used throughout the project and will be used after project completion

Communication Channels		
Channel	**Description**	**Content**
Website CCDR-N	As the coordinating entity of the project in the Norte Region, the CCDR-N website will be the most appropriate space to find information about the actions plans. This includes news covering the various phases of the project, as well as a page dedicated exclusively to FRONTSH1P in the "*Região Norte*" submenu.	News; Web page.
Social media CCDR-N	As a complement to the website, CCDR-N's social media channels can help boost the reach of news about the project. Instagram and LinkedIn are the platforms where the institution has the strongest presence within the community and should therefore feature posts related to the development of the action plans.	Post of the news.
Newsletter CCDR-N	This is the communication channel closest to the entities interested in the work developed by CCDR-N and should therefore serve as a means to share project-related news published on the website.	News.
Website FRONTSH1P Project	As part of a European consortium funded by the Horizon 2020 Programme, it is important to bring information about the Norte Region action plans to an international audience. Therefore, the project's website should report on key events held in the region, such as workshops and the results achieved.	News.
Social media FRONTSH1P Project	In order to reach the international audience of this European project, social media should be used to boost the reach of the news published on the website.	Post of the news.
FRONTSH1P Project Newsletter	It is the communication channel that should be used by the FRONTSH1P Project to reach the audience most engaged with its work, and should therefore serve as a means to share news that are published on the website.	News.
National Press	The media is inevitably the best interface for reaching the public. There are even media outlets that may see great news value in the project, such as publications more focused on the environment and the Norte region – Público, Observador, Porto Canal, Jornal de Notícias, and RTP.	Press release.
Partners	As an essential part of the development of the action plans, it is important to provide these partners with tools to also disseminate the results achieved and stimulate interest in the topic, in order to pave the way for the achievement of the proposed goals. Among the partners, we can find INEGI, PortugalFoods, Smart Waste Portugal	Roadmap Brochure; Social Media Post Template.

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	Association and the Portuguese Pact for Plastics (PPP).	
Direct mail	In order to disseminate the results achieved with the action plan, the information should reach the key stakeholders in the sector, particularly the companies. The most direct way to do this is through email.	E-mail.
Events	To convey the information about the action plan and engage the key players in the field, from companies to the scientific community and authorities, it is important to organize events that promote the co-creation of solutions, interaction among stakeholders, and raise awareness about the urgency of the topic.	Workshop; Seminar.

Scheduling

The project's communication plan should align with the schedule of the action plans, ensuring the dissemination of the most relevant data and newsworthy information, capable of engaging the target audience. Table 21 presents a proposed schedule for the implementation of the communication strategy.

Table 21 Scheduling of project communication actions

Phase	Month	Communication Actions
III	May	Workshop News CCDR-N Social Media's post CCDR-N News FRONTSH1P Project Social Media's post FRONTSH1P Project
	June	Workshop Newsletter CCDR-N Newsletter FRONTSH1P Project
IV	July	Workshops
	August	Webpage about FRONTSH1P Project
	September	Templates with Roadmap Brochure with Roadmap Call to Seminar
	October	News CCDR-N Social Media's post CCDR-N Press Release of the Action Plan Update webpage of the project
		Seminar
After-Project	November	E-mails to Stakeholders News CCDR-N Social Media's post CCDR-N News FRONTSH1P Project Social Media's post FRONTSH1P Project
	December	Newsletter CCDR-N Newsletter FRONTSH1P Project E-mails to I&D Centers and Think Tanks

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Operationalization

To put the communication plan into action, the CCDR-N communication team is responsible for implementing the planned actions, in close collaboration with the steering committee.

Now that the project has reached its final stage, there is a solid base of information to feed into a web page dedicated to Frontsh1p on the CCDR-N website, which can be accessed via the 'Norte Region' submenu, where other European programmes involving the institution can be found. This should include a presentation of the project, some data from the diagnosis of the food & feed and plastics & rubber sectors in the territory, the objectives of the action plan and some information on legislation.

In order to promote the dissemination of the action plan's results, a template should be created to share with partners so that they can disseminate it through their communication channels. A leaflet should also be prepared to be handed out at the project's final seminar, in case there are other opportunities for interaction with companies and academics from the industry.

After the end of Phase IV, the action plan was disseminated on a large scale, namely through a news item marking its completion on the CCDR-N website and the sending of a press release to the media, in order to bring the goals defined in the document to public debate. This action was coordinated between the various parties involved in drawing up the plan.

4.7 Governance

To reinforce the continuity of circular economy efforts in the region, at the end of the last seminar, a Regional Protocol for Circular Monitoring was signed by CCDR-NORTE, APA, INEGI, PortugalFoods, and Smart Waste Portugal, establishing a framework to track and replicate circular initiatives across the Norte Region.

Within this group, the Steering Committee comprised by CCDR-Norte, INEGI, PortugalFoods and Smart Waste Portugal will be responsible for the continuity of the project outside the Horizon 2020 framework.

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5. Conclusions

The developed proposal of a Roadmap for Circular Economy for the sectors of Food & Feed and Plastics & Rubber seeks to provide a blueprint for taking decisive action to achieve higher levels of circularity, putting the Norte Region of Portugal on a more sustainable path, reducing emissions, creating a cleaner and greener economy and society, and contributing, to the extent possible, to protecting against the devastating consequences of climate change, through the definition and demonstration of highly replicable regenerative Circular Systemic Solutions (CSS). The proposed Circular Systematic Solutions for the Food & Feed and Plastics & Rubber value chains aim to address the current challenges and needs of the region, transforming them into opportunities for economic growth, social inclusion, decarbonization of production and consumption systems, improvement of the quality of life for citizens, and reconnection between the urban and rural areas.

Taking into consideration the analysis of the region and the discussions with the stakeholders, four cross-sectional main goals were defined:

- Reduce the percentage of waste sent to disposal (e.g. landfill);
- Increase material valorisation rates;
- Increase energy valorisation rates (when material valorisation is not an option);
- Develop necessary and currently not-existing waste streams.

Over 16 months, the Norte Region promoted 10 events (7 workshops and 3 seminars), mobilised 700+ stakeholders across 250+ organisations. Just in 2025, 400+ Portuguese stakeholders participated in FRONTSH1P events with 33% representing industries and business, 22% Research Institutions, and 21% Public Authorities.

Aspect	Agri-Food Action Plan	Plastics & Rubber Action Plan	Proposed Roadmap
Main Goal	Transition to a **circular, regenerative, resilient agri-food system** with benefits for health, employment, and sustainability.	Transition to a **circular economy in plastics & rubber**, boosting resource efficiency and competitiveness.	Accelerate **circular economy transition** in both sectors through strategic pillars and actions.
Scope	Food & Feed sector (production, consumption, waste).	Plastics & Rubber sector (manufacturing, recycling, waste).	Both sectors: Food & Feed + Plastics & Rubber.
Methodology	Regional diagnosis, workshops, interviews, SWOT, governance model.	Sector diagnosis, stakeholder engagement, SWOT, legal review, governance model.	Value chain analysis, regional indicators, stakeholder engagement, prioritization of actions.

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Aspect	Agri-Food Action Plan	Plastics & Rubber Action Plan	Proposed Roadmap
Key Challenges	Food waste, low valorization of bio-waste, fragmented governance, lack of data.	Complex legislation, high cost of recycled materials, tech limitations, negative perception of recycled products.	High landfill rates, low recycling rates, lack of data visibility, bureaucratic barriers.
Strategic Axes / Pillars	5 Axes: Sustainable food systems, regenerative production, circular resource management, capacity building, governance & financing.	5 Axes: Regulatory framework, innovation & value chain, infrastructure & investment, awareness & training, institutional governance.	9 Pillars: Sustainable packaging, collaborative solutions, industrial symbiosis, improved recycling, non-PET recycling, better collection, energy recovery, streamlined bureaucracy, better data visibility.
Specific Objectives	Increase food sovereignty, reduce waste, promote regenerative agriculture, educate on circular economy, foster cooperation.	Simplify legal framework, promote eco-design, support investment, train professionals, ensure governance.	Reduce landfill, increase material and energy recovery, create new waste streams.
Key Actions	Local markets, short supply chains, food waste measurement, composting, education programs, governance council.	Legal studies, eco-design tools, pilot recycling units, B2B networking, training programs, monitoring tools.	Eco-design principles, industrial symbiosis networks, pilots for non-PET recycling, digital platforms for data, regulatory simplification.
Time Horizon	Medium to long term (regional systemic change).	2025–2030 (sector-specific transformation).	Short, medium, and long-term actions (phased roadmap).
Governance	Regional Advisory Council + CCDR-N oversight.	Monitoring committee + CCDR-N leadership.	Governance model + monitoring and evaluation tools.

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Annex 1

Selected indicators of sustainable development relating mainly to economic growth and circular economy in Portugal

Goal CDG	Goal SDG for Portugal	Indicator (units)	2021		2022		2023	
			Portugal	Norte	Portugal	Norte	Portugal	Norte
Goal 1. No poverty	Implement, at national level, adequate social protection measures and systems, for all, including thresholds, and by 2030 achieve substantial coverage of the poorest and most vulnerable	1.3.1 Proportion of population covered by social protection floors/systems (%)	39.80	37.80	32.20	30.20	30.40	33.20
	By 2030, increase the resilience of the poorest and most vulnerable, and reduce their exposure and vulnerability to climate-related extremes and other economic, social and environmental shocks and disasters.	1.a.2 Proportion of total government spending on essential services (education, health and social protection)	64.01		65.66			
Goal 2. Zero hunger	Increase investment, including through strengthened international cooperation, in rural infrastructure, research and extension of agricultural services, technology development, and plant and animal gene banks, to increase agricultural production capacity in developing countries, particularly in the least developed countries.	2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector (€ million)	0.54		0.73			
	Correct and prevent trade restrictions and distortions in world agricultural markets, including the elimination in parallel of all forms of export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round.	2.b.1 Agriculture export subsidies (€)	533 823					
	Adopt measures to ensure the proper functioning of the markets for agricultural raw materials and their derivatives, and facilitate timely access to market information, including on food stocks, in order to help limit the extreme volatility of food prices.	2.c.1 Indicator of food price anomalies (Index**)	-0.37		3.02			
Goal 6. Clean water and sanitatione	By 2030, achieve universal and equitable access to affordable drinking water for all.	6.1.1 Proportion of population using safely managed drinking water services - Proportion of dwellings served by water supply (%)	96.00	95.00				
	By 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, with special attention to the needs of women and girls and those in vulnerable situations.	6.2.1 Proportion of dwellings served by wastewater drainage (%)	86.00	82.00				
	By 2030, expand international cooperation and capacity building support for developing countries in water and sanitation-related activities and programs, including water extraction, desalination, water use efficiency, wastewater treatment, recycling and reuse technologies.	6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan - Total official development assistance for DAC 31140 and series 140 (gross disbursements) (€ million)	4.44		5.86			
iable and clean energy	By 2030, ensure universal access to modern, reliable and affordable energy services	7.1.2 Proportion of population with primary reliance on clean fuels and technology	100		100			
	By 2030, substantially increase the share of renewable energies in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption - Share of renewable energy in gross final energy consumption (%)	34.00		34.70			
		7.2.1 Renewable energy share in the total final energy consumption - Contribution of renewable resources to the electricity production (%)	58.40		61.00			
	By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP (toe / €)	105.3		100.9			

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Goal 7. Afford	By 2030, strengthen international cooperation to facilitate access to clean energy technologies and research, including renewable energy, energy efficiency and advanced and cleaner fossil fuel technologies, and promote investment in energy infrastructure and clean energy technologies	7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems (€ million)	0		0.67			
Goal 8. Decent work and economic growth	Achieving higher levels of economic productivity through diversification, technological modernization and innovation, namely by investing in high value-added sectors and labor-intensive sectors.	8.2.1 Annual growth rate of real GDP per employed person - Apparent labour productivity (€ thousand)	37.7	33.4	41.7	33.7		
	Progressively improve global resource efficiency in consumption and production by 2030, and actively seek to decouple economic growth from environmental degradation, in accordance with the ten-year framework of programs on sustainable production and consumption, with developed countries leading the way	8.4.1 Material footprint per capita (tonnes per capita)	18.2					
		8.4.2 Domestic material consumption per capita (tonnes per capita)	17.50		15.63			
	By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization (ILO)	8.b.1 Existence of a developed and operationalized national strategy for youth employment, as a distinct strategy or as part of a national employment strategy [3 – The country has operationalized a national strategy for youth employment]	3		3		3	
Goal 9. Industry, Innovation and Infrastructure	Promote inclusive and sustainable industrialization and, by 2030, significantly increase the share of industry in employment and GDP, in accordance with national circumstances, and double its share in the least developed countries.	9.2.1 Manufacturing value added as a proportion of GDP (%)	12.50		11.90		11.30	
		9.2.2 Manufacturing employment as a proportion of total employment - Proportion of employed people in manufacturing (%)	17.20	26.20	17.00	25.20	16.50	24.50
	Increasing the access of small industries and other businesses, particularly in developing countries, to financial services, including affordable credit and their integration into value chains and markets	9.3.1 Proportion of small-scale industries in total industry value added (%)	7.3		7.3			
	Strengthen scientific research, improve the technological capacities of industrial sectors in all countries, particularly developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per million people and public and private spending on research and development.	9.5.1 Research and development expenditure as a proportion of GDP (%)	1.67%	1.96%	1.70%	1.99%		
		9.5.2 Researchers (in full-time equivalent) per million inhabitants	5.4	5.8	5.7	6.1		
		9.a.1 Total official international support (official development assistance plus other official flows) to infrastructure	2.49 € million		11.20 € million			
		9.b.1 Proportion of medium and high-tech industry value added in total value added	23.7%		22.7%	18.2%		
cities and communities	By 2030, increase inclusive and sustainable urbanization and capacities for participatory, integrated and sustainable human settlement planning in all countries	11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically	100%		100%			
	By 2030, reduce the negative environmental impact per capita in cities, including paying special attention to air quality, the management of municipal waste and other waste	11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated per capita	512	479	509	472		
		11.6.2 Annual mean levels of fine particulate matter ($PM_{2.5}$ particles) in cities (population weighted)	7		7			
		11.6.2 Annual mean levels of fine particulate matter (PM_{10} particles) in cities (population weighted) ($\mu g/m^3$)	14		15			

Goal 11. Sustainable	By 2020, substantially increase the number of cities and human settlements that have adopted and implemented integrated policies and plans for inclusion, resource efficiency, climate change mitigation and adaptation, disaster resilience; and develop and implement, in accordance with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.	11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030 (Score of adoption and implementation of national DRR strategies in line with the Sendai Framework)	0.90		0.93			
	Support least developed countries, including through technical and financial assistance, for sustainable and resilient buildings using local materials	11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	8.77%		14.61%			
Goal 12. Responsible consumption and production	By 2030, achieve sustainable management and efficient use of natural resources	12.2.1 Material footprint per capita (tonnes per capita)	18.2					
		12.2.2 Domestic material consumption per capita (tonnes per capita)	17.5		15.6			
	By 2030, halve per capita food waste globally, both at retailer and consumer level, and reduce food waste along production and supply chains, including post-harvest waste	12.3.1 Food waste index (Index base 100=2000)	103.2		105.4			
	By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their negative impacts on human health and the environment.	12.4.2 (a) Proportion of hazardous sectorial waste, by type of management operation (%): Total - Recovery operations - Disposal operations	9.2		5.7			
			2.9		2.6			
			48.3		34.3			
		12.4.2 (b) Hazardous sectorial waste produced per capita (kg per capita), by type of waste management operation (kg per capita): Total - Recovery operations - Disposal operations	121.3		78.5			
			32.5		32.5			
			88.9		46			
	By 2030, ensure that people everywhere have relevant information and awareness of sustainable development and lifestyles in harmony with nature.	12.b.1 Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability (SEEA tables)	2		0			
Goal 13. Climate action	Integrating climate change measures into national policies, strategies and plans	13.2.2 Total greenhouse gas emissions per year (GHG total emissions, with LULUCF, including indirect emissions of CO_2) (ktonnes CO2 eq)	50 281		50 457			
	Implement the commitment made by developed countries in the United Nations Framework Convention on Climate Change [UNFCCC] to jointly mobilize 100 billion dollars a year, starting in 2020, from a variety of sources, in order to respond to the needs of developing countries, in the context of significant mitigation actions and transparent implementation; and operationalize the Green Climate Fund by capitalizing it as soon as possible.	13.a.1 Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the $100 billion commitment through to 2025	2.17 € million					
Goal 15. Life on land	By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in accordance with obligations under international agreements	15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type (%)	22.6	24.4	22.6	24.4		
	By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, droughts and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area (%)	6.1					
	By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounting systems	15.a.1 Official development assistance on conservation and sustainable use of biodiversity - Total official development assistance biodiversity marker (gross disbursements) (€ million)	1.19		1.04			
		15.b.1 Revenue generated and finance mobilised from biodiversity-relevant economic instruments - Total official development assistance for DAC series 312 (silviculture) (commitments) (€ million)	0.15		0.00			

Annex 2

Circular Economy Workshop for the Norte Region:

Agrifood and Plastics

11th July 2024

Location: INL, Braga

Time		Speaker
16:00 – 16:25	**Setting the Scene**	
	Intro to Frontsh1p and Relevance for Norte Region	Nuria Barros, INL
	What is Circupuncture approach? Experience in Poland	Ewa Kochanska, PROAKADEMIA
	Experience from a frontrunner: Friesland region	Erik Fledderus, Circular Friesland
16:25 – 16:50	**Circular Economy Use Cases**	
	Plastic & Rubber	Kamil Maszczyk, K-Flex
	Food & Feed	Daniele Turati, NOVAMONT
	Wood	Marco Baratieri, Unibz
	Water & Nutrients	Alberto Reis, LNEG
16:50 – 17:00	**Circular Economy Action Plan in the Norte Region**	
	Results from 1st stakeholders meeting in Norte region and next actions	Ricardo Simões, CCDR-N
17:00 – 18:00	**Working Groups**	
	Agrifood - Definition of challenges & opportunities	Moderated by Marta Brazão, Circular Economy Portugal
	Plastics - Definition of challenges & opportunities	Moderated by Smart Waste
	Conclusions	Ricardo Simões, CCDR-N

page 1

Figure 34 Agenda for the workshop entitled "Cicrular Economy Workshop for the Norte Region: Agrifood and Plastics" held on July 11st 2024 at INL.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Seminário "Economia Circular no setor dos plásticos na Região Norte: Legislação e Implementação"

Organização:

A **Associação Smart Waste Portugal**, em parceria com a **CCDR-Norte** - Comissão de Coordenação e Desenvolvimento Regional do Norte e o **INL** - International Iberian Nanotechnology Laboratory, e no âmbito do projeto europeu Frontsh1p, organiza o **seminário "Economia Circular no setor dos plásticos na Região Norte: Legislação e Implementação"**.

Data: 18 de dezembro de 2024

Local: INL - International Iberian Nanotechnology Laboratory

Enquadramento:

O projeto FRONTSH1P, com financiamento através do Programa Horizonte 2020, visa garantir uma transição verde e justa da região polaca de Łódzkie para a descarbonização e regeneração territorial através da demonstração de modelos sistémicos circulares altamente replicáveis, onde a Região Norte se inclui.

A CCDR-N e o INL participam desde 2021 no FRONTSH1P cujo término está previsto para outubro de 2025. A nível regional prevê-se:

- A caraterização da região, nomeadamente a nível dos setores dos Plásticos e Alimentar, na perspetiva dos 5R's;
- Análise das partes interessadas e das cadeias de valor;
- Desenvolvimento de um Roadmap e um Plano de Ação para a Região Norte, para cada um destes setores, com estratégias, inovação, monitorização, medidas e ações para se alcançar a circularidade.

Pretende-se assim criar iniciativas que promovam o envolvimento dos diferentes atores, criando uma plataforma de diálogo e cooperação entre eles.

No seguimento de workshops anteriores, este seminário surge com os seguintes objetivos:

- **Avaliar a dimensão regulamentar** na área dos plásticos e borracha;
- **Refletir desafios e oportunidades** da economia circular para a indústria;
- **Valorizar boas práticas e tecnologias** disponíveis para a implementação da economia circular;
- **Promover a partilha de experiências** e alimentar uma rede de cooperação entre os diferentes atores.

A ênfase numa economia circular e em sistemas de recursos sustentáveis poderia beneficiar a indústria, especialmente no que diz respeito a materiais ecológicos, redução de resíduos e transformação digital nos processos de produção.

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Programa:

14h00	Receção dos participantes
14h30	Sessão de abertura **Ado Jório**, INL **Ricardo Rio**, Câmara Municipal de Braga **Luísa Magalhães**, Associação Smart Waste Portugal
15h00	Painel: Estado da arte da Estratégia Nacional para a Economia Circular Perspetiva Ambiental - **Ana Cristina Carrola**, Agência Portuguesa do Ambiente Perspetiva Económica - **Carla Pinto**, Direção Geral das Atividades Económicas
15h30	Estudo de caso: Desafios tecnológicos Testemunho de parceiro do Projeto Frontsh1p – Maria Teresa Scrivani, Consorzio Proplast (EN)
15h45	Pausa para café
16h00	Estudo de caso: Pacto Português para os Plásticos: colaboração e envolvimento da cadeia de valor Patrícia Carvalho, Pacto Português para os Plásticos
16h15	Mesa-redonda: Legislação e Aplicabilidade prática Moderador: Luísa Magalhães, Associação Smart Waste Portugal Nuno Aguiar, APIP Filipe Carneiro, LIPOR Sandra Silva, Veolia
17h15	Síntese dos trabalhos Ricardo Simões, Unidade de Inovação CCDR-Norte
17h30	Sessão de encerramento **António Cunha**, CCDR-Norte

Inscrição gratuita mas obrigatória até dia 17 de dezembro às 13h

Link para inscrição

Para mais informações sobre o projeto FRONTSH1P: https://frontsh1p.eu/

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Figure 35 Agenda for the seminar entitled "Circular Economy in the plastics sector in the Norte Region: Legislation and Implementation" held on December 18th, 2024, at INL.

Seminário "Economia circular no setor agroalimentar na Região Norte: Desafios da Valorização para a alimentação humana e animal"

Organização:

A **PortugalFoods**, em parceria com a **CCDR-Norte** - Comissão de Coordenação e Desenvolvimento Regional do Norte e o **INL** - International Iberian Nanotechnology Laboratory, e no âmbito do projeto europeu Frontsh1p, organiza o **seminário "Economia circular no setor agroalimentar na Região Norte: Desafios da Valorização para a alimentação humana e animal"**.

Data: 27 de fevereiro de 2025

Local: INL - International Iberian Nanotechnology Laboratory

Enquadramento:

O projeto FRONTSH1P, com financiamento através do Programa Horizonte 2020, visa garantir uma transição verde e justa da região polaca de Łódzkie para a descarbonização e regeneração territorial através da demonstração de modelos sistémicos circulares altamente replicáveis, onde a Região Norte se inclui.

A CCDR-N e o INL participam desde 2021 no FRONTSH1P cujo término está previsto para outubro de 2025. A nível regional prevê-se:

- A caraterização da região, nomeadamente a nível dos setores dos Plásticos e Alimentos e Rações, na perspetiva dos SR's;
- Análise das partes interessadas e das cadeias de valor;
- Desenvolvimento de um Roadmap e um Plano de Ação para a Região Norte, para cada um destes setores, com estratégias, inovação, monitorização, medidas e ações para se alcançar a circularidade.

Pretende-se assim criar iniciativas que promovam o envolvimento dos diferentes atores, criando uma plataforma de diálogo e cooperação entre eles.

No seguimento de workshops anteriores, este seminário surge com os seguintes objetivos:

- **Analisar os desafios e oportunidades na valorização de resíduos** no setor agroalimentar;
- **Ponderar a regulamentação e a legislação** aplicável à valorização de resíduos;
- **Valorizar boas práticas e tecnologias** disponíveis para a implementação da economia circular;
- **Incentivar a inovação e o investimento** no campo da valorização de resíduos agroalimentares;
- **Promover a partilha de experiências** e dinamizar uma rede de cooperação entre os diferentes atores.

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Programa:

09h00	Receção dos participantes
09h45	**Sessão de abertura** **(a confirmar)**, INL **Ricardo Rio**, Câmara Municipal de Braga **Deolinda Silva**, PortugalFoods
10h00	**Painel: Regulamentação e Legislação na Valorização de Resíduos** - Estado da arte da Estratégia Nacional para a Economia Circular - **Ana Cristina Carrola**, Agência Portuguesa do Ambiente [a confirmar] - Regulamentação na utilização de materiais consoante origem – **(a confirmar)**, Direção-Geral da Alimentação e Veterinária
10h30	**Estudo de caso: Valorização de terras para obtenção de biogás** Testemunho de parceiro do Projeto Frontsh1p – **(a confirmar)**, Novamont (EN)
10h50	Pausa para café
11h20	**Estudos de caso: Valorização de Subprodutos para a Indústria Alimentar, Cosmética e Nutracêutica** **Manuela Pintado**, Universidade Católica Portuguesa
11h40	**Mesa-redonda: Desafios e Oportunidades na Valorização de Subprodutos Agroalimentares** Moderador: **Deolinda Silva/Teresa Carvalho**, PortugalFoods **Débora Campos**, AgroGrinTech [a confirmar] (a identificar), Grupo Soja de Portugal [a confirmar] **Telmo Machado**, Lipor [a confirmar] (a identificar), MORE CoLab (a identificar) Tecmafoods/Super Bock [a confirmar]
12h40	**Síntese dos trabalhos** Ricardo Simões, Unidade de Inovação CCDR-Norte
12h50	**Sessão de encerramento** **António Cunha**, CCDR-Norte

Inscrição gratuita mas obrigatória até dia 25 de fevereiro às 18h

Link para inscrição

Para mais informações sobre o projeto FRONTSH1P: https://frontsh1p.eu/

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Figure 36 – Agenda for the seminar entitled "'Circular economy in the agri-food sector in the Norte region: Challenges of valorisation for food and feed" to be held on February 25th, at INL.

Grant Agreement number: 101037031
Project acronym: FRONTSH1P
Project title: A FRONTrunner approach to Systemic circular, Holistic & Inclusive solutions for a new Paradigm of territorial circular economy
Type of action: Innovation Action (IA)

GREEK REGIONAL ROADMAP: CENTRAL REGION & LIVADIA MUNICIPALITY

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Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Table of Figures

Table of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Abbreviations

CCRI - Circular Cities and Regions Initiative
CE – Circular Economy
CEAP - Circular Economy Action Plan
CpEAP – CircuPuncture Economy Action Plan
CSS – Circular Systemic Solutions
CTC – Circular Territorial Cluster
ICT - information and communication technologies
LAP – Local Activity Place
LR – Lodzkie Region
NGO – Non-Governmental Organisation
RCT - Regional Cluster Team
SAT – self-assesment tool
SLOM – Stowarzyszenie Łódzki Obszar Metropolitalny (Lodz Metropolitan Area Association)
TRL - technology readiness level

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STAGE I: ANALYSIS OF CONDITIONS

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1 Stage 1: Analysis of Condition

1.1 Designation of the Region

The Region of Central Greece is one of the 13 administrative regions of Greece, it occupies the eastern half of the traditional region of Central Greece, including the islands of Euboea and Skyros, its capital city is Lamia and to the south it borders the region of Attica. Central Greece is the most populous geographical region of Greece, with a population of 4,591,568 people, and covers an area of 24,818.3 km^2 (9,582.4 m^2), making it the second largest of the country. Its climate is temperate along its coastlines, and dry in the interior. The region is one of the most mountainous in Greece, having some of the highest elevations in the country. The Greek gross domestic product (GDP) was 8.8 billion € in 2018, accounting for 4.7% of the Greek economic output. GDP per capita adjusted for purchasing power was 18,900 € or 63% of the EU27 average in the same year. The GDP per employee was 81% of the EU average. Central Greece is the region in Greece with the fourth highest GDP per capita.

Figure 1 Location of central Greece

The Municipality of Levadia was established by the amalgamation of the pre-existing Municipalities of Levadia, Davlia, Koroneia and Chaironea and the Community of Kyriaki according to the Act of Kallikratis Program (Administrative reorganization of Greece). The area of the new Municipality is 698.79 km^2 and its population is 31,035 inhabitants according to the census of 2021. The city of Levadia was designated to be the seat of the new municipality.

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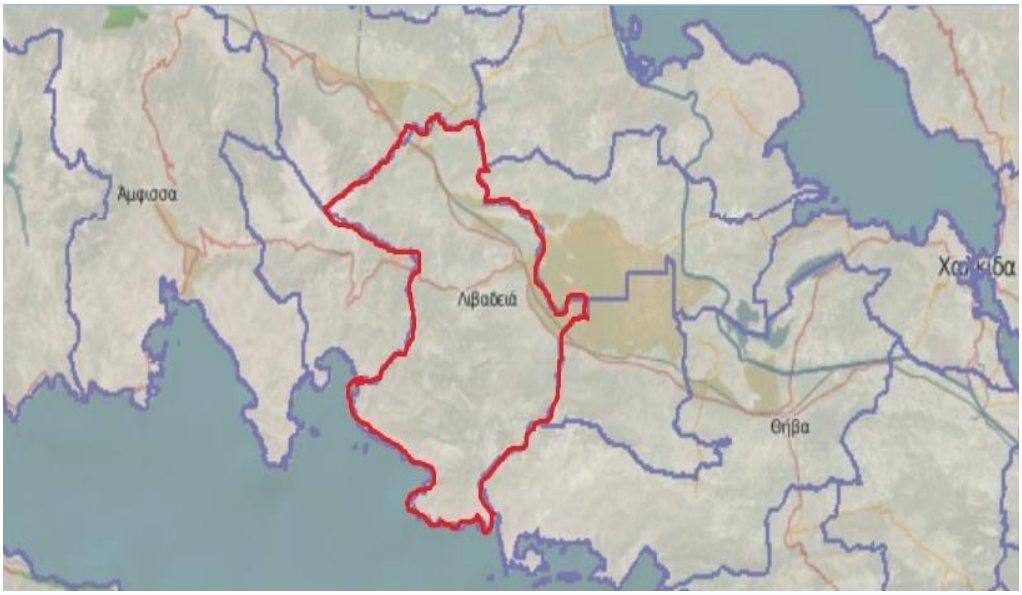

Figure 2 Location of Municipality of Levadia

The Municipality of Levadia is located in the western part of Boeotia which is one of the 5 regional unities of the Prefecture of Central Greece. It includes the largest and central part of Mount Helikonas, part of Mount Parnassos, part of the Kopaid and Parakopaid plain and the plain of Chaironia. It is located west of the dried up lake of Kopaida and is crossed by the river Kifissos and its tributaries, Erkyna and Potza. To the west of the municipality extends Mount Helikonas.

1.1.1 Demographic data of the Municipality of Levadia

According to Hellenic Statistical Authority 2021, the total population of the Municipality amounts to 31,035 permanent residents. The distribution of the permanent population by Municipal Unit (M.U.) according to the 2021 Population Census is presented in the following table:

Table 1 Distribution of permanent population by Municipal Unit (Greek Statistics 2021)

Municipal Unit	Permanent Population 2021
Levadia	21.932
Koroneia	3.552
Davlia	1.851
Chaironea	1.615

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Kyriaki	2.085
Total Population	31.035

It should be noted that, according to the table above, it appears that about 72.74% of the permanent population of Levadia resides at the M.U. Levadia, 10% is located in M.U. Koronia, 7.33% is located in M.U. Kyriaki, 5.38% in M.U. Davlia, and 4.41% in M.U. of Chaironia. According to the Hellenic Statistical Authority 2021, the total number of households in the Municipality of Levadia is 11,700 households, while the average household size is 2.4 members/household.

1.1.2 Industrial activities of Municipality of Levadia

Levadia in 1860-1950 was one of the four industrially developed cities of Greece. In Levadia the main industrial infrastructure, which developed near the springs of river Erkyna, were the water-powered factories. These production units were impressive for their time, leading Levadia to be labeled by travelers as 'Little Manchester'. The watermill or hydromill is the first man-made work-producing machine using a natural, mild and renewable source of energy. With the force created by water falling from above or its flow and with the help of the wheel, an invention that changed human history, simple and then complex machines were set in motion, meeting most of the needs of pre-industrial societies. Thus, thanks to the water, within a period of 90 years, many companies flourished and declined in Levadia. These companies were involved in ginning, spinning, weaving and dyeing cotton, milling grain, rice and processing woolen textiles in watermills.

During the long period many locals of the city worked in the factories of Levadia. Men, women and even small children worked in the factories. The men carted the products to the factories, while the women worked mainly in the spinning mills. At the height of the industrial infrastructure, 180 people were employed.

This thriving industrial sector has declined, there was an intensive deindustrialization of the city and the majority of the remaining industrial buildings are used for cultural activities.

Today the Municipality of Levadia is mainly an agricultural area with exemption of the city of Levadia where the majority of the labor force is occupied to services and commerce. According to the Hellenic Statistical Authority the distribution of labor force of the Municipality is shown to the following table.

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Table 2 Labor force in the Municipality of Levdia

Municipality of Levadia	Total	15-29	30-44	45-59	60-74	75+
	10,599	1,103	3,900	4,579	1,003	8
Senior managers and executives	382	14	113	198	59	0
Professionals	1,847	161	692	807	183	3
Technicians and practitioners of related professions	877	95	394	332	54	0
Office workers	787	77	313	347	52	0
Service workers and vendors	2.247	400	937	802	106	0
Skilled farmers, ranchers, foresters and fishermen	1.057	50	222	533	247	5
Skilled craftsmen and practitioners of related trades	1,113	88	419	502	106	0
Industrial plant, machinery and equipment operators and assemblers (fitters)	988	96	370	440	85	5
Unskilled workers, manual workers and small professionals	1,294	126	442	618	106	0

The total number of employees is 10,599 persons, of which 6,321 are men and 4,274 are women. The majority of them work in the municipal region (7,765 persons). From the total number of employees 3,413 persons hold university degree/master/PhD, 787 hold college degree, 3,952 persons hold secondary education, 1,574 persons are graduates of the nine years of education, 781 persons are graduated of primary education, according to National Census 2021.

The main industrial activities in the Municipality of Levadia include:

- **Agro-industry and Food Processing**: The region is rich in agricultural production, which favors the existence of food processing industries such as oil mills, flour mills, and pasta industries.
- **Mining Activity**: Boeotia has significant reserves of bauxite, and there are mining companies involved in the extraction and processing of this mineral.
- **Light and Medium Industry**: Crafts and factories that produce building materials, plastics and other industrial raw materials operate in the Municipality. Small industrial units related to mechanical engineering and construction are also active.
- **Energy**: In the wider area there are also activities related to energy production, mainly from Renewable Energy Sources (wind and solar).

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The industrial zones of the Municipality of Levadia have a significant contribution to the economic development of the region and offer employment to the residents of both the city and the surrounding areas.
According to the Chamber of Commerce of Boeotia, 308 manufacturing units (industries and smaller industries - crafts) operate in the Municipality of Levadia, covering the abovementioned range of manufacturing activities.

In the Municipality of Levadia there is an intensive agricultural activity and according to the Hellenic Statistical Authority the agricultural production for the entire prefecture of Viotia (there is no data for the Municipality of Levadia) for the years 2019-2021 is presented in Table 3:

Table 3 Agricultural production of Levadia

Agricultural Production	2019		2020		2021	
	Arable Area (hectare)	Production (tn)	Arable Area (hectare)	Production (tn)	Arable Area (hectare)	Production (tn)
Wheat	30.411,5	100.962	30.315,6	95.916	17.618,8	85.994
Legume	2.452.8	4.150	2.612,6	5.207	2.947,6	6.293
Potatoes & Sugar beets	1.037,5	28.940	778,7	21.446	829,00	8.299
Industrial & Oil plants	17.780.9	60.986	17.527,5	62.159	16.732	46.167
Aromatic & Pharmaceutical plants	109.83	284.54	150,43	369,98	157,57	400,40
Energy crops	108.80	482	278,3	688	192.6	226

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1.2 Identification of Key Resources for implementing circular economy activities (including the establishment of indicators)

Biomass supply is directly linked with agriculture (over 90 %) and relates to the production of food and feed. Smaller quantities are diverted into the bio-based materials market, along with smaller quantities of primary woody biomass from forests and wood pulp. Imports are sizeable but mostly refer to animal products. Bioenergy is a distant third in terms of biomass use, fuelled primarily from primary woody biomass (logwood) and to a lesser extent by imported co-/by-products (including wood pellets), crop (processing) residues and crop harvesting residues. Exports refer mostly to processed products from bio-based materials.

1.2.1 Forestry supply

As far as the forest supply is concerned, the state of Greek forests is difficult to assess due to the outdated National Forest Inventory, last updated in 1992. Despite their significant coverage, forests contribute only 0.2% to the national GDP, with production steadily declining over the past 25–28 years. A National Forest Strategy, adopted in 2018, aims to raise this percentage to 1%, however, experts question its feasibility. The Hellenic Cadastre (land registry) is responsible for updating, publication and approval of forest maps, covering 54.58% of the country so far, but legal challenges persist. Greek forests, mostly in mountainous areas, rely on traditional logging methods. The state owns 74.1% of the forests, one of the highest shares in Europe; 9% is owned by municipalities, 6.5% is private forests and 10.4% is owned by monasteries and joint ownership schemes. Fires are a major threat for the protection of forests, affecting 0.57% of the total area.

The Greek wood processing industry is relying heavily on imports, since domestic industrial roundwood production is not enough (or of the required quality) to cover its needs. Wood processing by-products are mostly already utilized for energy production, either in-house, through their upgrade into pellets, or by external biomass end-users Table 4.

Table 4 Forest resources and utilization in Greece [1]

	Value	Unit
Forest area	3,903.0	1,000 ha
Forest available for wood supply	3,594.7	1,000 ha
Growing stock	47	m^3/ha
	185	1,000,000 m^3
Coniferous trees	79	1,000,000 m^3
Deciduous trees	106	1,000,000 m^3
Annual increment	4,511.0	1,000 m^3

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Fellings in forests available for wood supply	1,463.0	1,000 m^3

The current biomass production from Greek forests is behind its potential due to difficult conditions, the lack of modern means and absence of updated forest management plans. Table 5 indicates the primary biomass potential from forests expressed in thousands of tons (Kton) of dry matter (d.m.)

Table 5 Primary biomass potential from forest in kton of dried matter [1]

Type	Ktons d,m
Final fellings from non-conifer trees	610
Final fellings from conifer trees	453
Thinnings from non-conifer trees	601
Thinnings from conifer trees	447
Logging residues from final fellings of non-conifer trees	68
Logging residues from final fellings of conifer trees	81
Logging residues from thinnings of non-conifer trees	36
Logging residues from thinnings of conifer trees	43
Total	2,339

Some relevant industries of the wood processing sector in Greece are [1]:

- **Alfa Wood** (www.alfawood.gr) is the largest wood processing industry in Greece and one of the largest in the Balkans. Alfa Wood owns three facilities in Larisa, Grevena and Nevrokopi; the last one includes the largest pellet mill in Greece, with an annual production capacity of 65,000 tons of wood pellets. All of its facilities feature biomass combustion plants, while those at Larisa and Nevrokopi have installed 1 MWe biomass CHP plants featuring the Organic Rankine Cycle technology.
- **AKRITAS** (www.akritas.gr) is the largest producer of synthetic wood products in Greece. Its production facilities are located in Tychero, Evros. In 2021 the company obtained Green Certificate for the utilization of biomass within the unit and the use of electricity produced from RES. The company also obtained EPD (Environmental Product Declaration) certification.
- **MOURIKIS S.A.** (www.mourikis.gr) is one of the largest wood processing industries in Greece, specializing in the production of wooden floors and veneer products. Its production facilities are near Corinth and feature a private jetty. Also uses wood residues in-house.

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- **Taglis S.A.** (www.taglis.gr) is a timber processing company in Dervenochoria Viotias managing wood logs from Greece and Central Europe. The company upgrades residues from wood processing (sawdust and chips) into briquettes.

1.2.2 Food and feed

The agriculture sector plays an important role in the economic activity of Greece, accounting to 4.2% of the GDP and 11% of the total employment. One of the main characteristics of Greek agriculture is its diverse production attributed to regional variations in terrain and climate allowing the cultivation of a wide range of crops. Another key feature of agriculture in Greece is its fragmentation as of the 684,950 agricultural holdings in the country, 77.3% correspond to a Utilized Agricultural Area of less than 5 ha, while the average holding size is only 6.6 ha.

There is also an important age gap, only 3.7 % of the holders being younger than 35 years, while 33.5% of them are more than 64 years. A gender cap is also apparent, with only 34.8% of farm holders being female.

In order to overcome these issues, farmers in Greece typically opt for collective forms of organization. Agricultural cooperatives are the main collaborative scheme that has been used in Greece. Lately other organization types such as producer groups are also gaining in popularity.

Current biobased industries

- **PolyHealth S.A.** (www.polyhealth.gr) located in Larisa, uses state of the art and eco-friendly, patented technologies to produce ingredients used in foods, beverages, cosmetics or nutritional supplements. The main raw material used by the company is vegetation water from olive mills, without any involvement of organic solvents.
- **Coffeeco** (https://coffe-eco.gr/) is a start-up company that is working on the isolation of phenolic compounds from coffee waste. The extracted phenols can be used as food supplements and for the production of pharmaceuticals and cosmetics. Winner in several competitions, the company has attracted funding from investors and is collaborating with companies like Nestle and Rezos Brands.
- **ProsPer** is a spin-off company of researchers from the Agricultural University of Athens. The company aims to produce 1,200 tons per year of “fish powder” from the by-products of fish processing (e.g. cutting). The material has a high nutritional value and flavour. ProsPer won the first prize in the FoodTech category of the first “Trophy – Τροφή Challenge” competition [1].

1.2.3 Indicators

Eu indicators selected for circular economy are based on Eurostat data. It is visible that in comparison of EU and Greece indicators there are some differences. For instance, Greece has a lower material footprint (12 tonnes per capita in 2023) than the EU average (14 tonnes), but its resource productivity is slightly higher (151.4 vs. 144.5). However, Greece generates

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significantly less waste per capita (2,858 kg vs. 4,991 kg for the EU in 2022), yet it lacks in recycling rates. Additionally, Greece has a much higher circular material use rate (19.5% vs. 11.5%), suggesting better reuse of materials. However, Greece falls behind in private investment and employment in circular economy sectors, with only 0.1% of GDP investment and 1.3% employment, compared to 0.8% and 2.1% in the EU, respectively. These insights indicate that while Greece generates less waste, its recycling infrastructure and circular economy investments require improvement to align with EU standards.

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Table 6 EU indicators for circular economy

Production and consumption			EU				Greece					
					update 1**					update 1**		
			base value	date	base value	date	base value	date	(+) above the EU average / (-) below the EU average	Value	data	(+) above the EU average / (-) below the EU average
Material consumption												
1	Material footprint	tonnes per capita	15	2022	14	2023	14	2022	-1	12	2023	-2
2	Resource productivity	index 2000 = 100	137.5	2022	144.5	2023	136.3	2022	-1.2	151.4	2023	6.9
3	Green public procurement											
Waste generation												
4	Total waste generation	per capita kg per capita	4,815	2020	4,991	2022	2651	2020	-2164	2858	2022	-2133
5	Generation of waste excluding major mineral wastes per GDP unit*(2010)*	kg per thousand euro, chain linked volumes	65	2020	60	2022	74	2020	9	70	2022	10
6	Generation of municipal waste per capita	kg per capita	513	2022	513	2022	509	2021	-4	509	2021	-4
7	Food waste	kg per capita	131	2021	132	2022	191	2020	60	193	2021	61

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8	Generation of packaging waste per capita	kg per capita	188.7	2021	186.5	2022	81.1	2019	-107.6	105	2022	-81.5
9	Generation of plastic packaging waste per capita	kg per capita	35.9	2021	36.1	2022	20.8	2019	-15.1	24.7	2022	-11.4
Waste Management												
Overall recycling rates												
10	Recycling rate of municipal waste	percentage	48.6	2022	48.7	2022	17.5	2021	-31.1	17.5	2021	-31.2
11	Recycling rate of all waste excluding major mineral waste	percentage	58	2020	58	2020	27	2018	-31	27	2018	-31
Recycling rates for specific waste streams												
12	Recycling rate of overall packaging	percentage	64	2021	65.4	2022	60.1	2019	-3.9	43.4	2022	-22
13	Recycling rate of plastic packaging	percentage	39.7	2021	40.7	2022	37.6	2019	-2.1	31.8	2022	-8.9
14	Recycling rate of WEEE	percentage	81.3	2021	80.7	2022	80.9	2021	-0.4	74.9	2022	-5.8

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	separately collected											
Secondary raw materials												
Contribution of recycled materials to raw materials demand												
15	Circular material use rate	percentage	11.5	2022	11.5	2022	31	2022	19.5	3.1	2022	-8.4
16	End-of-live recycling input rates (EOL-RIR), aluminium	percentage	N/A		N/A		N/A			N/A	N/A	
Competitiveness and innovation												
Private investment, jobs and gross value added related to circular economy sectors												
17	Private Investments	percentage of gross domestic product (GDP) at current prices	0.8	2021	0.8	2021	0.1	2021	-0.7	0.1	2021	-0.7
18	Persons employed	percentage of total employment	2.1	2021	2.1	2021	1.3	2021	-0.8	1.3	2021	-0.8
19	Gross value added	percentage of gross domestic product (GDP)	2.1	2021	2.1	2021	0.5	2021	-1.6	0.5	2021	-1.6

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		at current prices										
Innovation												
20	Patents related to waste management and recycling	number	206.6	2020	206.6	2020	0.5	2020	-206.1	0.5	2020	-206.1
Global sustainability and resilience												
Global sustainability from circular economy												
21	Consumption footprint	Index 2010=100	109	2022	109	2022	97	2022	-12	97	2022	-12
22	GHG emissions from production activities	kg per capita	6,481.20	2022	6475.8	2022	7,479.60	2022	998.4	7479.6	2022	1003.8
Resilience from circular economy												
23	Material import dependency	percentage	22.4	2022	22	2023	39.2	2022	16.8	39.4	2023	17.4
24	EU self-sufficiency for raw materials, aluminium	percentage	11	2022	11	2022	N/A					

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1.3 Characterization of the region through the prism of the identified resources

1.3.1 Management of Wood Packaging waste (CSS1)

Regarding the management of municipal packaging waste, currently, the separated collection of non-household packaging waste is not mandatory for all non-household sources. For businesses, there is a specific collection system covering only specific packaging waste.

Relating to the management of the Municipality's packaging waste, the Municipality makes an average of 2 routes per day to collect it from the blue bin. After their collection, the packaging waste, after being weighed, is collected in a 10 tn container, and then forwarded in accordance with the legislation to a Recyclable Materials Sorting Center in Schimatari, Boeotia. There, after their sorting, the separated streams are bundled and the outgoing materials, which are characterized by greater purity, are promoted to the materials recycling industry. From the quantity of recyclables that has been achieved by the Municipality, the Hellenic Company of Utilization - Recycling SA as a return finances it with the amount of €10/tn.

As regards green waste (pruning), this is collected separately from mixed waste and its total amounts to approximately 150tn per year. According to the Cleanliness Regulation of the Municipality of Levadia, the collection, transport and disposal of green waste takes place within 4 days from the notification of the competent cleaning service of the Municipality. In this case, green waste is collected by the cleaning service without charge. Part of the green waste (logs, etc.) is available free of charge from the Municipality to needy citizens for their heating.

1.3.2 Management of Food and Feed waste (CSS2)

One of the main cultivations in the region of Municipality of Levadia is the oil production. In our Municipality there are 9 oil mills that produce almost 1,800 tons of waste per year. The main byproducts produced from olive oil extraction are olive kernel residues, olive leaves and a waste known as pomace.

Olive kernel waste is a byproduct consists of olive pits, skins, and pulp. It is a renewable resource and it is sold from the olive oil factories for the production of olive kernel oil that is an olive oil that is extracted from olive pulp after the first press. Once the mechanical oil extraction of olive oil is complete, approximately 5–8% of the oil remains in the pulp, which then needs to be extracted with the help of solvents, an industrial technique used in the production of most other edible oils including canola, peanut, and sunflower. Although the oil extracted in this manner is still olive oil, at retail it may not simply be called "olive oil". This is because the International Olive Council defines olive oil as "the oil obtained solely

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from the fruit of the olive tree to the exclusion of oils obtained using solvents or re-esterification processes.

The olive kernel waste could be used for energy production. The use of olive kernel waste as fuel has gained attention in recent years due to its environmental and economic benefits. Olive kernel waste it is a sustainable fuel source that reduces waste and the use of agricultural waste reduces disposal costs and provides an affordable energy alternative and produce less carbon dioxide. It could be used as follows:

- Pellet Production: Olive kernel waste can be processed into biomass pellets. These pellets are suitable for use in residential and industrial heating systems.
- Direct Combustion: Dried olive kernel waste can be directly burned in specially designed biomass boilers or stoves.
- Biogas Production: Olive kernel waste can be used as feedstock in anaerobic digestion systems to produce biogas, which is a mix of methane and carbon dioxide.
- Co-firing with Coal: Olive kernel waste can be co-fired with coal in power plants to reduce reliance on fossil fuels and decrease carbon emissions.
- Charcoal Production: The waste can be converted into charcoal or biochar, which can be used as a fuel or soil amendment.

Another waste product from olive processing is the pomace. Olive pomace is the main by-product extracted from olive mills, but for many years it was considered "toxic" and particularly harmful to the environment. This is because olive pomace contains substances, polyphenols, which when they fall into water, bind oxygen and deprive it of living organisms. Therefore, the direct disposal of olive mill waste into the existing sewage system is prohibited and there is strict legislation for the uncontrolled disposal of olive mill waste to natural recipients.

However, today, olive pomace should no longer be considered toxic waste but a valuable "resource", rich in potassium, nitrogen, phosphorus, organic matter and water. With the proper processing which is known to the owners of olive oil factories it is used for fertilizing the olive grove and by doing so the save money for the producer and a way out is provided for the disposal problem of olive oil mills. Thus, olive producers can earn money from fertigation, which they would otherwise spend on fertilizers. Furthermore, the olive oil tree leaves with the proper processing can be used as fertilizers. Finally, the olive oil pomace is used as animal feed due to its nutritional value as it is composed of fibers, fat, phenolic compounds and nutrients. Its use requires careful processing and integration into a balanced diet to maximizing benefits for the feed of cattle and sheep.

All the above-mentioned usages of olive oil waste are used from the olive oil factories and by this way they participate in the procedure of circular economy with economic and environmental profits.

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Management of urban waste

Except the agricultural waste, the Municipality has to deal with the quantities of urban solid wastes (USW) that are disposed/buried at the Levadia Landfill for 2022 and 2023 are as following:

Table 7 Quantities of USW (balance sheets) of the Municipality of Levadia for 2022-2023

Year	Urban Solid Waste in tones (tn)
2022	11.377,66
2023	11.594,88

The quantities of recycling waste that are collected separately and taken to the Recyclable Material Sorting Center (RMSC) for the year 2022 are shown in the following table.

Table 8 Quantities of Recycling Waste (from the balance sheets of RMSC) of the Municipality of Levadia (2022 - 2023)

Year	Packaging Waste (tn)
2022	684,00
2023	556,89

Quality Characteristics of USW

In the Municipality of Levadia, no study has been carried out to ascertain the quality of the USW. For the purposes of this plan, elements of the quality recommendation are used according to the approved study of the Revision of the National Solid Waste Management Plan (July 2014), which is as follows:

Table 9 Qualitative Composition of Urban Solid Waste of the Municipality of Levadia

Material	% (per weight)
Organic	44,30%
Paper – Cardboard	22,20%
Plastic	13,90%
Metal	3,90%
Glass	4,30%
Wood	4,60%
Others	6,80%
Total	100,00%

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1.3.3 Current Infrastructures and Management Systems USW

The Municipality of Levadia is responsible for the collection of solid waste of M.U. Levadia, Koroneia, Davlias, Chaironea and Kyriaki. The urban solid waste for final disposal is transported and ends up in the Sanitary Waste Landfills of Levadia.

According to data of Municipality, the Collection Service has 12 garbage tracks with a capacity of 8m^3, 12m^3, 14m^3, 16m^3, and 2 of them serve the collection of recyclable materials. The characteristics of garbage tracks of the Municipality and the number of existing mixed bins are shown below.

Table 10 Characteristics of Garbage Tracks

Type of Garbage Tracks	Number
Wrecker	7
Closed Tracks	4
Recycling Wrecker	1
Total	12

Table 11 Mixed and recyclable waste bins of the Municipality of Levadia

Bin Capacity	Number
Green bins (mixed waste) 1100 lt	1,387
Blue bins (recyclable) 1100 lt	709
Green bins 240 lt	20
Total	2,116

The collection of mixed waste and transport to the Livadeia Landfill takes place 6 times a week in Levadeia, 5 times a week in Koroneia, 5 times a week in Davlia, 5 times a week in Chaironia and 5 times a week in Kyriaki.

Additionally, the Municipality of Levadia has entered into a cooperation agreement with the Hellenic Company of Utilization - Recycling SA for the alternative management of municipal packaging waste (paper, plastic, glass, metal). In the current phase, the recycling program is implemented with 709 recycling bins (blue bins) of 1100 lt. The Hellenic Company of Utilization - Recycling SA has supplied the Municipality with 2 recycling vehicles of 16 m^3. From the analysis of the data presented in the following table, it appears that the Municipality of Levadia has 1 recycling bin per 55 permanent residents.

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Table 12 Network of Recycling Bins

Municipal Unit	Permanent population (2011)	Recycling bins in total	Residents per bin
Levadia	21.932	555	40
Kyriaki	2.085	41	51
Koroneia	3.552	57	62
Davlia	1.851	26	71
Charonia	1.615	30	54
Total	31.035	709	55

Evaluating the data on the low volume of recyclable waste and the high volume of urban waste that ends up in the landfill it is concluded that both residents and businesses in the area need to be made aware so that the volume of waste is reduced.

1.4 Analysis of barriers to implement circular economy or green transition solutions

1.4.1 Technical

One of the main challenges faced by Producer Responsibility Organizations is the **contamination and the impurities** of the collected material due to the citizens' unawareness of the acceptable materials for recycling and the conditions to which they should dispose of their recyclables (empty, clean, etc.)[2].

Regarding to wood waste, there are no firm plans to improve the wood collection, however there are ongoing discussions to enhance separate collection of wood. Currently, wood waste is collected via lower service level bring points in cities, towns, and suburbs. For businesses, there is a separate collection system covering only specific packaging waste, such as pallets. In rural areas, no separate collection of wood is provided [3].
For Greece to achieve the targets, separate collection of good quality is a pre-condition with no impurities, which can only be accomplished by implementing separate collection. To validate the potential expectations, it is highly advisable to perform a waste composition analysis regularly.

As for the treatment capacity, **bio-waste treatment capacity** is below 80% of the generated municipal bio-waste and plans to increase capacity are not sufficient to close the gap. Practically, the current treatment capacity (145,000 tonnes) is adequate to treat only a very small share of the bio-waste generated. Although Greece is in the process of increasing

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capacity substantially, the total capacity will still be below 50% of generated biowaste after the implementation of the plan [1].

1.4.2 Legislative

The standard **VAT rate** in Greece is 24 %. Among many others, it applies to the use of biomass as fuel: firewood, wood pellets, exhausted olive cake, etc. The high VAT could slow down the adoption of advanced biofuels, biorefinery processes, and other innovative bio-based technologies. Investors and businesses may hesitate to integrate new technologies due to higher operational costs and lower price competitiveness.
A reduced VAT of 13 % is applied to several food products as well as many agricultural inputs. An extra reduced VAT of 6 % applies to certain energy products (electricity, natural gas and heat from district heating) and pharmaceuticals. However, bio-based industrial products that do not qualify for reduced VAT might face higher costs, making them less attractive compared to conventional alternatives [1].

The **landfill tax** is currently law. The Landfill Tax was introduced in 2014 and the implementation was delayed due to: a) no basic waste management infrastructure, b) waste was not weighed at the landfills, c) recycling faced serious problems, which the State and the Greek Recycling Organisation would not solve, d) the Brown Bin did not exist, e) sensitisation was presented as a cost and not as an investment [4]. Thus, Prevention remained non-existent, and Separation at the Source has remained stagnant. In 2021, the Landfill Tax was reintroduced by Law 4819/2021, at 20€/tonne for the year 2022 and would gradually reach 55€/tonne in 2027 [4].
However, an increase in the cost of official waste disposal might also lead to a rise in illegal waste dumping, causing failure to achieve both environmental and revenue-raising objectives [5].
According to Article 43 of Law 4042/2012, all revenues from the landfill tax (estimated approximately EUR 140 to 250 million per year) are supposed to go to the 'National Green Fund' set up by the Greek Government in 2010. The objective is that these revenues could finance waste recovery and disposal projects.

Pay-as-you-throw (PAYT) schemes implemented in some regions and municipalities (50-80% of population covered) or in some municipalities, less than 50% of the population covered by PAYT or even not implemented at all [3]. This scheme applies the pivotal environmental principal of "the polluter pays" aiming to reduce waste produced at source. So far, only pilot projects in some municipalities have been implemented [3], [6]. According to the Article 37 of Law 4819/2021 PAYT schemes will become the basic pricing model for municipal waste; from 1st January 2023 and onwards, municipalities of a population between 20,000 and 100,000 should apply PAYT for biodegradable waste from food establishments; municipalities of a population of 10,000 should apply PAYT from hotels;

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municipalities of more than 100,000 should apply PAYT schemes; and, finally, from 1st January 2028, municipalities of a population between 20,000 and 100,000 should apply PAYT schemes. However, the Greek authorities consider this recommendation not implemented. Also, this radical change of charging municipal tax has not been properly communicated to the local authorities nor to the citizens who will be obliged to alter their long-term everyday habits [6].

Greece has transposed the amended **Waste Framework Directive** into national law with delay of > 12 months as the directive has been transposed into national legislation in late July 2021, slightly more than one year after the deadline of July 2020. Timely transposition of the Waste Framework Directive, as amended by Directive 2018/851 into national law within the foreseen period is key for a waste management system in line with EU requirements. Greece has transposed the amended Waste Framework Directive into national law: Law 4819/2021 on Integrated framework for waste management - Transposition of Directives 2018/851 and 2018/852 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste and Directive 94/62/EC on packaging and packaging waste, organizational framework of the Hellenic Recycling Organization, provisions for plastic products and the protection of the natural environment, spatial planning, energy and related urgent arrangements [3].

1.5 Identification and analysis of the stakeholders (including existing networks and connections between them)

The Region of Central Greece, in collaboration with the Municipality of Levadia and NTUA, has identified a list of local stakeholders operating in sectors relevant to the two selected CSSs (CSS1 – wood packaging and CSS2 – food and feed). These include wood processing companies, livestock and dairy product industries, and agricultural cooperatives located across Fthiotida, Evia, Viotia and Evrytania as indicated in Table 13.

Table 13 Stakeholder mapping

Stakeholder	Location	Short description
XYLOMET S.A.I.C	Lamia Fthiotida	Trade and processing of wood
Wood processing industry Vassilios Pilatos&Son	Lamia Fthiotida	Trade and processing of wood
EY TREFO AVEE	Aliveri, Evoia	Production and trade of animal nutrition
DRIVAS (Farm Drivas)	Lamia Fthiotida	Livestock breeding and trading

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KREATAGORA LAMIAS PC	Lamia Fthiotida	Import-export of livestock, wholesale, meat standardization, and meat product sale
Agricultural Cooperative of Lamia (L' ami)	Lamia Fthiotida	Production and trading of dairy products, collection, and milk processing
I. Chountasis - A. Zografos G.P. / Karystos Slaughterhouses S.A.	Karistos, Evoia	Butchery, breeding, and trading of livestock
KOLLIMENOS WOOD	Karpenisi. Evritania	Trade and processing of wood
Zisimos Dairy Products	Lamia Fthiotida	Production and trading of dairy products
RENTZOPOULOU L, S.A.	Lamia Fthiotida	Trade and processing of wood
Vootrofiki Ritsonas - Kylertzis	Chalkis, Evoia	Breeding and trading of livestock, fresh meat trading
BIOMAZ	Magoula, Attiki	Production and trading of pellet

While the initial list of stakeholders included a relatively broad set of businesses, after initial screenings and informal feedback collection, the number of truly relevant and approachable stakeholders was significantly reduced. Many actors either did not operate directly in the targeted resource missions or lacked the capacity or interest to engage in circularity-oriented dialogue.

Nevertheless, some targeted outreach has already begun, mostly through direct contact. For instance:

- *Kollimenos Wood*, based in Karpenisi (Evrytania), was contacted by phone and was introduced to the project scope and goals. The company expressed interest in hearing more about opportunities, especially if pilot collaborations or funding become available.
- Similarly, the dairy industry “L’ami” in Lamia was also approached. During the exchange, representatives expressed preliminary interest in engaging, especially concerning the valorization of production residues and potential resource efficiency improvements.

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Through this process, it became clear that most stakeholders currently demonstrate interest only when funding opportunities are directly visible, and less in the establishment of a long-term knowledge base that could support them sustainably in the future. This limits their immediate engagement and complicates the formation of a stable circular innovation ecosystem.

A small subset of businesses—mostly larger or more export-oriented—have already implemented some circular practices on their own initiative. However, these actors are typically hesitant to openly share knowledge or participate in collaborative pilots, as they perceive circular innovations as competitive advantages.
In summary, the Region of Central Greece acknowledges that stakeholder identification is an evolving process, and that cultural attitudes and historical experiences influence local business engagement. Overcoming skepticism and shifting the narrative from cost and funding dependence to long-term value creation will require dedicated effort, time, and personnel.

1.5.1 Map stakeholders in terms of location and their interest value chain

The stakeholders identified across the Region of Central Greece are geographically distributed across the four regional units most relevant to the resource missions (Fthiotida, Viotia, Evrytania and Evia), with concentration around specific value chains:

CSS1 – Wood Packaging & Wood Processing

- **Karpenisi (Evrytania)**:
  – *Kollimenos Wood* – timber processing, residual utilization potential.
  – Focus: Upstream wood supply, potential circular interventions in by-product management.
- **Lamia (Fthiotida)**:
  – *Pilatos & Son*, *Rentzopoulou S.A.*, *Xylomet* – wood trade and transformation.
  – Focus: Industrial reuse potential, link to packaging production, small-scale residue valorization.
- **Dervenochoria (Viotia)**:
  – *Taglis S.A.* – industrial-scale timber processing.
  – Focus: High-volume residue streams, potential for energy valorization and circular logistics.

CSS2 – Food & Feed Sector

- **Lamia (Fthiotida)**:
  – *Agricultural Cooperative L'ami* – milk collection and dairy production.
  – Focus: Dairy waste valorization, circular by-product exploitation.

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– *Kreatagora Lamias*, *Drivas Farm* – livestock and feed trading.
– Focus: Organic waste management, potential circular feed loops.

- **Karystos (Evia)**:
  – *Karystos Slaughterhouses S.A.* – butchery and livestock operations.
  – Focus: animal by-product handling and processing, opportunity for bioresource circularity.
- **Aliveri (Evia)**:
  – *Ey Trefo AVEE* – animal feed production.
  – Focus: Industrial reuse of organic inputs, potential integration of local waste flows.
- **Levadia (Viotia)**:
  – Focus: Plant-based ingredient processing, waste valorization opportunities, sustainable cultivation systems.
- **Lamia (Fthiotida)** – **Stevia Hellas**:
  – Innovative agri-food company specializing in the cultivation and processing of stevia.
  – Focus: Bio-based circular practices in precision agriculture, potential use of crop residues, and alignment with green processing.

While these stakeholders are positioned at different points in the value chain (producers, processors, aggregators), **most operate in traditional linear models**. A few (like *Taglis S.A.* or *L'ami*) show **early-stage alignment with circular principles**, while others could be integrated through targeted incentives and demonstration pilots.

Levadia (Viotia) and Lamia (Fthiotida) – Stevia Hellas represent examples of more innovation-oriented actors in the region, especially within the niche field of plant-based nutrition and natural sweeteners. Their experience in certification, exports, and sustainable cultivation potentially positions them as early adopters or knowledge carriers within the CSS2 scope, although further engagement would be required to confirm the extent of their alignment with the FRONTSH1P objectives.

1.5.2 Collection of Contact Information

In the current phase of stakeholder mapping, basic contact details have been collected for the majority of the key stakeholders listed, either through public company registries, prior collaborations (e.g. via local chambers of commerce), or initial outreach.

- For companies such as **Kollimenos Wood**, and **L'ami Dairy Cooperative**, **direct phone contact was established** as part of the first round of exploratory

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communication. The discussions were informal and limited to initial presentation of the project and brief exchanges regarding potential interest.

- In the case of other stakeholders such as **Stevia Hellas**, **Taglis S.A.**, and **Karystos Slaughterhouses**, **publicly available contact information was gathered** for future use (company websites, local industry directories, or the Boeotia Chamber of Commerce database).
- No formal cooperation agreements or consent for structured data exchange have been established at this stage, as the goal of this phase was primarily to gauge interest and identify initial communication entry points.

Due to the lack of dedicated regional staff and structured stakeholder engagement strategy thus far, contact has remained sporadic and preliminary. However, the information collected is sufficient to initiate targeted invitations for the upcoming engagement activities, such as stakeholder meetings, circular economy awareness events, or data-sharing workshops.

Initial outreach to stakeholders, including companies operating in the wood packaging and food/feed sectors, revealed that their interest in FRONTSH1P is mostly linked to the potential for new funding opportunities or access to technical support. Several businesses expressed a positive attitude toward exploring ways to exploit their by-products or improve their resource efficiency, but this interest is highly conditional on the presence of concrete and immediate benefits.

It became evident during the initial teleconferences organized within the framework of the project that, although the Region of Central Greece had initiated communication with local businesses, the effort lacked structured support tools such as:

- standardized presentation material introducing the project and its relevance to specific sectors;
- ready-to-use questionnaires or engagement forms tailored to the circular potential of each industry;
- and most importantly, a clear and strategic framework for stakeholder engagement.

This gap was openly communicated by the Region during coordination meetings, emphasizing the need for centrally provided support and harmonized materials. As a result, the current engagement model emerged gradually through a combination of bottom-up feedback and learning-by-doing.
Nevertheless, it must be highlighted that effective stakeholder engagement, particularly in a region with limited prior exposure to circular economy programs, requires dedicated personnel, time, and financial resources. Without such investment, efforts tend to remain fragmented, and valuable opportunities for deeper collaboration are lost. A robust and

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ongoing stakeholder management strategy cannot be built on ad hoc outreach alone; it demands consistency, monitoring, and long-term planning.

1.5.3 Stakeholder interest in FRONTSH1P and circular economy knowledge development

From the outreach efforts conducted so far, it is evident that most stakeholders view FRONTSH1P primarily through the lens of financial opportunities rather than long-term strategic benefits. Their main expectation is to explore how circularity can generate tangible cost savings or new revenue streams, particularly through:

- More efficient management of production by-products, reducing waste disposal costs.
- Potential new markets for secondary materials (e.g., wood residues, food waste repurposing).
- Access to funding mechanisms that support circular business models.

However, a significant knowledge gap remains regarding the broader benefits of circular economy principles. Most businesses have limited prior exposure to structured circular transition frameworks and tend to prioritize immediate profitability over systemic sustainability.
While some more advanced companies (such as Stevia Hellas) have already integrated elements of circularity due to market demands and certification standards, they remain selective in knowledge-sharing and hesitant to engage in collaborative initiatives.
To address this, the Region of Central Greece acknowledges the need for:

1. **Targeted awareness-raising initiatives**, showcasing real-world business cases of circularity.
2. **A structured dialogue mechanism**, where businesses can exchange knowledge without fearing competitive disadvantages.
3. **Policy alignment and economic incentives**, ensuring that circular transition is not perceived as an additional cost but as a long-term investment.

By fostering an incremental and trust-based engagement strategy, FRONTSH1P can help businesses move beyond a funding-driven mindset and towards sustainable circular practices that offer long-term resilience and market advantage.

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1.6 Engagement of stakeholders

Stakeholder engagement in the Region of Central Greece is currently in an early exploratory phase, shaped by initial communications, informal feedback collection, and local insights into the business landscape. The Region, in collaboration with the Municipality of Levadia and NTUA, has initiated direct contact with a selected number of companies relevant to the CSS1 (wood packaging) and CSS2 (food & feed) sectors. However, the engagement strategy must now be structured into a more systematic approach.

Stakeholder Identification & Mapping

The Region of Central Greece has mapped key stakeholders in two major categories:
✓CSS1 – Wood Packaging & Processing
✓ CSS2 – Food & Feed Industry
The stakeholder identification process initially included a broad range of businesses, but after an initial assessment and outreach, the list has been refined to focus on actors that are:

- Hesitant stakeholders: Businesses with limited exposure to circular economy initiatives, which remain skeptical about the added value.
- Potentially engaged stakeholders: Businesses that show interest but require clear incentives before committing.
- Advanced businesses: Companies that have already implemented circular practices independently but are reluctant to share knowledge.

This classification highlights the need for differentiated engagement strategies to match the level of awareness and willingness of each group.

Communication Plan

During the early teleconferences within FRONTSH1P, it became clear that the Region of Central Greece lacked structured engagement tools, such as:

- Standardized presentation materials explaining the project and its benefits.
- Questionnaires tailored to each business sector.
- A clear strategy for approaching stakeholders, adapted to local market conditions

As a result**, early communication efforts were fragmented,** with outreach occurring mainly via:

- Informal phone calls and emails to selected businesses (e.g., *Kollimenos Wood, L'ami Dairy Cooperative*).

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- Leverage of existing local business networks for initial connections.
- Ad-hoc explanations of the project's goals, without a structured engagement script.

Moving forward, the Region aims to develop a **more formalized communication strategy** focusing on:

1. Developing engagement materials – structured presentations and targeted messaging.
2. Adapting the approach based on stakeholder profiles – ensuring relevance for each sector.
3. Using multiple communication channels – workshops, direct meetings, and digital platforms.

Assessment of the Existing Plan Using Feedback

The initial outreach efforts highlighted several key challenges:

- Most businesses prioritize funding opportunities over knowledge-sharing or long-term circular transition goals.
- Companies that have already implemented circular solutions view their strategies as competitive advantages and are reluctant to participate in open discussions.
- There is a general skepticism towards public and European initiatives, due to past experiences where projects did not yield immediate financial benefits.
- Effective engagement requires dedicated personnel, time, and financial resources, which are currently limited at the regional level.

To overcome these challenges, the Region must explore alternative engagement incentives, such as:

- Participation in future research and innovation initiatives.
- Training and advisory support on circular practices.
- Networking opportunities with similar enterprises and knowledge hubs.

By shifting the focus from immediate financial incentives to long-term value creation, the Region can gradually change perceptions and encourage participation.

Meetings & Stakeholder Council

- **Meetings**

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The Region is planning a series of stakeholder engagement meetings, where:
* Businesses will be introduced to the opportunities and benefits of circular economy participation.
* Practical examples and pilot initiatives will be showcased to increase credibility.
* Open discussions will be encouraged to address concerns and skepticism.

- **Stakeholder Council**

To ensure continuous engagement and trust-building, the Region is considering the formation of a Stakeholder Council, which will:
* Include representatives from businesses, local government, research institutions, and industry associations.
* Act as a monitoring and advisory body, providing feedback on circular economy activities.
*Facilitate collaboration between stakeholders, helping to bridge gaps between businesses and policymakers.

The success of this Council will depend on:

- The willingness of stakeholders to actively participate.
- The establishment of a clear operational framework.
- The allocation of necessary resources to sustain it over time.

The Region of Central Greece recognizes that effective stakeholder engagement requires **a structured, long-term strategy**, rather than ad-hoc interactions. Moving forward, the focus will be on:

- Structuring targeted communication tools that align with business realities.
- Organizing engagement meetings and a stakeholder council to create a sustained dialogue platform.
- Addressing trust and knowledge-sharing challenges by developing incentives beyond direct financial support.

By establishing a regional stakeholder engagement framework, FRONTSH1P can help lay the foundation for a sustainable circular transition that benefits both businesses and the broader regional economy.

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1.7 Analysis of the supply value chain

Based on the analysis above, the identified areas that require support in terms of circularity are the food and feed industry, and the wood processing. Regarding the food and feed industry, the requirements of Greece are focused more on the dairy products and the breeding and trading of livestock.

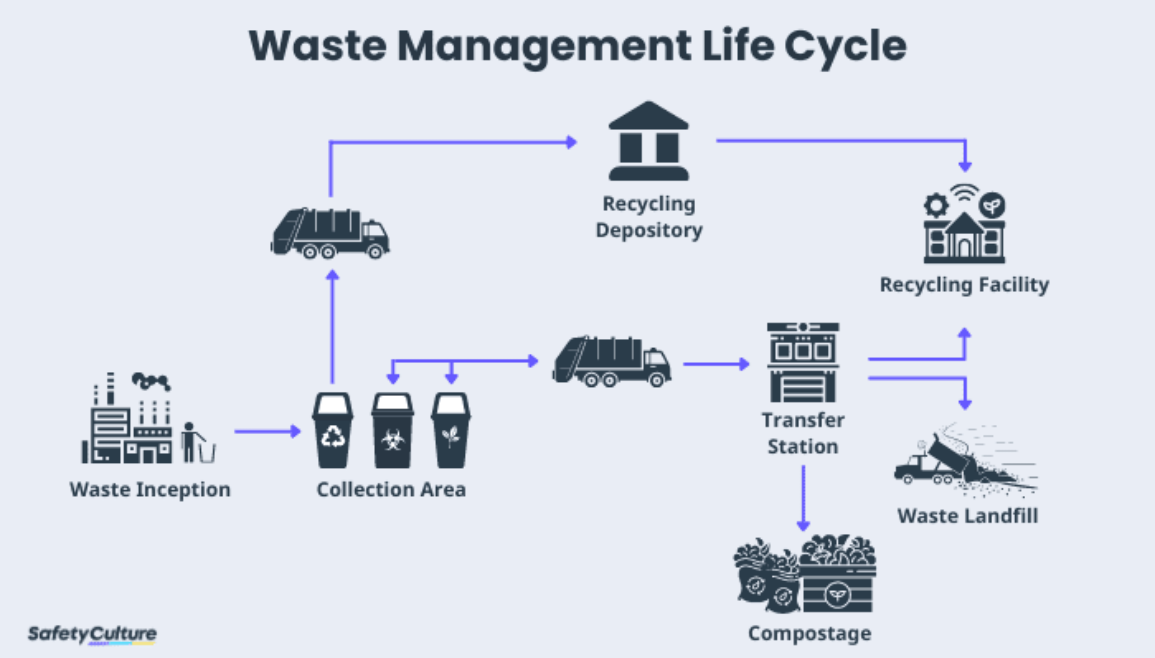

Figure 3 Waste management value chain[7]

The value chain of waste management is a five-step process that includes the primary waste collection system in which the segregation of wastes in specialized containers takes place, followed by the transportation system at waste treatment sites. After the processing of the collected waste, the residues are sent to a sanitary landfill facility.

1.7.1 Wood

The consequences from the disposal of pallets, old furniture, and branches in landfills are two-fold. Not only does it harness the environment by creating greenhouse gas emissions, but also it is not utilized as a secondary energy source. Therefore, environmentally friendly techniques in wood recovery from wood-waste need to be implemented.
One possible alternative is wood recycling as it promotes the natural resources' protection, enhances the volume reduction of waste in the landfills, and produces good-quality compost meeting the National Recycling Goals.

The origin of the waste for recycling is usually from worn pallets that are broken and can not be reused, wooden boxes of all kinds, timber from buildings and mainly from demolitions, Branches of pruning trees, remnants from furniture workshops, carpentry, etc, and advanced industrial wood.

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Firstly, the waste is collected, transported, and then treated for the recovery of useful materials or the production of secondary materials. The treatment of the wood waste is initially hand-based to remove possible impurities from the main material stream. Then, the clean wood input stream is crushed through a special shredder. During the extraction process of the shredded material from the shredder, the wood stream passes through a magnet. The magnet's purpose is to isolate and collect any remaining small metal piece (nails, screws, hoops, etc.). The final fine product is now ready to be used as a raw material in the wood industry, for the production of paper or even for the production of alternative fuels through composting or biogas procedures [8].

Several industries in Greece recycle wood wastes. For instance, ELDIA as well as Rewood use special equipment (crushers and sieves) to convert wood waste into a usable alternative fuel source (biomass). Siakandaris Group operates a wood recycling center with modern technological equipment and specialized personnel, in accordance with the requirements of domestic and EU legislation and also provides portable equipment for working in situ.

1.7.2 Food and feed

The **dairy industry** has an important position among the food industries. Milk and other processed dairy products can form the main components of food waste in significant amounts. Such waste can be produced during the production, processing, and distribution of dairy products. Sources of dairy waste include a wide range of substances like excess milk from spills, cleaning solutions, whey, residues from equipment, and other organic matter[9]. Considering their high organic contents, the treatment of dairy wastes is harmful to the environment, as these wastes can contaminate water sources, contribute to air pollution, and harm ecosystems.

However, dairy wastes are evaluated as an alternative substrate in microbial production processes such as bioenergy, enzymes, organic acids, biopolymers, biomass, etc. A common dairy waste management method is aerobic or anaerobic biological treatment, in aerobic or anaerobic ponds accordingly [9]. This process promotes the growth of bacteria that helps break down the organic matter (Figure 4). Composting, is another sustainable approach to manage dairy waste as it can convert it into a nutrient-rich product, using microorganisms to break down detrimental organisms.

The production of value-added products such as nisin, biomass, and lactic acid can be included in sustainable consumption and production goals, while the production of bioethanol, biogas and biohydrogen can be suitable for affordable clean energy.

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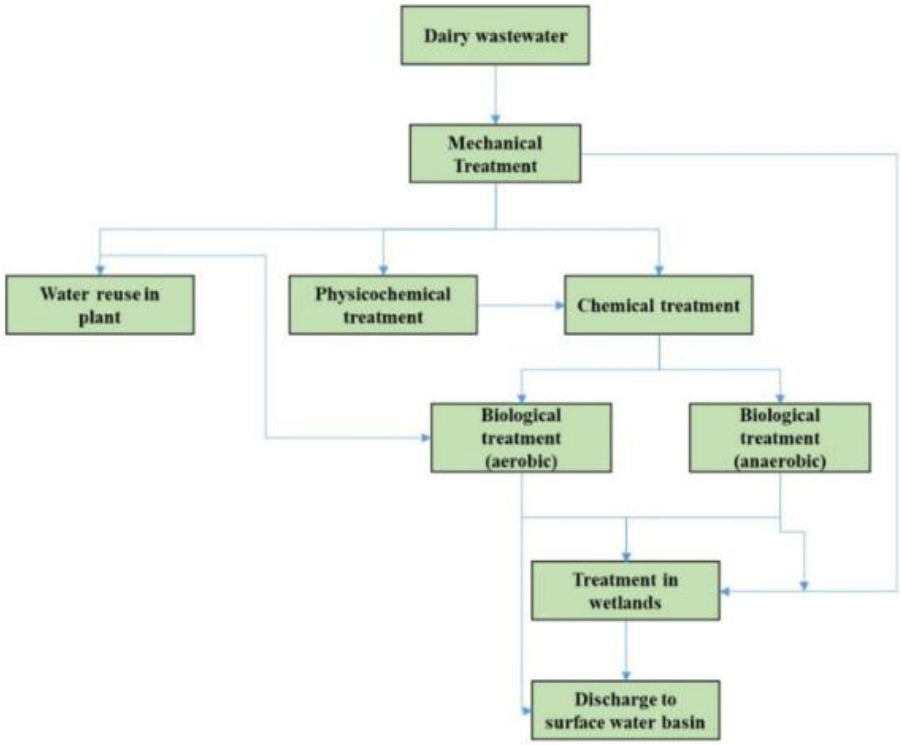

Figure 4 Value chain of management of dairy wastewater [9]

The waste materials generated in a **butchery industry** typically include organic waste from trimmed meat, fat trimmings, bones, and other organic by-products produced during meat processing. Also, recyclable materials (plastic, glass), mostly from packaging materials are produced. Effective separation and recycling of these materials can significantly reduce their environmental impact. Overproduction, production spoilage due to improper storage, processing losses, packaging failures, retail and restaurant overstocking are potential reasons for waste production.

The mishandling of butchery waste carries significant environmental risks, including soil contamination and reducing agricultural productivity in nearby areas, greenhouse gas emissions, water pollution, and biodiversity loss. Contaminated environments and disrupted ecosystems can result in the loss of various plant and animal species, further destabilizing natural habitats.
Sustainable disposal, such as composting, and anaerobic digestion for the production of biogas or fertilizers is preferable to conventional methods of incineration and landfilling (Figure 5).

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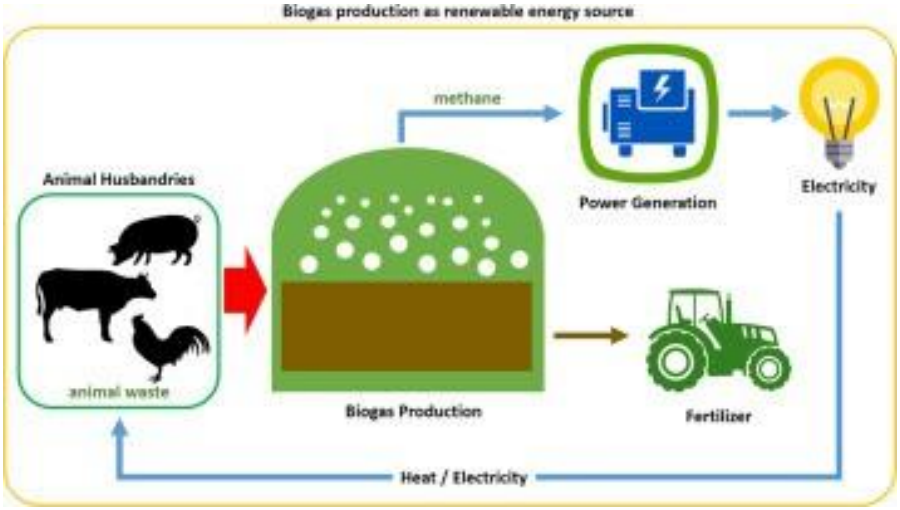

Figure 5 added value products from butchery waste [10]

Furthermore, repurposing of waste materials is also a sustainable solution. Animal fats can be transformed into products like soap or biodiesel, bones can be used to create gelatin, and meat organs find application in pet food. Meat waste can also be composted and used as a nutrient-rich fertilizer in agriculture. Other industries can also be benefited as well, for instance fashion and textiles industry, by utilizing leather. Lastly, unsellable meat can be donated to community programs, enhancing local needs while reducing waste [11].

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STAGE II. RESOURCES MISSIONS AND CSSs

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2 Stage 2: Resources & Missions Selection

In line with the analysis in Stage 1 for the replication strategy, to be integrated in the central region and the Levadia municipality, the main related sectors are agricultural activities and livestock industries. Based on the preceding analysis, agriculture emerges as the primary activity in the region, playing a crucial role in the local economy. Additionally, the identified stakeholders include wood processing companies, livestock and dairy product industries, and agricultural cooperatives. Therefore, local stakeholders in the municipality of Levadia are mainly operating in three sectors. These include animal breeding and trading, the production and trading of dairy products, and the production and trading of wood and pellets. These sectors correspond to the broader categories of wood, food, and feed processing. Moreover, these sectors are directly linked to Circular Systemic Solution 1 (CSS1) and Circular Systemic Solution 2 (CSS2), as the waste streams generated from their operations can be repurposed as inputs for these circular solutions, thereby enhancing sustainability and resource efficiency within the region.

2.1 CSS Definition

According to the selection of resources and the project specifications, the Greek replication plan involves Circular Systemic Solution 1 (CSS1), concerning the valorization of wood packaging waste, and Circular Systemic Solution 2 (CSS2), referring to the valorization of food and feed waste.

CSS1

The CSS1 focuses on the sustainable management of wood packaging waste through end-of-life disposal, reuse, and recycling. CSS1 aims to contribute to a circular economy by reducing the environmental impact associated with wood packaging through improved design, manufacturing, and end-of-life management strategies.

From the perspective of sustainably using raw wood through a circular economy approach, it is crucial to properly manage the wood waste generated at each stage of the value chain. The classification of wood waste varies based on the chosen subdivision criterion. There are three main groups of wood waste. The first group consists of waste from forest management, such as residues from maintenance activities. The second group includes wood waste from industry, which is generated during the production of final goods. Industrial wood waste arises from processing raw wood materials and can include particles, shavings, sawdust, wood dust, wood chips, and bark. The third group encompasses post-consumer waste, which derives from the consumption of final goods. This group is the most diverse and includes, among others, wood from demolition, furniture, windows and doors, and packaging, such as pallets or paneling and flooring.

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To this end, CSS1 integrates innovative solutions to improve sustainability and efficiency. Within the project, the CSS1 system introduces a polygeneration scheme for processing wood waste for the simultaneous production of bio-energy, bio-syngas, biogenic CO2, and char, a solid by-product containing carbonaceous and metallic elements. Additionally, the valorization of waste facilitates the recovery of valuable side products, such as tar, a significant organic compound. FRONTSH1P incorporates gasification technology not only to optimize poly-generation capabilities across three basic energy streams but also to value all potential by-products as part of the circular economy, leveraging the versatility of gasification technology.

Additionally, Carbon Storage and Capture can be applied to the emissions generated by CO_2, thus integrating with other systemic circular solutions. These technologies complement each other throughout the process, enhancing resource efficiency and promoting a more sustainable and ecological system.

CSS2

The CSS2 focuses on the utilization of biodegradable waste from urban and industrial areas to produce bioenergy, compost, and bioplastics. Bio-waste, primarily composed of food and garden waste, is a key waste stream with significant valorisation potential, supporting the transition to a circular economy. It produces valuable materials that enhance soil and fertilizer quality, as well as biogas, a renewable energy source. With a share of 34%, bio-waste is the largest homogeneous component of municipal waste in the European Union. Biodegradable fractions in the municipal waste stream, classified into group 20, according to the waste catalogue for Municipal Waste with Separately Collected Fractions, primarily include:

- Kitchen waste as well as expired food and food that is unsuitable for eating,
- Green waste from the maintenance of green areas, gardens, parks, and cemeteries,
- Paper, cardboard, wood,
- Clothes and textiles of natural and biodegradable materials.

Depending on the source of biodegradable waste and the place it is produced, it can be classified as municipal or non-municipal waste. The latter one refers to industrial and production waste, including:

- Agricultural and food waste: produced on agricultural, horticultural, and breeding farms, in sugar factories, distilleries, abattoirs, dairies, cold stores, and other plants dealing with food production and processing. This group includes agricultural and processing waste, which means: plant-tissue waste and animal tissues, animal manure (solid manure, liquid manure, chicken manure), products unfit for eating and further processing, washing and material preparation waste,
- Forest and industry waste, energy crop waste,
- Sewage sludge from sewage treatment plants,

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- Paper and cardboard, wood, and natural fibre textile packaging waste.

Industrial waste also includes the biodegradable fraction from the process of mechanical treatment of mixed municipal waste.

In the project, CSS2 is closely interconnected with other CSSs. It aims at obtaining Free Fatty Acids (FFAs) as a component for foaming biomaterials through the pre-treatment of agro-industrial waste combined with biotechnological treatments. It also aims to develop innovative oil crop cultivation in marginal and abandoned agricultural areas to produce vegetable oils, which can be converted into biodegradable biolubricants and locally available animal feed supplement formulations. Additionally, another goal is the production of biobased building blocks, such as diols and dicarboxylic acids, from second-generation feedstock derived from regional agro-industrial waste rich in sugars, to formulate new compostable bioplastics like compostable bags for municipal solid waste collection.

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STAGE III. CHALLENGES

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3 Stage 3: Challenges

The circular challenges identified in previously defined Resource Missions (Stage 2) emphasise sustainability, innovation and adaptability. Circular Challenges will often require circular innovative solutions, sometimes they will require circular systemic solutions (CSS). The catalogue of challenges is open and includes, for example:

1. legal framework
2. innovation, product design and value chain
3. infrastructure, investments, entrepreneurship
4. social inclusion, awareness, and knowledge

The implementation of circular challenges is a kind of 'circular acupuncture' targeting 'touch-shot' at key initiation points. It implies a point-of-care approach to intervening in different areas of resource management in the region. The identification of challenges responds to previously diagnosed potentials, barriers and incentives (see step one). Challenges can be interdependent, meaning that the implementation of one of the Circular Challenges in a Mission can affect the implementation status of other Missions.

The tables below describe the challenged identified in Central Region and Levadia Municipality, for CSS1 and CSS2:

Table 14 CSS1 Challenges

CSS 1 Wood Packaging	
Legal Framework	
Regulatory and Legislative Reforms	Clarification of the distinction between waste and products that can be used as secondary raw materials
	Update the National Waste Management Plan annually, based on calculations of total packaging waste generated, reused, and recycled, in alignment with EU target rates
	Completion of the legislative framework for wood waste management
	Ensure strong and close follow-up by YPEN during the implementation of separate collection within the next years concerning the regions and municipalities
	Active participation in public consultations to influence

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	legislative changes regarding the circular management of wooden packaging waste and by-products
Local Level	Creation of Green Points, which are specially designed spaces equipped with the appropriate infrastructure for citizens to deposit separately collected recyclable municipal waste or used objects for recycling or reuse
	Developing the potential of the institutional framework of Law 4513/2018 on Energy Communities at the local level, through RES technologies and improvement of energy efficiency
	Results of the collection schemes should be evaluated monthly
	Checking all stages of wood waste management, and installing a GPS system to monitor the transportation of waste by road
	Development of tailored incentives for diverse stakeholder groups, entrepreneurs, non-governmental organizations, and local communities, to promote the circular management of wooden waste
Governance	Incentivised citizens owning small private properties with reduced wood waste generation
	Evaluation results of the collection schemes and treatment capacities should be reported for each region in Greece, based on data supplied from the region's biannual report to YPEN
Awareness and Knowledge	
Education	Organise workshops, conferences, and educational programs to inform students about the circularity of wooden waste recyclable packaging
	Informational activities concerning wood packaging, gasification technologies, and the possibility of using by-products throughout the value chain in alignment with circular economy principles
Information and Promotion	Creating and promoting Guides for improving energy efficiency in packaging productive procedures
	Awareness campaigns through the local mass media (i.e. magazines, newspapers), leaflets in several languages to include refugees and tourists, and an annual waste calendar with current news on the management of packaging waste

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	Obligation to inform consumers of repairable products such as furniture (Article 17 of Law 4819/2021)
Economic Incentives	
Regulatory and Legislative Reforms	Ensure the implementation of the legally defined fines for the disposal of untreated waste
	Implement a circular economy penalty on all municipalities that fail to comply with the national strategy obligations
	Establish a "Circular Economy fee" on single-use containers and promote other incentives for reusable packaging
	Implementation of a micro-grant program for residents to support the promotion of their own circular initiatives, including those related to wooden packaging
Local Level	Require all involved stakeholders in each region (Municipalities, Government representatives) to attend regular biannual exchange meetings regarding progress in the separate collection of packaging waste

Table 15 CSS2 Challenges

CSS 2 Food and Feed	
Legal Framework	
Regulatory and Legislative Reforms	Completion of the legislative framework for municipal waste management
	Clarification of the distinction between waste and products that can be used as secondary raw materials or for bioenergy production
	Develop a methodology framework to measure and monitor food waste by setting quality standards for compost as End-of-Waste criteria
	Set evaluation standards for composting from pre-selected organic waste
	Perform regular analyses of the waste composition at regional level at treatment facilities and update NWMP and the evaluation of the EPR systems based on the results
	Ensure that input waste analyses and output waste streams, including impurities from all treatment facilities,

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	comply with EC decision 2019/1004 concerning waste data calculation
	Establishing a regulatory framework to facilitate the production of bio-methane from organic waste and its injection into the natural gas grid
Local Level	Establishment of Green Points that are urban centres for collecting, sorting, and recycling municipal waste at source
	Apply waste collection without trucks, in different bins in high-touristic islands. The bins should be of high aesthetics, to achieve harmonization with the surrounding environment
	Implementation of a tourist tax to cover additional costs for separate collection, new transfer stations for dry recyclables, and treatment facilities for bio-waste
	Encourage knowledge sharing regarding improving collection efficiency by facilitating regular exchanges between departments in each Region or on a national level
	Increase the collection frequency in summer in densely populated areas and touristic islands
Governance	Ensure the implementation of the legally defined fines for the disposal of untreated waste
	Support the utilization of the revenues from landfill tax to enhance the separate collection schemes (bins, trucks, awareness campaigns)
Awareness and Knowledge	
Education	Encouraging the local communities through informational campaigns and training initiatives to adopt a circular approach to the use of organic waste
	Administration Education and Training Programmes for local circular economy leaders, regarding efficient municipal waste management
	Promote the importance of reduce, reuse, and recycle as educational activities in school
Information and Promotion	Informational activities concerning possibilities of food&feed waste processing, align with circular economy principles
	Special programmes for informing -raising awareness on food waste
	Developing and implementing an ongoing social media campaign focused on organic waste management

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	Formulation of proposals and measures to enhance knowledge and information on various issues of circular economy
Infrastructure	
Infrastructural investments	Include capital costs into the annual budget for waste management – and regularly update the machinery (about 8 to 10 years latest)
Financing	
Governance	Promotion of available funding sources for initiatives carried out in the value chain of organic waste, its by-products and marginal lands
	Develop sustainability criteria for the funding and implementation of biomass projects by establishing working groups, including relevant stakeholders
	Incentivized citizens , through waste compensation for citizens implementing home composting

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Stage IV. Action Plan

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4 Circular Economy Action Plan for central region & Levadia - CircuPuncture Action Plan

The Region of Central Greece and the Municipality of Levadia face very specific challenges, identified in previous stages, that require the adoption of innovative solutions for the development of the circular economy.

These challenges are **technical, legislative,** and **organizational** (lack of synergies among the businesses operating in the area), as well as **geographical,** with large distances between them, which hinder the development of corporate collaborations. The stakeholders are positioned at different points in the value chain (producers, processors, aggregators), resulting in operations that are mostly conducted in traditional linear models. A few (like *Taglis S.A.* or *L'ami*) show early-stage alignment with circular principles, while others could be integrated through targeted incentives and demonstration pilots.

Although local government does not have the authority to directly intervene in legislative matters, it plays a crucial role in promoting sustainable practices at the local level. Through the adoption and implementation of appropriate technical and organizational tools, it can effectively address challenges faced by local communities and businesses. Furthermore, local authorities can initiate awareness and training programs for both entrepreneurs and the general public in order to enhance the circular economy concept.

Such education is essential, as it helps citizens and business owners recognize the economic and environmental benefits that arise from applying the principles of the circular economy in their daily lives. Through targeted seminars, workshops, and informational campaigns, local government can promote practices such as reuse, recycling, and resource waste reduction, thus contributing to a more sustainable and environmentally friendly way of living.

To effectively support the transition to a circular economy, local authorities such as the Municipality of Levadia can implement targeted actions aimed at addressing key technical challenges. These include developing and upgrading infrastructure for the separate collection and processing of wood waste, food waste, animal feed residues, and agricultural by-products. Establishing decentralized composting units can offer practical solutions, especially in rural areas.
Since the Municipality of Levadia includes both urban centers and extensive rural/agricultural areas, the approach to strengthening the circular economy must be examined separately for urban environments and for more remote agricultural regions. For promoting the circular economy, it is essential that the suggested solutions are implemented and differentiated in Urban and Rural Areas.

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4.1 MUNICIPALITY'S ACTION PLAN FOR URBAN AND RURAL AREAS

Table 16 Actions and indicators for CSS1 and CSS2

CSS 1, CSS2	
Enhancement of Waste Management Infrastructure – Green Points	
Key actions	- Site selection based on population and routes. - Design and procure user-friendly bins and signage. - Conduct community awareness. - Train staff on operations. - Schedule regular waste collection. - Monitor usage and gather feedback. - Continuously improve based on data and feedback.
Responsible Parties	Municipal Waste Dept., Urban Planning Dept., Local Contractors
Indicators	-Number of green points installed -Participation rates -Volume of separated waste collected -Resident satisfaction surveys
Strengthening Citizen Participation in the Circular Economy	
Key actions	- Run awareness campaigns. - Hold workshops and seminars. - Organize community engagement events. - Develop digital platforms. - Implement incentive programs. - Partner with local NGOs, schools. - Create citizen advisory committees. - Maintain regular communication channels.
Responsible Parties	Municipal Communication Dept., Environmental NGOs, Schools, Community Groups
Indicators	-Attendance at workshops and events -Number of app downloads/users -Participation in incentive schemes -Surveyed an increase in awareness and behavior change
Collaboration with Local Businesses	
Key actions	- Map and engage businesses. - Host info sessions and networking events. - Create business networks.

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	- Provide training and toolkits. - Offer municipal incentives. - Pilot circular economy projects. - Develop certification schemes. - Monitor waste reduction and CO_2 savings.
Responsible Parties	Economic Development Office, Local Business Associations, Environmental NGOs
Indicators	-Number of businesses engaged -Number of pilots launched -Waste reduction percentages -Certified circular businesses count
Promote "Recycling Champions" programmes - Incentive and Reward Systems	
Key actions	- Design program and eligibility. - Implement rewards and recognition. - Engage partners in rural and urban areas. - Develop tracking tools. - Promote via campaigns and events. - Hold recognition ceremonies. - Collect feedback for improvement.
Responsible Parties	Municipal Waste Dept., Community Groups, Local Businesses, Cooperatives
Indicators	-Number of registered Recycling Champions -Quantity of waste recycled by participants -Number of reward redemptions -Community awareness and satisfaction surveys
Development of Local Circular Bio-economies	
Key actions	- Establish composting and bioenergy facilities. - Promote use of organic fertilizers. - Develop pilot projects (pellets, biogas). - Provide training to farmers. - Facilitate market linkages.
Responsible Parties	Agricultural Dept., Farmer Cooperatives, Bioenergy Providers, Environmental Agencies
Indicators	-Number of composting units operational -Volume of organic waste processed -Number of farmers trained -Amount of bioenergy produced -Market sales of bio-based products
Rural Training Programmes and Stakeholder Partnerships	
Key actions	- Assess needs and stakeholders.

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	- Develop tailored training. - Deliver mobile and on-site sessions. - Partner with cooperatives and NGOs. - Train local ambassadors. - Provide remote materials. - Integrate with extension services.
Responsible Parties	Agricultural Extension Services, Local NGOs, Cooperatives, Rural Development Agencies
Indicators	-Number of training sessions delivered -Number of participants trained -Number of local ambassadors trained -Feedback scores on training effectiveness

4.1.1 Urban Centers – Targeted Interventions

4.1.1.1 Enhancement of Waste Management Infrastructure – Green Points

The establishment of modern source-separation facilities, commonly known as "green points," represents a fundamental component in advancing waste management and circular economy objectives within the Municipality of Levadia and other densely populated settlements, including the communities of Kyriaki, Agios Georgios, Chaeronea, and Davleia. These strategically located facilities will promote the efficient segregation of recyclable materials, organic waste, and other specialized waste streams directly at the source, thereby enhancing the quality and quantity of materials recovered for recycling and reuse. The implementation of green points will not only improve operational efficiency and reduce contamination rates but also foster active community participation and awareness regarding sustainable waste management practices. Furthermore, these facilities will significantly contribute to reducing landfill use and mitigating environmental impacts, aligning with regional and national sustainability targets. The proposed initiative emphasizes the integration of green points as accessible, user-friendly, and well-maintained infrastructures, supported by ongoing educational campaigns and stakeholder collaboration to ensure their long-term success and impact.

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Practical Steps for Enhancing Waste Management Infrastructure through Green Points

- **Site Selection and Planning:**

Identify strategic locations for green points based on population density, accessibility, and existing waste collection routes to maximize usage and efficiency.

- **Design and Equipment Procurement:**

Design user-friendly green points with clearly marked bins for different waste streams (e.g., plastics, glass, organic waste, paper, metal). Procure durable containers, signage, and safety equipment.

- **Community Engagement and Awareness:**

Conduct local outreach campaigns to inform residents about the purpose, location, and proper use of green points. Use flyers, social media, workshops, and public meetings to encourage participation.

- **Staff Training and Management:**

Train municipal staff or contracted personnel in the operation, maintenance, and monitoring of green points to ensure cleanliness and functionality.

- **Operational Setup:**

Establish regular collection schedules aligned with waste processing facilities to ensure timely removal and avoid overflow.

- **Monitoring and Feedback:**

Implement a system for tracking the quantity and quality of materials collected at each green point. Gather community feedback to identify issues and opportunities for improvement.

- **Continuous Improvement:**

Adjust locations, services, and educational efforts based on monitoring data and community input. Explore opportunities for technological upgrades, such as smart bins or digital reporting.

Expected Results from Enhancing Waste Management Infrastructure through Green Points

- **Increased Recycling Rates:**

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A significant rise in the volume and quality of recyclable materials collected, due to easier access and clearer separation at source.

- **Reduction in Mixed Waste Volume:**

Decrease in the amount of non-separated (residual) waste sent to landfills or incineration, helping extend landfill lifespan and reduce environmental impact.

- **Improved Citizen Participation:**

Greater public involvement and responsibility in waste sorting and recycling, supported by awareness campaigns and user-friendly infrastructure.

- **Better Data Collection and Monitoring:**

Ability to monitor quantities and types of waste collected, enabling data-driven decisions for future improvements in waste management planning.

- **Support for Circular Economy Goals:**

Strengthening of local circular economy practices by facilitating material recovery, reuse, and reintegration into production cycles.

- **Cleaner Public Spaces:**

Reduced illegal dumping and cleaner neighborhoods, as residents gain reliable alternatives for proper waste disposal.

- **Economic and Environmental Benefits:**

Lower waste management costs over time, reduced greenhouse gas emissions, and increased recovery of valuable materials (e.g., metals, plastics, organic matter).

- **Replicable Model for Other Areas:**

Creation of a tested, scalable model that can be replicated in other municipalities or regions with similar characteristics and needs.

4.1.1.2 Strengthening Citizen Participation in the Circular Economy

Active citizen participation is essential for the successful transition towards a circular economy. The Municipality of Levadia aims to strengthen public engagement by implementing comprehensive awareness campaigns, educational programs, and community-

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driven initiativesthat promote sustainable consumption and waste reduction. These efforts will include workshops, seminars, and collaboration with local schools, businesses, and civic organizations to foster a shared understanding of circular economy principles.

By empowering citizens to take an active role, the municipality seeks to create a culture of sustainability that supports environmental protection, economic benefits, and improved quality of life for all residents.

In addition to awareness-raising actions targeting residents and businesses, the Municipality is oriented towards the pilot implementation of the **"Pay-As-You-Throw" (PAYT) system**, which aims to provide financial incentives for reducing the amount of waste generated. Through this system, residents will be encouraged to separate and minimize their waste, significantly contributing to the promotion of the circular economy and the improvement of environmental sustainability in the region.

Practical Steps for Strengthening Citizen Participation in the Circular Economy

- **Awareness Campaigns:**

Launch targeted campaigns using various media (social media, local radio, posters) to explain circular economy concepts and their benefits to citizens.

- **Educational Workshops and Seminars:**

Organize regular workshops for residents, schools, and businesses focusing on practical actions, such aswaste reduction, recycling, reuse, and composting.

- **Community Engagement Events:**

Host events such as clean-up days, swap markets, repair cafés, and zero-waste fairs to involve citizens in hands-on circular economy activities.

- **Digital Platforms and Tools:**

Develop user-friendly apps or online portals that provide information, track participation, and enable feedback or reporting on waste management practices.

- **Incentive Programs:**

Implement reward schemes (discounts, coupons, public recognition) for households and businesses that actively participate in circular economy initiatives.

- **Partnerships with Local Organizations:**

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Collaborate with schools, NGOs, community groups, and businesses to broaden outreach and support for circular economy projects.

- **Citizen Advisory Committees:**

Establish committees or forums in collaboration with the voluntary group “We change our City”, where residents can contribute ideas, discuss challenges, and participate in decision-making regarding local sustainability policies.

- **Regular Communication and Reporting:**

Provide updates on program progress, success stories, and upcoming activities through newsletters, social media, and community meetings to maintain engagement and transparency.

Expected Results of Strengthening Citizen Participation in the Circular Economy

- **Increased Public Awareness and Understanding:**

Citizens gain a clearer understanding of circular economy principles and their role in reducing waste, conserving resources, and supporting local sustainability goals.

- **Higher Participation Rates in Recycling and Reuse Activities:**

Greater community involvement in initiatives such as recycling programs, composting, repair cafés, and clean-up events, leading to measurable improvements in waste separation and reduction.

- **Behavioral Change at the Household and Community Level:**

A shift in everyday consumer behavior toward more sustainable practices, such as reduced single-use plastics, increased reuse, and better sorting of recyclable materials.

- **Improved Communication Between Citizens and the Municipality:**

Enhanced dialogue and trust between the community and local authorities through advisory committees, digital feedback tools, and transparent reporting.

- **Greater Engagement from Schools, NGOs, and Businesses:**

Active collaboration from educational institutions, local NGOs, and private enterprises in promoting and implementing circular economy practices within the wider community.

- **Innovation and Citizen-Led Initiatives:**

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Emergence of grassroots initiatives (e.g., community composting projects, tool-sharing libraries, upcycling workshops) driven by informed and motivated citizens.

- **Social Inclusion and Community Cohesion:**

Broader participation across all demographic groups, including youth and vulnerable populationsleads to a stronger sense of community and shared responsibility for sustainability.

- **Recognition of Good Practices:**

Increased visibility and motivation through recognition of individuals, schools, or businesses as “Recycling Champions” or leaders in local circular economy efforts.

- **Scalable and Replicable Model:**

Development of a participatory model that can be scaled across other neighborhoods or municipalities, serving as a best practice example for citizen engagement in circular economy transitions.

4.1.1.3 Collaboration with Local Businesses

The Municipality actively seeks to strengthen collaboration with local businesses to advance circular economy practices. Key initiatives include promoting the use of recycled materials in secondary production processes, thereby supporting resource efficiency and reducing environmental impact. Additionally, incentives will be offered to businesses that adopt reuse, repair, or remanufacturing models, such as zero-waste shops and repair cafés. These measures aim to foster sustainable business practices, stimulate local economic development, and contribute to waste reduction across the community.

Practical Steps for Collaboration with Local Businesses

- **Stakeholder Mapping and Outreach:**

Identify and engage key local businesses across sectors (retail, manufacturing, agriculture, hospitality) that have the potential to implement circular practices such as reuse, recycling, repair, or resource efficiency.

- **Information Sessions and Networking Events:**

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Organize meetings, roundtables, or networking events to present the benefits of the circular economy, share successful case studies, and encourage dialogue between businesses and the municipality.

- **Creation of a Local Circular Business Network:**

Establish a platform or working group of local businesses committed to circular practices, enabling knowledge exchange, collaboration, and peer support.

- **Technical Support and Guidance:**

Provide stakeholders with Frontsh1p's training toolkit in order to help businesses transition toward circular.

- **Incentive Programs:**

Introduce municipal incentives such as reduced waste fees, public recognition, or access to grant programs for businesses that adopt circular economy practices (e.g., zero-waste shops, repair cafés, upcycling).

- **Pilot Projects and Demonstration Initiatives:**

Co-develop pilot projects with willing businesses to test innovative circular models (e.g., closed-loop supply chains, product-as-a-service models), and use these as local success stories.

- **Certification and Branding Opportunities:**

Support the development of a local sustainability label or "circular business" certification that businesses can use to promote their commitment to sustainability and attract eco-conscious customers.

- **Monitoring and Evaluation:**

Track participation and outcomes through KPIs (e.g., waste reduction, materials reused, CO_2 savings) and share aggregated results to highlight community-wide progress.

Expected Results of Collaboration with Local Businesses

- **Increased Adoption of Circular Practices:**

A growing number of local businesses will integrate circular economy models—such as reuse, recycling, repair, remanufacturing, or product-as-a-service—into their operations.

- **Creation of a Local Circular Business Ecosystem:**

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The establishment of a functioning network of "circular businesses" will encourage collaboration, innovation, and mutual support, reinforcing local economic resilience and reducing dependency on linear resource flows.

- **Improved Business Competitiveness and Innovation:**

Businesses that adopt circular solutions will benefit from cost savings, resource efficiency, enhanced brand image, and access to new markets driven by sustainability-conscious consumers.

- **Reduction in Commercial Waste and Environmental Impact:**

Circular practices will lead to measurable reductions in commercial waste generation, lower carbon emissions, and decreased use of virgin materials, contributing to local and regional climate and sustainability targets.

- **Stronger Public-Private Partnerships:**

Strong collaboration between the Municipality and the private sector will result in shared responsibilityfor sustainable efforts and foster a more inclusive approach to implementing local environmental policies.

- **Replication of Successful Circular Models:**

Pilot projects and demonstration initiatives will serve as practical examples that can be scaled or replicated by other businesses, locally and regionally, accelerating the circular transition.

- **Increased Visibility and Recognition of Sustainable Businesses:**

Participating businesses will gain recognition through certification schemes, branding opportunities, and public campaigns, improving customer trust and loyalty.

- **Data-Driven Policy Development:**

Through monitoring and evaluation, the Municipality will collect valuable data on circular economy performance (e.g., waste reduction, CO_2 savings), enabling more informed and targeted policy decisions.

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4.1.1.4 Promote "Recycling Champions" programmes- Incentive and Reward Systems

To encourage active participation in recycling and sustainable waste management, the Municipality will promote "Recycling Champions" programs that recognize and reward exemplary efforts by both businesses and residents. These programs will implement incentive schemes such as discounts, coupons, or public recognition awards to motivate and acknowledge those who maintain high recycling standards. In rural areas, the Municipality will collaborate with local cooperatives, markets, and community organizations to offer benefits linked to recycling initiatives, thereby fostering a culture of environmental responsibility and reinforcing the adoption of circular economy practices. Such targeted reward systems are expected to enhance community engagement, increase recycling rates, and contribute to the overall sustainability goals of the region.

Practical Steps for promoting "Recycling Champions" programmes- Incentive and Reward Systems

- **Design the Programme Framework:**

Define the objectives, eligibility criteria, and performance indicators (e.g. quantity or quality of recyclables, participation in composting, or innovative reuse initiatives) that will be used to identify "Recycling Champions" among residents, schools, businesses, and neighborhoods.

- **Implement a Reward System**
  Introduce tangible incentives such as:
  - Discounts on municipal fees or utility bills
  - Coupons or vouchers for local businesses
  - Access to community services (e.g., free bulky waste collection)
  - Public recognition (e.g., certificates, press features, social media spotlights)
- **Engage Rural and Urban Stakeholders:**

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Collaborate with local markets, cooperatives, and community groups in rural areas to offer context-specific rewards—e.g., discounts on farming supplies, free compost, or promotional space at local events.

- **Create a Digital and Physical Tracking Mechanism:**

Develop an app, website, or simple form-based systemwhere participants can register, log their activities, and track progress. Use QR codes on recycling bins or weigh-based systems where feasible.

- **Promotional Campaign:**

Launch a public campaign to raise awareness of the program. Include posters, local media announcements, school competitions, and business outreach to ensure wide participation.

- **Recognition Events and Celebrations:**
  Host an annual or seasonal "Recycling Champions" ceremony, where top participants are publicly recognized. This could be linked to environmental days or local festivals to increase visibility.
- **Feedback and Continuous Improvement:**
  Collect feedback from participants to evaluate and adapt the programme annually. Include new categories (e.g., best upcycling idea, youth champion) to keep engagement high.

Expected Results for promoting "Recycling Champions" programmes - Incentive and Reward Systems

- **Increased Household and Business Recycling Rates:**

Motivated by rewards and recognition, participants are more likely to recycle correctly and consistently, improving waste sorting and reducing contamination.

- **Strengthened Environmental Culture and Civic Pride:**

Recognition programs create a sense of ownership and pride among residents, reinforcing positive behavior and building a community identity towards sustainability.

- **Greater Participation Across All Demographics:**

Incentives attract a wide range of participants, including those who might not otherwise engage in environmental initiatives, ensuring inclusivity.

- **Waste Reduction and Improved Resource Recovery:**

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By encouraging correct separation and reuse, the programme contributes to reduced landfill use and increased diversion of materials into recycling and composting streams.

- **Support for the Local Economy:**

Rewarding partnerships with local businesses helps promote eco-conscious consumer habits and stimulates the circular local economy.

- **Scalable and Replicable Model:**

The programme can be scaled to new districts or replicated by neighboring municipalities, creating broader regional impact.

- **Positive Public Relations for the Municipality:**

Demonstrating leadership in innovative citizen engagement enhances the Municipality's environmental profile and strengthens its case for national or EU-level funding.

4.1.2 Rural areas– Targeted Interventions

4.1.2.1 Development of Local Circular Bio-economies

The Municipality is committed to fostering the development of local circular bio-economies by implementing sustainable solutions for the management of agricultural residues and organic waste. This includes the establishment of composting units aimed at transforming organic matter into valuable soil amendments, thereby enhancing soil health and reducing reliance on chemical fertilizers. Additionally, support will be provided for bioenergy production initiatives, such as biogas and biomass facilities, through collaboration with farmer cooperatives and community-based projects. These efforts not only promote the efficient use of local resources but also contribute to energy self-sufficiency, rural development, and the reduction of greenhouse gas emissions.

Additionally, due to the great volume of agricultural waste from olives in the Municipality of Levadia,the Municipality must develop an integrated program aimed at helping olive mill owners understand the benefits of a holistic approach to managing olive kernel waste. Such comprehensive management not only addresses waste disposal challenges but also unlocks

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valuable economic and environmental opportunities. The olive kernel waste can be effectively utilized in several ways, including:

Pellet Production: Processing olive kernel waste into biomass pellets, which can serve as a renewable fuel for residential and industrial heating systems.

Direct Combustion: Utilizing dried olive kernel waste as fuel in specially designed biomass boilers or stoves.

Biogas Production: Employing olive kernel waste as feedstock in anaerobic digestion systems to generate biogas, a mixture of methane and carbon dioxide that can be used as a renewable energy source.

Co-firing with Coal: Co-firing olive kernel waste alongside coal in power plants to reduce dependence on fossil fuels and lower carbon emissions.

Charcoal Production: Converting the waste into charcoal or biochar, which can be used either as a sustainable fuel or as a soil amendment to improve soil health.

Olive Pomace Utilization: Using olive pomace as an organic fertilizer for olive groves, which reduces costs for producers and provides a sustainable solution for the disposal challenges faced by olive oil mills.

By promoting these practices, the Municipality will support circular economy principles, foster sustainable agricultural development, and contribute to reducing the environmental impacts associated with olive kernel waste.

Practical Steps for the development of Local Circular Bio-economies

- **Stakeholder Engagement:**

Organize workshops and meetings with olive mill owners, farmers, and local businesses to raise awareness about the benefits of integrated waste management and available technologies.

- **Technical Support:**

Provide expert guidance and training on waste processing methods, technology adoption, and best practices.

- **Pilot Projects:**

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Initiate pilot programs to demonstrate the practical application and benefits of pellet production, biogas systems, and composting units.

- **Infrastructure Development:**

Facilitate investment in necessary infrastructure, such as pelletizing plants, anaerobic digesters, and biochar production facilities.

- **Monitoring and Evaluation:**

Establish monitoring systems to assess environmental, economic, and social impacts and optimize processes accordingly.

Expected Benefits:

- **Economic Gains:**

Creation of new revenue streams for olive mill owners through the sale of biofuels and organic fertilizers.

- **Environmental Protection:**

Reduction of greenhouse gas emissions and prevention of pollution from improper waste disposal.

- **Sustainable Agriculture:**

Improvement of soil quality and fertility through organic amendments, enhancing long-term productivity.

- **Energy Independence:**

Increased production of renewable energy sources contributing to local energy security.

- **Circular Economy Advancement:**

Integration of waste into valuable resources, fostering a sustainable and resilient local economy.

4.1.2.2 Rural training Programmes and Stakeholder Partnerships

To effectively promote circular economy practices in rural areas, the Municipality will implement comprehensive training programs focused on recycling techniques, composting, and sustainable waste management. These programs will be tailored to the specific needs

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of rural communities and agricultural producers, providing practical knowledge and skills to enhance local waste handling and resource recovery. Additionally, the Municipality will establish strong partnerships with agricultural cooperatives and other local stakeholders to facilitate the widespread dissemination of circular economy principles. Through collaborative efforts, these partnerships will support the adoption of best practices, encourage innovation, and foster a shared commitment to environmental sustainability and economic resilience in the region.

Practical Steps for Rural Training Programmes and Stakeholder Partnerships

- **Needs Assessment in Rural Areas:**

  Conduct field surveys and consultations with farmers, cooperatives, and rural residents to identify current waste management practices, challenges, and training needs.

- **Development of Tailored Training Modules:**

  Design practical training programs focused on sustainable agricultural waste management, composting, recycling, and bio-based solutions. Content should be adapted to the local context (e.g., olive mills, livestock waste, food surplus).

- **On-Site Demonstrations and Mobile Training Units:**

  Organize hands-on training sessions directly on farms or in rural communities, using mobile training units or demonstration plots to showcase circular practices in real conditions.

- **Partnerships with Agricultural Cooperatives and Local Stakeholders:**

  Collaborate with agricultural cooperatives, farmer associations, local NGOs, and educational institutions to co-deliver training and ensure widespread participation and trust.

- **Capacity Building for Local Leaders:**

  Train community leaders or cooperative members as “local circular economy ambassadors” who can guide others and sustain the knowledge transfer after the initial training phase.

- **Inclusion of Digital Learning Tools:**

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Develop online or offline digital training materials (e.g., video tutorials, mobile apps, booklets) to support continuous learning and reach remote areas with limited access to in-person events.

- **Integration with Existing Agricultural Support Services:**

Align training activities with existing rural development or extension services to increase uptake and long-term sustainability.

Expected Results of Rural Training Programmes and Stakeholder Partnerships

- **Improved Knowledge and Skills in Rural Communities:**

Farmers and rural residents acquire practical knowledge on circular practices such as composting, organic waste reuse, and small-scale bioenergy solutions.

- **Reduction in Agricultural and Organic Waste:**

The adoption of circular practices leads to measurable reductions in improperly disposed agricultural residues, food waste, and other organic materials.

- **Enhanced Soil Fertility and Farm Productivity:**
- The use of compost and organic amendments from agricultural waste improves soil quality and reduces dependency on synthetic fertilizers.
- **Creation of Local Circular Economy Champions:**

Trained local leaders and cooperative members serve as multipliers of circular economy practices in their communities, encouraging wider participation.

- **Strengthened Stakeholder Networks:**

Established partnerships between the Municipality, cooperatives, and rural actors foster long-term collaboration on sustainability and innovation projects.

- **Economic Diversification and Job Creation:**

New local micro-enterprises may emerge around composting, biogas production, or repair services, creating green jobs in rural areas.

- **Increased Community Engagement and Ownership:**

Rural citizens feel empowered and involved in shaping solutions, increasing the long-term viability of circular economy initiatives.

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Table 17 Municipality's Planned Actions, Results, and Indicators for Circular Economy Implementation

Action plan	
1. Resource Flow Mapping and Baseline Assessment	
Timeframe	Short-term (0-6 months)
Expected Results/ outputs	Comprehensive understanding of material flows and waste streams
Indicators	- Material Footprint (EU Circular Economy Monitoring framework) - Waste generation per capita (EU, national stats)
Notes	Baseline to identify hotspots and set realistic targets
2. Implementation of Recycling & Reuse Programs	
Timeframe	Medium-term (6-18 months)
Expected Results/ outputs	Increased rates of recycling and reuse in target sectors
Indicators	- Recycling rate of municipal waste (%) (EU, national) - Reuse rate of products/materials (regional/local indicators)
Notes	Focus on measurable improvements in recycling infrastructure and behaviors
3. Deployment of Monitoring & Control Systems	
Timeframe	Medium-term (6-18 months)
Expected Results/ outputs	Real-time data on material flows and process efficiency
Indicators	- Number of monitored waste streams (local) - % reduction in process inefficiencies (company/region level)
Notes	Use IoT, big data for continuous improvement
4. Training and Stakeholder Engagement	
Timeframe	Short-term to Medium-term (3-12 months)
Expected Results/ outputs	Enhanced skills and awareness among stakeholders
Indicators	- Number of training sessions and participants (local) - Stakeholder satisfaction/engagement index (regional)
Notes	Capacity building is essential for sustainable behavioral change
5. Waste Reduction Initiatives	
Timeframe	Medium to Long-term (12-36 months)
Expected Results/ outputs	Reduction in waste generation and landfill use
Indicators	- Total waste generated per sector (kg/tonne) (EU, national) - Landfill diversion rate (%) (EU)
Notes	Requires time for behavioral and process changes to manifest

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6. Circular Product Design and Innovation	
Timeframe	Long-term (18+ months)
Expected Results/ outputs	Introduction of products designed for durability and recyclability
Indicators	- Number of circular products launched (company/region) - Percentage of products with eco-design features (EU Eco-design Directive)
Notes	Innovation cycle is longer; tracking product lifecycle improvements
7. Reporting and Continuous Improvement	
Timeframe	Ongoing, evaluated quarterly/annually
Expected Results/ outputs	Transparent progress reports and adaptive management
Indicators	- Frequency of circular economy reporting (local/regional) - Improvements in KPIs over time (all relevant metrics)
Notes	Feedback loops essential for system evolution

Potential Funding Sourcing

- **European Union Funds:** Programs such as the European Agricultural Fund for Rural Development (EAFRD) and Horizon Europe for environmental innovation.
- **National Grants:** Support from Greek government initiatives promoting circular economy and renewable energy.
- **Private Sector Partnerships:** Collaborations with companies specializing in biomass, bioenergy, and waste management technologies.
- **Local Funding:** Municipal budgets allocated for environmental sustainability projects and rural development.

4.2 Monitoring & Evaluation

A very important factor for the development of the circular economy is ongoing monitoring and timely correction of any issues that may arise during its implementation. The circular economy focuses on managing resources efficiently through reuse, recycling, and waste reduction; however, applying these principles requires careful supervision at every stage of the production process.

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Without regular monitoring, dysfunctions may occur, such as the accumulation of non-recyclable materials, inefficient use of raw materials, or environmental impacts that contradict the goals of the circular economy. For example, if a company does not systematically evaluate the progress of its processes, it may overlook the need to improve recycling techniques or fail to detect the production of toxic residues.

Moreover, the ability to address problems in real-time ensures the system's flexibility and adaptability, which are essential for the growth and sustainability of the circular economy. Through continuous monitoring, businesses and organizations can identify and implement improvements, innovate processes, and contribute to achieving more environmentally friendly and efficient solutions.

Overall, monitoring and correction serve as "feedback mechanisms" that turn the circular economy from a mere concept into a dynamic, living process that continually evolves for the benefit of society and the environment. The action plan will be evaluated every 12 months using performance indicators and policy adjustment proposals.

Table 18 Activities of the evaluation with their durations

Evaluation of the action plan				
Phase	**Activity**	**Duration**	**Timeframe**	**Notes**
1. Planning	Define objectives and KPIs	2 weeks	Week 1 - Week 2	Set clear goals and performance indicators
	Stakeholder engagement and team setup	1 week	Week 1	Identify key partners and form working groups
2. Baseline Assessment	Assess current resource flows and waste	3 weeks	Week 3 - Week 5	Map material lifecycle and current issues
3. Implementation	Introduce circular economy processes	4 weeks	Week 6 - Week 9	Start reuse, recycling, waste reduction initiatives

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	Deploy monitoring tools (IoT, data systems)	3 weeks	Week 7 - Week 9	Install sensors, analytics platforms
4. Monitoring & Control	Continuous data collection and review	Ongoing	Week 10 onwards	Track KPIs, identify deviations
5. Correction & Improvement	Analyze data, identify issues, implement fixes	Ongoing	Week 10 onwards	Real-time interventions and process optimization
6. Reporting & Feedback	Regular reporting to stakeholders	Monthly	From Week 12 onwards	Share progress, update strategy if needed
7. Review & Scale-up	Comprehensive evaluation and scaling plan	Every 6 months	Month 6, Month 12	Assess success and plan wider implementation

4.3 Risks & Mitigation

Table 19 Potential Risks and Mitigation Actions

Risk	Mitigation
Low citizen participation	Invest in education, community-based incentives
Lack of infrastructure in rural areas	Promote mobile compost units, cooperative bio-digesters
Contamination of organic waste	Clear labeling, bin monitoring, pilot enforcement
Weak market demand for compost or recycled wood	Subsidies, public procurement, quality standards

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References

[1] E. Karampinis, “D2.2 Biobased Economy Business Opportunities in 6 CELEBio Neighbouring Countries,” Aug. 2020.

[2] I.Frantzis & Associates Ltd and BlackForest Solutions GmbH, “Guide on separate collection of municipal waste in Greece, Final report,” Apr. 2020.

[3] European Environment Agency, “Early warning assessment related to the 2025 targets for municipal waste and packaging waste,” Jun. 2022.

[4] Joint Press Release, “The landfill tax should become fully reciprocal for the local authorities!,” MedINA. Accessed: Mar. 11, 2025. [Online]. Available: https://med-ina.org/the-landfill-tax-should-become-fully-reciprocal-for-the-local-authorities/

[5] T. Zachariadis, “Landfill Tax in Greece,” Cyprus, Dec. 2016.

[6] C. Emmanouil, K. Papadopoulou, I. Papamichael, and A. A. Zorpas, “Pay-as-You-Throw (PAYT) for Municipal Solid Waste Management in Greece: On Public Opinion and Acceptance,” *Sustainability (Switzerland)*, vol. 14, no. 22, Nov. 2022, doi: 10.3390/SU142215429.

[7] A. Hussain *et al.*, “Recycling of waste materials based on decision support system using picture fuzzy Dombi Bonferroni means,” *Soft comput*, vol. 28, no. 4, pp. 2771–2797, Feb. 2024, doi: 10.1007/S00500-023-09328-W.

[8] Siakandaris Group, “WOOD RECYCLING.” [Online]. Available: https://www.siakandaris.gr/en/recycle/wood-waste-recycling/

[9] T. Sar *et al.*, “Potential utilization of dairy industries by-products and wastes through microbial processes: A critical review,” *Science of The Total Environment*, vol. 810, p. 152253, Mar. 2022, doi: 10.1016/J.SCITOTENV.2021.152253.

[10] M. Khalil, M. A. Berawi, R. Heryanto, and A. Rizalie, “Waste to energy technology: The potential of sustainable biogas production from animal waste in Indonesia,” *Renewable and Sustainable Energy Reviews*, vol. 105, pp. 323–331, May 2019, doi: 10.1016/J.RSER.2019.02.011.

[11] “Butchery Waste Solutions: Meat Waste Disposal,” Skipshapiro enterprises. [Online]. Available: https://shapiroe.com/blog/butchery-waste-solutions-managing-meat-sustainably/

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101037031

Grant Agreement number: 101037031
Project acronym: FRONTSH1P
Project title: A FRONTrunner approach to Systemic circular, Holistic & Inclusive solutions for a new Paradigm of territorial circular economy
Type of action: Innovation Action (IA)

ITALIAN REGIONAL ROADMAP: CAMPANIA REGION AND GAL IRPINIA

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Table of Contents

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Table of Figures

Table of Tables

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Abbreviations

CCRI - Circular Cities and Regions Initiative
CE – Circular Economy
CEAP - Circular Economy Action Plan
CpEAP – CircuPuncture Economy Action Plan
CSS – Circular Systemic Solutions
CTC – Circular Territorial Cluster
ICT - information and communication technologies
LAP – Local Activity Place
LR – Lodzkie Region
NGO – Non-Governmental Organisation
RCT - Regional Cluster Team
SAT – self-assesment tool
SLOM – Stowarzyszenie Łódzki Obszar Metropolitalny (Lodz Metropolitan Area Association)
TRL - technology readiness level

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STAGE I:
Analysis of Conditions

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1 Stage 1: Analysis of Conditions

1.1 Characterization of CAMPANIA and GAL Irpinia

Figure 1 Location of Campania

Campania is one of the 20 Italian Regions; it is located in Southern Italy in the south-western portion of the Italian Peninsula (with the Tyrrhenian Sea to its west), its capital city is Naples. Campania has a population of 5,575,025 as of 2025, making it Italy's third most populous region, and, with an area of 13,590 km^2, its most densely populated region. Based on its GDP, Campania is also the most economically productive region in Southern Italy and the 7th most productive in Italy. It includes the metropolitan area of Napoli and the 4 provinces of Avellino, Benevento, Caserta and Salerno.

Territorial Characterization of GAL Irpinia

The GAL Irpinia's reference territory is located within the Province of Avellino. Specifically, it extends across three development systems (as identified by the Campania Territorial Plan): B4 - Valle Ufita, a system with a predominant rural-cultural focus; C1 - Alta Irpinia, a system with a predominant rural-manufacturing focus; and A12 - Terminio Cervialto, a system with a predominant naturalistic focus. The population within the area represented by GAL Irpinia is approximately 108.000 inhabitants, accounting for about 28% of the total population of the entire Province of Avellino [www.regione.campania.it]. (See *Figure 2)*

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GAL Irpinia is a Local Action Group (GAL) representing from local socio-economic interests, both public and private, who decided to join in a partnership to develop and implement participatory local development strategies. The primary objective is to foster the economic and social growth of the territory [https://www.galirpinia.it/].

Figure 2 Comuni GAl Irpinia

The economy of the area is primarily based on agriculture and livestock farming. Regarding the main agricultural crops, the region is particularly known for the cultivation of wheat, corn, and legumes. The GAL is distinguished by several excellent products, including the production of fine wines, with notable examples such as *Fiano di Avellino, Taurasi,* and *Greco di Tufo.* Additionally, the area boasts a long-standing tradition of excellence in the production of extra virgin olive oil and chestnuts.

As for livestock farming, the area is home to cattle and pig farms, with a strong tradition of artisanal meat processing. [https://fondoambiente.it/ ; http://www.irpiniadocg.it/]

Circular Economy in Italy and in the GAL Irpinia Territory

In Italy, the national strategy for the Circular Economy is outlined in the document *"Strategia Nazionale per l'Economia Circolare"* (2022), adopted within the broader framework of the National Recovery and Resilience Plan (NRRP – PNRR).

The Italian approach reflects the EU action plan and is structured around key thematic areas: sustainable production and consumption, waste prevention and management, and the

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promotion of secondary raw materials. Implementation operates on three levels: national, sectoral, and territorial. At the national level, legislation and incentives drive systemic change. At the sectoral level, priority is given to high-impact value chains such as agri-food, construction, textiles, plastics, and packaging.

At the territorial (micro) level, local development strategies are aligned with the principles of circularity, particularly in rural and inner areas.

Within this framework, Local Action Groups (GALs), such as GAL Irpinia, have integrated circular economy objectives into their Local Development Strategies (LDS), focusing on valorising local resources, reducing agri-food waste, promoting short supply chains, and encouraging the reuse of organic matter. Considering the agricultural and agri-food vocation of the area, particular attention is placed on CSS2 – Food and Feed, with actions supporting innovation in food processing and by-product valorisation. **Additionally, CSS3 – Water and Nutrients is relevant due to the presence of small production clusters related to agriculture and irrigation materials. These sectors offer strong potential for integrating circular solutions, particularly through eco-design, bioplastics, and organic waste and nutrient recovery initiatives.** [Source: MiTE, 2022; GAL Irpinia LDS 2023–2027; PNRR documents]

1.2 Characterisation of the food and feed industry

As mentioned in the previous paragraph, the GAL Irpinia area is distinguished by its excellence in agriculture, olive growing, and viticulture. For this reason, it is essential to implement best practices that help preserve biodiversity to ensure ecosystem resilience and species survival.

The area is characterised by a predominance of small and medium-sized farms engaged in sustainable and traditional agriculture. Key productions include high-quality wines (such as Fiano di Avellino, Taurasi, and Greco di Tufo), extra virgin olive oil, chestnuts, legumes, as well as staple crops like wheat and maize. Livestock farming, particularly cattle and pigs, plays a vital role in the local economy, supported by a strong tradition of artisanal meat and dairy processing. This agricultural profile aligns with national and regional priorities in circular economy strategies. Italy's National Strategy for the Circular Economy, embedded in the National Recovery and Resilience Plan (PNRR), emphasizes sustainable food systems, reduction of agri-food waste, and valorisation of local resources. At the territorial level, GALs like GAL Irpinia have begun implementing these principles through their Local Development Strategies. In this context, **CSS2 – Food and Feed** become highly relevant, given the potential for closing nutrient loops via organic by-product recovery, local feed production, and biodiversity preservation through germplasm conservation. Indeed, Campania is investing in

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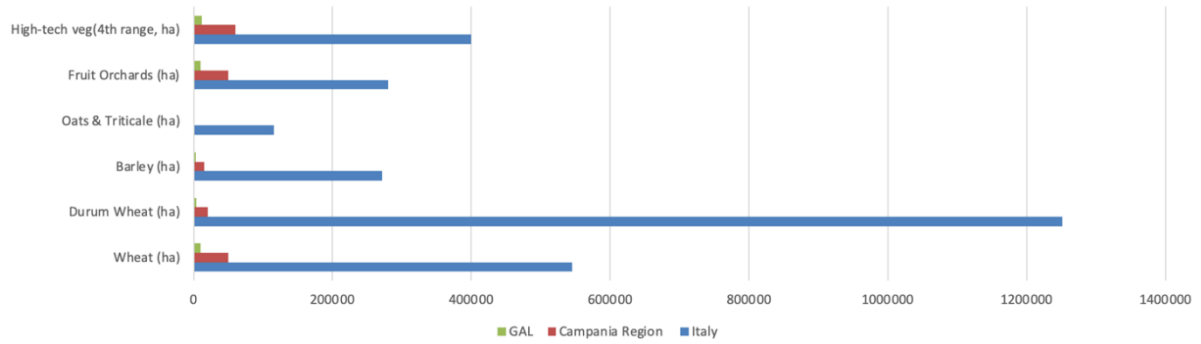
the safeguarding of native olive and grape cultivars—such as Ravece, Ogliarola Campana, Ritonnella, and Ruveia—further reinforcing resilience and sustainability. Although statistical data at the GAL level is limited, supporting evidence—including visual summaries of production volumes and agricultural typologies—confirms the region's readiness to serve as a pilot area for circular models in agri-food. Additionally, due to CSS2 and CSS3 sectors close relationship, **CSS3 – Water and Nutrients** may also be considered relevant, particularly in terms of promoting efficient water use, nutrient recycling, and sustainable irrigation technologies in synergy with local agricultural production chains.

Table 1 Crop Production Data (2021–2023 average, Italy; estimates for Campania and GAL Irpinia)

Area	Cereals (% UAA)	Wheat (ha)	Durum Wheat (ha)	Barley (ha)	Oats & Triticale (ha)	Fruit Orchards (ha)	High-tech veg(4th range, ha)
Italy	31%	545000	1251000	272000	115550	280000	400000
Campania Region	28%*	50000	20000	15000	5000*	50000	60000
GAL	27%*	10000	4000	3000	1000*	10000	12000

* *Estimated data*



References:

- https://www.crea.gov.it
- https://www.oliveoiltimes.com/production/sustainability-biodiversity-good-for-business-this-campania-farmer-believes/
- https://agricoltura.regione.campania.it/PSR_2014_2020/]
- Faccini N, et. All 2023. Triticale in Italy. Biology (Basel).

Primary animal production

The GAL Irpinia territory is characterized by a rural and mountainous landscape, which fosters a strong tradition of livestock farming. Compared to the national average, Irpinia focuses more on small to medium-sized farms that prioritize quality and traditional methods over industrial scale. The main types of livestock in the area include cattle, sheep, goats, and pigs, with a strong emphasis on dairy production (notably for cheese such as caciocavallo and pecorino) and meat (especially lamb and pork).

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The following chart and table illustrate the estimated primary animal production in the GAL Irpinia area:

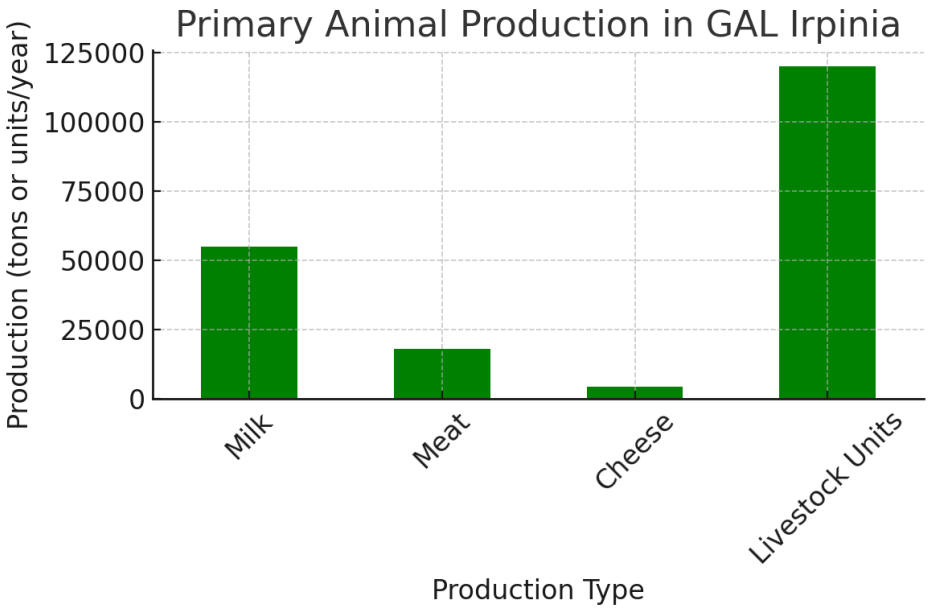

Figure 3 Primary Animal Production in GAL Irpinia

Table 2 GAL Irpinia primary animal production per year

Production Type	**GAL Irpinia (tons or units/year)**
Milk	55,000
Meat	18,000
Cheese	4,500
Livestock Units	120,000

Fishing and aquaculture are limited in the GAL Irpinia area due to its inland position, with activity mainly confined to small-scale freshwater aquaculture (primarily trout farming) and some marginal fishing in artificial lakes. The following chart and table show estimated aquaculture data for GAL Irpinia:

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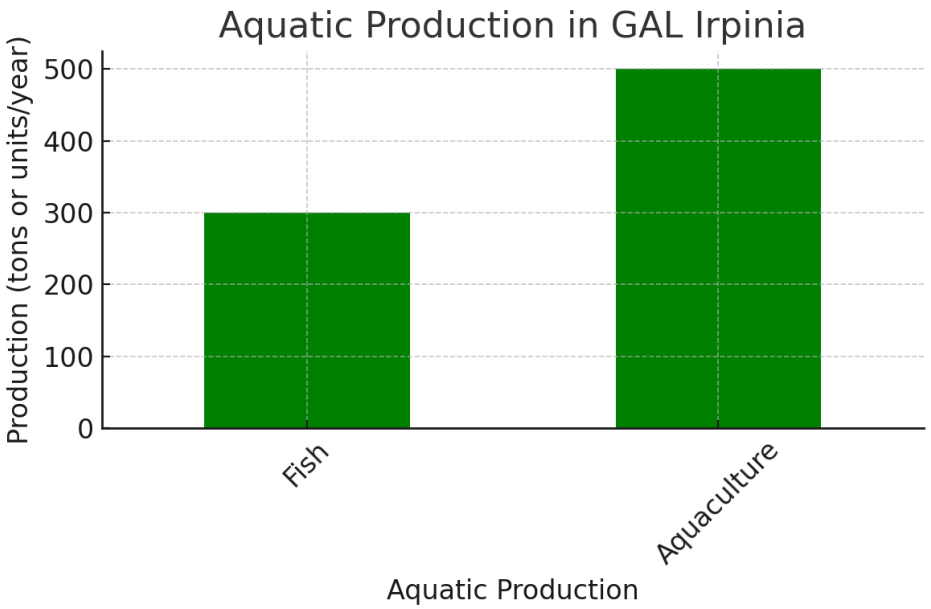

Figure 4 Aquatic Production in GAL Irpinia

Table 3 GAL Irpinia Aquatic production per year

Aquatic Production	GAL Irpinia (tons/year)
Fish	300
Aquaculture	500

A critical aspect of the animal production sector in Irpinia is the generation of organic waste, including manure, slaughter by-products, and dairy processing residues. These by-products, if not managed properly, pose environmental risks. Therefore, adopting circular economy principles is vital. This includes practices such as anaerobic digestion to produce biogas, composting for agricultural reuse, and recovering nutrients and water. Promoting cooperative models and local bioeconomy initiatives can help transform waste into valuable resources, supporting both environmental sustainability and rural economic development.

References:

- ISTAT (Italian National Institute of Statistics), 2023 Livestock and Aquaculture Reports.
- Regione Campania, 'Piano Sviluppo Rurale 2023'.

1.3 Characterisation of the water and nutrients sector

The economic activities with the highest turnover in the GAL Irpinia area are mainly related to agriculture and agri-food processing, followed by manufacturing and construction. Key sectors with relevance to water and nutrients include:

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- Food and beverage production (wine, dairy, preserved foods), which relies on clean water and nutrient recycling;
- Irrigation systems and water-efficient agricultural practices;
- Nutrient recovery from agricultural and food waste;
- Wastewater treatment and reuse technologies.

Although not always visible as a distinct industrial sector, the water and nutrients sector is increasingly strategic, linked to both environmental protection and innovation in agriculture. It includes activities classified under various ATECO codes such as 36 (Water collection, treatment and supply), 37 (Sewerage), and parts of 38 (Waste management).

Several companies and public utilities operate in wastewater treatment, irrigation technologies, and nutrient recovery. These include both SMEs and larger public-private consortia. Key municipalities active in this area include Carife, Lioni, Ariano Irpino, and Montella.

The use of advanced technologies such as phytoremediation, anaerobic digestion, and precision irrigation is expanding, particularly in rural and mountainous areas where traditional infrastructure may be limited.

The following graphs shows how the Campania region is the best southern Italy region in wate water and water reuse management.

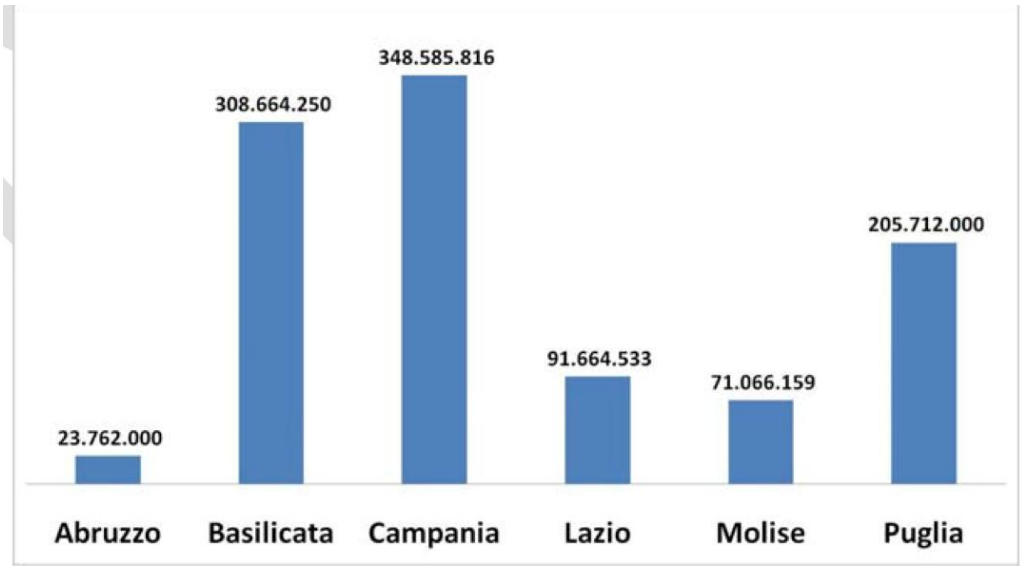

Figure 5 Water waste and reuse management

Reference: Tabella si sintesi regionale dei Consorzi di Bonifica – Fonte ANBI (*https://www.distrettoappenninomeridionale.it/images/_pdgAcque/I%20FASE/ELAB%20DI*

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1.4 Indicators

As in the rest of Italy, circular economy indicators at sub-regional level (such as in the GAL Irpinia area) are scarce or not directly available. The most relevant indicator currently published is the municipal wastewater treatment coverage rate (ISTAT, ISPRA), along with indicators related to water losses in distribution networks and nutrient pollution from agriculture (e.g. nitrates in groundwater).

For other indicators related to sustainable development in the water and nutrients sector, data are generally available at national or regional (Campania) level. Collaboration with ARPAC, ISTAT, or local water management authorities may be necessary to obtain granular data for monitoring.

A list of national indicators relevant to water management, nutrient recovery, and SDG targets (especially SDG 6 – Clean Water and Sanitation) is provided in **Annex I**. (https://www.istat.it/wp-content/uploads/2024/05/SDGs-2023-English-version-Ebook.pdf?utm , ISTAT).

1.5 List of projects implemented in the circular economy area

In recent years, several projects have been funded and continue to receive support to promote the circular economy in both the food and feed sectors, as well as in wastewater treatment and nutrient recovery. Below are some initiatives within the Province of Avellino, the area that encompasses the GAL Irpinia territory (Water and Nutrients) and some at Regione Campania level (Food & Feed)

1.5.1 List of projects in the Water and Nutrients sector

- **Phytoremediation plant in Carife** – A natural wastewater treatment system using aquatic plants and microorganisms. Managed by Multiservizi S.p.A., it treats over 6 million cubic meters of wastewater annually. [https://www.ottopagine.it/]

- **NUTRI-REUSE** – Nutrient recovery from agricultural runoff and wastewater for use in local fertilization cycles. Pilot tested in Campania (2023–2025).

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- **AQUA-AGRO** – Integration of precision irrigation systems and water reuse in vineyards and olive groves. Co-funded by the Ministry of Agriculture, started in 2022.

- **BIOLOOP H2O** – Development of closed-loop systems for water reuse in food processing plants. Partners include local cooperatives and universities.

- **WATER GUARD** – AI-based system for monitoring leaks and optimizing water distribution in rural networks. Under implementation in Irpinia Nord-Est (2024–2026)

1.5.2 List of projects in the Food and Feed sector

- **CARINA** – CARinata and CamelINA to boost the sustainable diversification in EU farming systems - Demo in Campania - The project focuses on new sustainable and diversified farming systems including 2 new oilseed crops, carinata and camelina, able to provide multiple low iLUC feedstocks for the bio-based economy. (2022–2026).

- **BRILIAN** – Circular Future for Rural Areas - The project focuses on the cultivation and use of low-input oil crops based on a circular approach in a regional pilot area. The raw materials produced are enhanced through sustainable processes, developing innovative agro-industrial supply chains for the production of bio-products with targeted applications. (2023–2027).

1.6 Analysis of barriers to implement a circular economy

The implementation of the Circular Economy takes place through circular business models. In particular, a circular transformation involves rethinking the value proposition, the value creation architecture, the revenue model, and the competitive strategy.

The German Economic Institute defines circular business models as follows: “Circular business models are business models that focus on enabling, closing, creating, or extending cycles while preserving value and conserving resources for as long as possible, while maintaining competitiveness.”

The economy is largely non-circular due to objective challenges that arise when companies attempt to adopt circular business models.

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The large-scale implementation of Circular Economy solutions faces several barriers, mainly due to the lack of reliable information that can quickly guide stakeholders toward the most sustainable choices. According to the specialized literature (Rizos et al., 2016), the barriers can be fundamentally classified as:

- **Corporate culture barriers**, stemming from resistance by management and employees toward "business-as-unusual" solutions.
- **Lack of capital**, a barrier created by the need for initial investments in innovative technologies and the costs associated with controlling and managing the supply chain;
- **Lack of adequate legislative support**;
- **Lack of information**, often due to corporate confidentiality and the lack of sharing successful paradigms;
- **Excessive administrative burden**, resulting from the need to produce reports, analyses, and other documents when accessing funding (regional, national, or European), often outsourced to external consultants, thereby incurring additional costs;
- **Lack of technical know-how**, often related to Linear Economy practices, which tend to be more cost-effective and easier to implement.

1.6.1 Barriers identified for CSS2 – Food and Feed

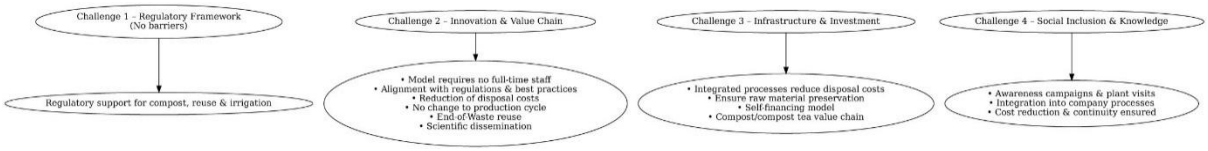

Figure 6 Barriers identified for CSS2

Challenge 1 – Regulatory Framework

The current regulatory context supports the proposed replication model for CSS2, as the technological solutions provided are regulated in the field of both recovery and reuse for irrigation and agricultural purposes (see Ministerial Decree 187/2005, Regulation EU 2024/1765). The regulatory framework also favors the use of natural organic fertilizers such as compost and compost tea. In conclusion, there are no regulatory barriers.

Challenge 2 – Innovation, Product Design, and Value Chain

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- **Lack of resources for innovation** – the technological solution proposed by GAL Irpinia within the replication model does not require full-time personnel.
- **Lack of motivation from companies to invest in local/sustainable products** – companies will align with the regulatory framework and best practices within the End-of-Waste approach.
- **Price factor associated with innovation** – the proposed technological solution is functional in reducing disposal costs for wastewater, liquid waste, and sludge. In terms of germplasm conservation, this guarantees continuity of activities.
- **Difficulty in modifying innovation-based processes** – the proposed solutions will not introduce changes to the production cycle of companies/businesses.
- **Traceability within value chains** – the value of the solutions translates into lower costs for businesses.
- **Use of waste for other purposes, such as water or soil treatment** – the proposed solutions foresee the end-of-waste status and reuse as secondary raw materials.
- **Mapping, analysis, and understanding of urban/regional metabolism to increase circularity and innovation (cross-pollination of ideas and opportunities)** – scientific dissemination activities will be promoted.
- **Lack of disruptive thinking and inertia to change** – scientific dissemination activities will be promoted.

Challenge 3 – Infrastructure, Investment, Entrepreneurship

- **Scale and continuous availability** – small companies may not be able to provide the scale and continuity of resources to be incorporated into other processes – this barrier is absent, as the proposed technological solution integrates and improves company management processes, leading to reduced waste disposal costs. Moreover, continuity over time will be ensured through raw material preservation.
- **Logistics, procurement of circular raw materials, waste disposal/treatment** – this barrier is absent, as the proposed technological solution integrates and improves company management processes, reducing waste disposal costs and ensuring continuity through raw material conservation.
- **Seasonality of production** – absent, as companies interested in replication must manage wastewater and waste issues on a daily basis.
- **Lack of resources** – the technological solution is self-financing as it reduces the cost of off-site water and waste disposal. The reuse of sludge as compost and/or compost tea helps create a value chain within the End-of-Waste framework.

Challenge 4 – Social Inclusion, Awareness, and Knowledge

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- **Lack of consumer literacy**: low consumer awareness regarding the use of natural systems for treating wastewater and waste – awareness will be raised through scientific dissemination and visits to existing plants.
- **Resistance of SMEs to innovation**: SMEs are accustomed to a linear economy; they are reluctant to experiment as it represents an additional investment – this barrier is absent, as the proposed technological solution integrates and improves company management processes, reduces waste disposal costs, and ensures continuity over time through raw material preservation.

1.6.2 Barriers identified for CSS3 – Water and Nutrients

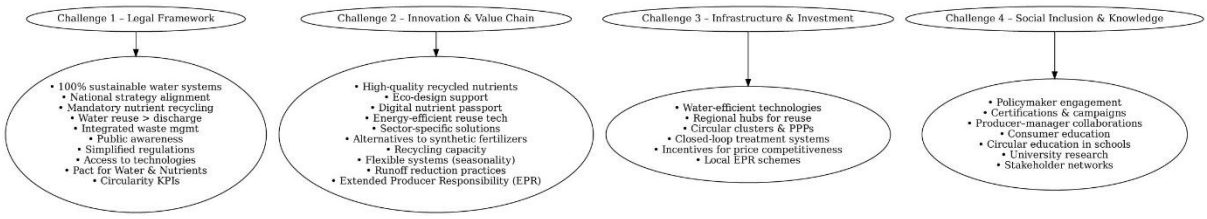

Figure 7 Barriers identified for CSS3

Challenge 1: Legal framework

- **100% sustainable water management** – Promote the design and implementation of water use systems that ensure full sustainability and compliance with EU water directives and national regulations.
- **National Strategy for the Circular Economy** – Ensure continuity and integration across regions (including Irpinia) in the implementation of the Strategia Nazionale per l'Economia Circolare, focusing on sustainable water and nutrient management, avoiding disruptions from government changes. Develop a coordinated regional-local strategy aligned with GAL Irpinia's sustainable development plans.
- **Mandatory nutrient recycling** – Consider legislative instruments to make nutrient recovery and reuse obligatory where feasible, especially in agriculture. Enforcement mechanisms must prevent greenwashing, based on ARERA and ISPRA guidelines.
- **Water reuse over discharge** – Increase investment in water treatment and reuse infrastructure to comply with Italy's Piano Nazionale di Gestione delle Acque, aiming to reduce freshwater extraction and pollution.
- **Management systems for nutrient-rich waste** – While some frameworks exist for organic waste, integrated management systems for nutrient recycling in agriculture and industry are needed, especially in regions like Irpinia.
- **Public awareness on water and nutrient conservation** – Develop and disseminate regional education campaigns tailored to local realities (schools, local authorities).

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- **Overregulation and compliance burdens** – Complex, overlapping national and EU regulations limit innovation in water and nutrient circularity. Simplification and clarification are needed, with input from local entities such as GAL Irpinia.
- **Technology for water and nutrient circularity** – Promote access to and deployment of advanced technologies for nutrient recovery and water reuse, especially in southern and rural regions.
- **Consumer literacy and PPP adaptation** – Adapt successful models like the Portuguese Water and Nutrient Pact to Italy (Italian Pact for Water and Nutrients), ensuring regional representation and action at the level of GALs.
- **Circularity metrics** – Establish standardized KPIs and measurement tools for water and nutrient circularity, integrated into GAL projects.

Challenge 2: Innovation, product design and the value chain

- **Quality of recycled nutrients** – Invest in improving nutrient recovery and processing infrastructure to produce high-quality recycled fertilizers aligned with national standards.
- **Eco-design** – Promote product and process designs that reduce water use and nutrient loss; support SMEs in Irpinia with guidance and incentives for eco-design in agriculture and industry.
- **Digital nutrient passport –** Prepare for the adoption of digital product passports (DPP) related to nutrient flows and water use, as planned under EU regulations, ensuring support for small producers.
- **Water reuse technologies** – Promote energy-efficient water-from-waste and nutrient recovery solutions in compliance with environmental regulations, ensuring minimal impact.
- **Sector-specific needs (e.g., agriculture, food)** – Address specific barriers to water and nutrient circularity in local agri-food businesses and clusters in Irpinia.
- **Alternatives to synthetic fertilizers** – Encourage life-cycle assessments (LCA) for bio-based nutrient sources and sustainable water treatments, following Italian and EU guidelines.
- **End-of-life for nutrient products** – Strengthen treatment and recycling capacity for nutrient-rich waste streams in southern Italy; improve sorting capabilities at the municipal level.
- **Seasonal agricultural sector** – Develop flexible systems for water and nutrient supply and reuse in Irpinia's agriculture, considering seasonal variability and best practices like shared irrigation and nutrient distribution systems.
- **Micro-nutrients and agricultural runoff** – Implement best practices to minimize nutrient runoff and micro-pollutants in agriculture; support valorization of nutrient-rich waste in local industries.

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- **Extended Producer Responsibility (EPR)** – Expand EPR systems to cover water and nutrient management products, considering small producers and rural contexts.

Challenge 3: Infrastructure, investment, entrepreneurship

- **Water-efficient technologies** – Prioritize the use of water-saving and nutrient recovery technologies in industrial and agricultural processes, especially in Irpinia's food and beverage sector.
- **Avoiding water resource depletion** – Develop regional hubs for water reuse and nutrient recycling to minimize environmental impact and costs.
- **Circular Economy Clusters** – Encourage cluster development in Irpinia to connect technology providers, water managers, and producers. Promote public-private partnerships through GAL-facilitated projects.
- **Water reuse systems** – Support innovation for closed-loop water treatment and reuse systems relevant to local environmental priorities.
- **Price competitiveness** – Address cost disparities between virgin and recycled water and nutrient inputs through national and regional incentives (e.g., tax credits or green public procurement).
- **EPR** – Further develop and enforce EPR schemes for water and nutrient-related products, with regional engagement via GALs to ensure local needs are met.

Challenge 4: Social inclusion, awareness and knowledge

- **Awareness among policymakers** – Engage local and regional authorities in dialogue to ensure legislation on water and nutrient circularity is feasible, effective, and locally adapted.
- **Quality perception of recycled water and nutrients** – Launch awareness campaigns and certifications to boost confidence in recycled-content products.
- **Promotion of recycled water and nutrients** – Facilitate collaborations between resource managers and producers to secure consistent, high-quality recycled feedstock.
- **Product and system recyclability awareness** – Promote labeling and consumer education to improve post-use water and nutrient recovery.
- **Circular Economy education** – Integrate water and nutrient circular economy principles into educational curricula and youth programmes supported by GAL Irpinia.
- **Academia partnerships** – Encourage research and experimentation on nutrient recovery, water treatment, and performance with universities in Campania.
- **Stakeholder engagement** – Foster a regional network of producers, resource managers, policymakers, and citizens to co-create solutions for water and nutrient circularity.

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1.7 Stakeholder and Supply Value Chain Analysis

The analysis has been performed at different scales, **Regional** and **Local** (GAL Irpinia).

The involvement and identification of stakeholder started with 2 regional level initiatives:

- The 2023 **EnergyMed**, **Conference Exhibition on Renewable Sources and Energy Efficiency**, in which the FRONTSH1P Project and approach has been first presented;
- The 2024 **GREEN MED Expo & Symposium** in a dedicated conference on June 13th, with the participation of a representative from the Circular Cities and Regions Initiative CCRI, the presentation of each of the CSSs and the direct involvement of the Campania Regional Authority.

Programs of the events are available in Annex 2.

The first identification of stakeholders at regional level included mainly **Research Centres** or **Universities** from the different provinces:

- **Agritech,** the National Research Center for Technology in Agriculture (with main office in Naples), CSS2;
- **CREA,** Council for Agricultural Research and Economics, the center on *Cereal and Industrial Crops* is located in Caserta, CSS2;
- **National Research Council,** their *Institute for Composite and Biomedical Materials IMCB* is located in Portici (NA), CSS2 - CSS3;
- **University of Naples Federico II** with its dedicated *University Task Force (TFdA) in Circular BioEconomy (BEC)*, CSS2 - CSS3;
- **University of Salerno** with its *Department of Chemistry and Biology*, CSS2 - CSS3.

The Campania Regional Authority has been interacting with the FRONTSH1P partners since the proposal stage, but did not actively participate in the activities.

A second step was related to the **GAL Irpinia** area, located in the Province of Avellino (Irpinia) and grouping 44 municipalities, 3 mountain communities, various public organizations and private enterprises (mainly SMEs) where different categories of local stakeholders were identified:

Research Centres or **Universities**

- **University of Naples Federico II**, the *Department of Agriculture* has its *Abellinum Enological Center* in Avellino, CSS2*;*

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- **Centro Diagnostico Baronia**, private research centre supporting R&D activities on environmental and waste management, biofiltration and bioremediation systems, CSS2 - CSS3.
- **National Biodiversity Future Center (NBFC)** a national initiative implementing a research action on *Biodiversity and Anthropogenic Impact in the Partenio regional Park*, CSS2.

Government

- **Città dell'Alta Irpinia,** a special aggregation of municipalities promoted by the Department for Cohesion Policies of the Presidency of the Council of Ministers, with the aim of supporting the potential of the territory and promote its sustainable development, CSS2 - CSS3.

Civil Society

- **Consorzio di Bonifica dell'Ufita**, a consortium dedicated to land reclamation and water management, CSS3;
- **Biodistretto d'Irpinia**, association operating in the province of Avellino, promoting sustainable development through organic farming and enhancement of the local natural and cultural resources, CSS2;
- **Confederazione Italiana Agricoltori** di Avellino, provincial charter of the national organization dedicated to the safeguard and promotion farmers, CSS2.
- **Federazione Provinciale Coltivatori Diretti** di Avellino, provincial charter of the largest association representing and assisting Italian agriculture, CSS2.
- **Alto Calore Servizi,** a public company that manages water collection, supply, and distribution services in the province of Avellino, CSS3.

Business

Many small businesses have been identified, mainly small farming business (CSS2), oil producing companies (CSS2, CSS3) and agronomists (CSS2).

1.8 Engagement of stakeholders

After the initial regional stakeholder identification and engagement actions, various activities have been organized at GAL Irpinia level, in different locations in Irpinia to have a wider local outreach, a final event will be performed in the last month of the Project.

Stakeholder engagement. ***Activities***	**Total Participants**	**Business**	**Academia/ Research Centres**	**Civil Society/ Governmental Agencies**

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1st General meeting	13	3	4	7
2nd Meeting – CSS2	17	17		
3rd Meeting – CSS2	10	10		
4th Meeting – CSS3	8	8		
5th Meeting – CSS3	*tbd*	*tbd*	*tbd*	*tbd*

1.8.1 Dialogue Council

The first meeting in Grottaminarda was a general introductory meeting, with representatives of different stakeholder categories, that were originally identified as local Key Players.

A specific committee named "**L'Economia Circolare per crescere insieme**" – Circular Economy to grow together - was created. Such Committee, chaired by GAL Irpinia, will act as the core group of the local dialogue council.

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Stage II: Resources & Missions Selection

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2 Stage 2: Resources & Missions Selection

The Campania Region, with its 6 million inhabitants, is one of the most densely populated regions in Southern Italy. While the coastal areas are well known for tourism, the inner areas of the region have a very important value for agriculture and environment. From a geographical point of view, the Campania region can be divided into two areas: one mountainous and one flat. The mountainous area includes the Campania Apennines, formed by a series of elevations and plateaus stretching across the provinces of Benevento, Avellino (Irpinia) and part of the province of Salerno (Cilento). It is an area very rich of waters, and thanks to the Calore river and its tributaries Ufita, Tammaro and Sabato it is the e largest hydrographic basin in southern Italy. The flat area is not a single surface, but is divided into two big plains. The northern one is bathed by the river Garigliano and by the river Volturno; such area surrounds the gulf of Naples and and Mount Vesuvius. The second plain pens onto the Gulf of Salerno and is bathed by the river Sele, also originated in Irpinia. There are several regional areas of excellence that will play a decisive role for investments related to green and digital transition and the Campania Region can offer a strong focus on innovative content, particularly related to sustainability. Campania is building its green transition on its focal areas: the conservation of its natural water assets, the agri-food sector, an ecosystem of innovation, the maritime economy, the aerospace district and tourism.

The Frontsh1p activities have been focusing in the **Irpinia province** and in particular on the municipalities associated with **GAL Irpinia**, characterized by a strong agricultural and agri-food vocation, with high-quality productions (DOCG wines, extra virgin olive oil, chestnuts, legumes, cereals, dairy) and a fragmented but valuable production fabric.

The priority areas for circular transition in the **GAL Irpinia** territory are in line with the main Regional focuses and will refer to:

- CSS2 – Food & Feed: valorization of agricultural and agri-food residues, sustainable management of livestock and dairy by-products, reduction of food waste, and industrial symbiosis.

- CSS3 – Water & Nutrients: integrated water resource management, nutrient recovery from wastewater and sludge, treatment technologies, and water reuse in agriculture.

The territory is ready to pilot circular models thanks to the presence of cooperatives, agri-food companies, local authorities, and Campania universities, but barriers remain at infrastructural, economic, and regulatory levels.

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Territorial Profile

- GAL Irpinia area: ~108.000 inhabitants (28% of Avellino Province population). Includes Valle Ufita, Alta Irpinia, and Terminio Cervialto systems.
- Economy: dominated by agriculture and livestock, with SMEs in manufacturing and agri-food transformation.
- Typical productions: Fiano di Avellino, Taurasi, Greco di Tufo wines; Ravece olive oil; Montella chestnuts; cereals and legumes.
- Livestock: cattle, pigs, sheep, and goats, with dairy (caciocavallo, pecorino) and meat production.

2.1 CSS Definition

2.1.1 CSS2 – Food & Feed

Agriculture is centered on wheat, maize, legumes, vineyards, and olive groves, with DOP/IGP products. Livestock counts 120,000 LU, producing ~55,000 tons milk, 18,000 tons meat, 4,500 tons cheese annually. Relevant residues include grape pomace, olive mill wastewater, cheese whey, meat by-products, and cereal residues.

Possible application opportunities for CSS2:

- Anaerobic digestion (biogas/biomethane)
- Composting and organic fertilizers
- Recovery of nutrients and feed ingredients
- Upcycling (fibers, extracts, biobased products)

Identified Barriers for the implementation of CSS2:

- Limited investment capacity of SMEs
- Territorial dispersion of productions
- Lack of collection and treatment infrastructures
- Low awareness and resistance to change

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2.1.2 CSS3 – Water & Nutrients

Key sectors: viticulture, dairy, fruit & vegetables, cereals. Water management is supported by consortia. Ongoing projects: Phytoremediation (Carife), NUTRI-REUSE, AQUA-AGRO, BIOLOOP H2O, WATER GUARD.

Possible application opportunities for CSS3:

- Wastewater treatment and reuse (phytoremediation)
- Nutrient recovery for fertilization
- Precision irrigation and smart monitoring systems
- Creation of water-nutrient clusters and PPPs

Identified Barriers for the implementation of CSS3:

- Complex and overlapping regulations
- Low public awareness on water reuse
- Limited adoption of advanced technologies in rural areas
- Cost competitiveness of virgin vs. recycled inputs

The entire reference value chain for both CSSs is summarized below:

- **Institutions** - Campania Region, Province of Avellino, municipalities (GAL Irpinia);
- **Consortia/Cooperatives** - Montella chestnuts, DOCG wine consortia, Ravece olive oil, dairy and cereals cooperatives;
- **Agri-food SMEs** - wineries, olive mills, dairies, cereal processors;
- **Water & Waste managers**: Multiservizi S.p.A., irrigation consortia, provincial waste companies;
- **Research & universities**: University of Naples Federico II, University of Salerno, University of Campania, CNR, CREA centres.

2.2 Combined SWOT Analysis related to the application of both CSS2 and CSS3

The analysis is based on overall regional regulations and strategies.

From a regulatory point of view, the Campania Region promulgated Regional Law n°14 in 2016 to establish an active undertaking geared towards the implementation of a model of

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circular economy, with associated aims of sustainable development and realization of the principles of a bioeconomy. Such Regional Law states that:

"*Campania Region assumes as a reference for its actions in the field of waste treatment the priorities established at European and National regulation:*

- ***prevention**, as a set of interventions aimed at reducing the production of waste at the source;*
- ***preparation for reuse**, aimed at promoting the reuse of products or components not to be considered waste;*
- ***recovery**, for purposes other than recycling, including energy production;*
- ***disposal**, as a residual and minimal system for non-treatable waste*

The Campania Region recognizes the validity of the principles of the circular economy, whereby waste from a production and consumption process circulates as a new entry into the same or a different process, giving rise to a new model of production and consumption which aims at eliminating waste, through high-level innovative design of materials, reuse of goods, reconditioning of the product, regeneration of components."

Additionally, *"the Region pursues the creation of a circular economy model through concrete actions and supports, also with reward criteria in the allocation of European, state and regional resources, scientific research aimed at the design and production of reusable, repairable and recyclable goods and research on materials used in production cycles in order to minimize the environmental effects of their production and their post-consumption management, helping to encourage the reduction of the use of virgin raw materials and the maintenance of resources within the production cycle as much as possible as long as possible, to offer consumers durable and innovative products capable of generating savings and improving the quality of life."*

The same law sets the following objectives:
a) at least 65% of separate waste collection
b) for each separated fraction, at least 70 % of material actually recovered.

From a strategic point of view, the **Smart Specialization Strategy** addressed the future innovation needs for the Region's economic development and has defined various technological trajectories specifically dedicated to circularity, some of those have been directly inspired also by the FRONTSH1P CSSs:

- Wastewater treatment using sustainable technologies; Innovative models and advanced technologies for waste treatment and recycling;
- Development of advanced digital technologies to support "industrial symbiosis"

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- Materials and components from Circular Systemic Solutions for green cities
- Enhancement of organic waste and sludge for the production of bioplastics and biochemicals

Based on these assumptions and taking into account the positive approach to circularity that, in principle, the Campania Region has declared, the following analysis refers to the possible application of and CCS2 and CSS3 in the GAL Irpinia territory, that can guide further replication on a wider regional scale.

Strengths:

- high-quality productions,
- strong agricultural tradition,
- local cooperation,
- pilot projects,
- Presence of universities and research.

Weaknesses:

- fragmented SMEs,
- limited investment capacity,
- insufficient infrastructures,
- lack of territorial data.

Opportunities:

- EU and national funds (PNRR, PSR),
- biomethane market,
- sustainable product demand,
- water reuse technologies.

Threats:

- climate change,
- international competition,
- negative perception of recycled products,
- complex regulatory framework.

Additional Resource Missions will be investigated, also beyond the project lifetime, applying the 4NO Filter approach in order to identify: Areas of NOT developed resources; Areas of NOT closed added value chains; Areas of NO adaptation to climate change and Areas of NO convergent activities.
Such approach, in a very densely and developed Region as Campania, is not always applicable but it is advisable and will be proposed for a wider Regional Circular Economy Action Plan of Campania.

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2.3 Conclusions

Irpinia, with GAL Irpinia as territorial facilitator, has the right conditions to be a piloting territory for CSS2 and CSS3 replication. The overall challenge lies in the coordination between institutions, enterprises, and research, taking into account access to financing, and the integration of innovation and tradition into practical circular models.

Ther activities will continue and the next steps will focus on:

- Mapping local agri-food by-products and wastewater streams;
- Piloting anaerobic digestion plants for grape pomace, olive wastewater and cheese whey;
- Promoting water-nutrient clusters with irrigation consortia and farmers;
- Promoting industrial symbiosis agreements between SMEs and treatment plants;
- Capacity building for SMEs and cooperatives on circular economy models and access to funding.

The following indicators will be used to assess the success of the local Irpinia actions:

- Tons of biowaste collected and exploited;
- Local biogas/biomethane production;
- % of treated and reused wastewater;
- Nutrients recovered and reintegrated in agriculture;
- Number of industrial symbiosis agreements;
- Number of SMEs engaged in pilot projects.

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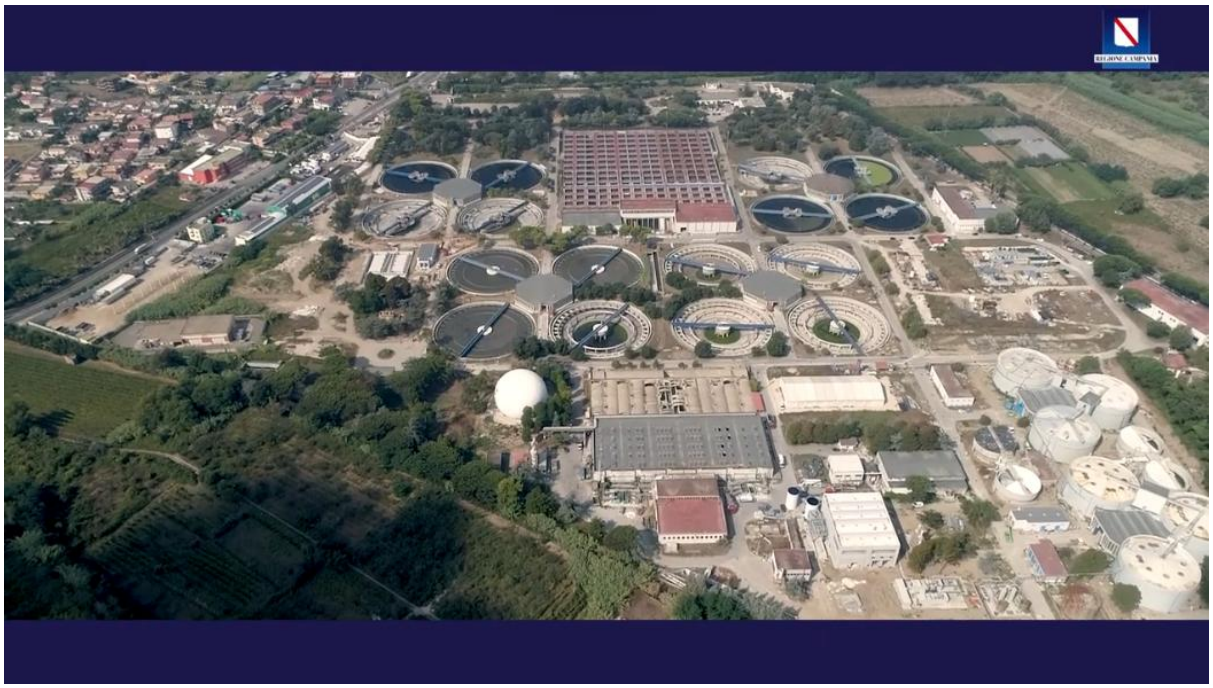
STAGE III: CHALLENGES



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3 Stage 3: Challenges

The circular challenges identified in previously defined Resource Missions (Stage 2) emphasise sustainability, innovation and adaptability. Circular Challenges will often require circular innovative solutions, sometimes they will require circular systemic solutions (CSS). The catalogue of challenges is open and includes, for example:

1. legal framework
2. innovation, product design and value chain
3. infrastructure, investments, entrepreneurship
4. social inclusion, awareness, and knowledge

The implementation of circular challenges is a kind of 'circular acupuncture' targeting 'touch-shot' at key initiation points. It implies a point-of-care approach to intervening in different areas of resource management in the region. The identification of challenges responds to previously diagnosed potentials, barriers and incentives (see step one). Challenges can be interdependent, meaning that the implementation of one of the Circular Challenges in a Mission can affect the implementation status of other Missions.

The tables below describe the challenged identified in Campania Region – GAL Irpinia, for CSS2 and CSS3:

Table 4 CSS2 Challenges

CSS 2 Food and Feed	
Legal Framework	
Regulatory and Legislative Reforms	Clarify the distinction between waste and end of waste (EoW) that can be used as secondary raw materials or for bioenergy production
	Update assessment standards for waste and end of waste (EoW) from pre-selected organic waste
	Ensure that input waste analyses and output waste streams, including impurities from all treatment facilities, comply with the EU Waste Framework Directive (2008/98/EC) and Directive (EU) 2018/851, and that records are maintained in the National Electronic Waste Traceability Registry (RENTRi).
	Establish Municipal Collection Centers (MCCs) to collect, sort and recycle municipal waste at source.

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Local Level	Bioactive composters: small-scale, proximity-based micro-plants for the recycling of green pruning and grass clippings. Develop local value chains that avoid costly transport and enable the recovery of these residues as end-of-waste products.
	Encourage knowledge sharing to improve collection efficiency by facilitating regular exchanges between regional and local departments.
Governance	Reduce waste treatment fees for companies that deliver waste to bioactive composters.
	Introduce fiscal incentives to support the construction of small-scale treatment plants across different categories.
Awareness and Knowledge	
Education	Encourage local communities through information campaigns and training initiatives to adopt circular approaches to organic waste management.
	Provide education and training programmes for local circular economy leaders on efficient municipal waste management.
	Promote 'Reduce, Reuse, Recycle' principles as educational activities in schools.
Information and Promotion	Carry out information campaigns on food and feed waste processing options, aligned with circular economy principles.
	Develop special awareness-raising programmes focused on food waste prevention and reduction.
	Develop and implement an ongoing social media campaign focused on organic waste management.
	Formulate proposals and measures to strengthen knowledge and communication on circular economy topics.
Infrastructure	
Infrastructural investments	Support capital investments for Municipal Collection Centers (MCCs) and small-scale treatment facilities.
Financing	
Governance	Promote the use of EU structural funds for initiatives that support the local circular value chain (e.g., Memorandum of Understanding between the Region of Campania and GAL Irpinia).
	Develop sustainability criteria for funding and implementing biomass projects by establishing multi-stakeholder working groups.
	Provide incentives to citizens through compensation schemes for those implementing home composting.

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Table 5 CSS3 Challenges

CSS 3 Water and Nutrients	
Legal Framework	
Regulatory and Legislative Reforms	Complete the legislative framework for local wastewater management to facilitate safe reuse and nutrient recovery.
	Reference Regulation (EU) 2020/741 as the basis for agricultural reuse of treated wastewater; ensure local implementation for agricultural applications from 26 June 2023 onwards.
	Develop a methodological framework to measure and monitor wastewater quality consistently across the territory.
	Define local standards for the reuse of treated water in agricultural applications, aligned with Italian and EU regulations.
Local Level	Support the deployment of phytopurification (constructed wetland) plants in agricultural areas not served by sewerage systems.
	Convert sludge dewatering beds at existing treatment plants into phyto-dehydration systems to reduce sludge volumes destined for landfill.
	Encourage knowledge sharing through regular exchanges among regional wastewater management agencies.
Governance	Support the deployment of phytopurification (constructed wetland) plants in agricultural areas not served by sewerage systems.
	Support the deployment of phytopurification (constructed wetland) plants in agricultural areas not served by sewerage systems.
Awareness and Knowledge	
Education	Encourage local communities through information campaigns and training initiatives to adopt circular approaches to organic waste management.
	Provide education and training programmes for local circular economy leaders on efficient municipal waste management.
	Promote 'Reduce, Reuse, Recycle' principles as educational activities in schools.
Information and Promotion	Carry out information campaigns on food and feed waste processing options, aligned with circular economy principles.
	Develop special awareness-raising programmes focused on food waste prevention and reduction.
	Develop and implement an ongoing social media campaign focused on organic waste management.

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	Formulate proposals and measures to strengthen knowledge and communication on circular economy topics.
Infrastructure	
Infrastructural investments	Support capital investments to construct consortium-based wastewater treatment plants employing phytodepuration technologies.
Financing	
Governance	Promote the use of EU structural funds for initiatives that support the local circular value chain (e.g., Memorandum of Understanding between the Region of Campania and GAL Irpinia).
	Develop sustainability criteria for funding and implementing biomass projects by establishing multi-stakeholder working groups.
	Provide incentives to citizens through compensation schemes for those implementing home composting.

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Stage IV:
Action Plan

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4 Circular Economy Action Plan for Campania Region: GAL Irpinia - CircuPuncture Action Plan

Regional Law No. 14/2016 assigned to the **Campania Regional Authority**, among the others, the power to promote measures to reduce the quantity of waste, encouraging prevention, recovery of raw materials, and reuse, also with reference to the principles of the circular economy. In 2019 the Region formally launched the process of revising/updating the **Regional Plan for Special Waste Management** in order to equip itself with a planning tool adapted to the changed European regulatory framework, economic, social, and technological changes also taking into account updated data on waste production and regional plant requirements. Such regional plan also included the promotion of measures to reduce the quantity of waste, encouraging prevention, recovery of raw materials, and reuse, also with reference to the principles of the circular economy.

In 2020 the Region has decided to prepare a regional circular economy model for the efficient management of resources in the Campania Region and initiated a process of knowledge sharing with representatives from the academic and productive worlds to define a common direction and concrete actions in order to implement a circular economy model at the regional level. Such process led to the establishment of a Discussion and Contribution Table, chaired by the Vice President together with the Councilor for Productive Activities and Scientific Research, with the participation of the heads of the relevant regional structures, representatives of Campania universities, the National Research Council, Confindustria Campania and the Foundation for Sustainable Development that, through a prior collaboration agreement with the Campania Region, provided technical and scientific contributions to the development of the circular economy model for the Campania Region.

Such “Regional Round Table on the Circular Economy” produced a document describing a “Circular economy model for the efficient management of resources in the Campania Region”. Such a document included an analysis of the economic structure of the Campania Region for the definition of a circular economy model comprising detailed analysis on different sectors including: Agriculture and the Food Industry, Construction and Infrastructure Sector (including Wastewater Management) and other Industrial sectors; it also reported that with regard to the plant capacity dedicated to the treatment of individual separated fractions, there is a deficit in the treatment of organic waste, while in relation to wastewater management the region boasts a large number of wastewater treatment plants (473 plants), 65% of which are secondary or advanced level, nevertheless in specific rural areas the need for wastewater treatment is not fully satisfied.

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In the same year, the Campania Region expressed interest in the FRONTSH1P proposal and signed a Letter of Support expressing interest in evaluating a regional adaptation of the circular economy approach proposed by the FRONTSH1P Project.

During the FRONTSH1P project duration there has been a continuous interaction between the local partners involved in the replication activities in Campania and the Regional Authority. Such interaction led to the development of several joint initiatives, the latest of which, was the organization of the WP8 workshop at the GA in Naples (July 2025), when the region hosted the entire consortium and presented a formal Collaboration Agreement based on the results of FRONTSH1P (Executive Decree No. 307 of July 2, 2025).

The agreement was signed by Campania Region and GAL Irpinia and is aimed at an institutional collaboration agreement for activities involving the recovery of residual vegetal biomass outside the waste circuit as well as the treatment and reuse of civil wastewater in rural areas. Based on these premises, the Circular Economy Action Plan proposed hereafter focuses on the GAL Irpinia area and is referred specifically to the issues covered by the agreement and is based on the local adoption of the CircuPuncture methodology.

This **CircuPuncture Economy Action Plan for the GAL Irpinia** area is focusing on CSS2 and CSS3 and will be presented to the Campania Regional Authority to be used as a Guideline for the entire Campania Region Circular Economy Action Plan.

The Collaboration Agreement is the fundamental framework for the implementation of this process which consolidates the role of GAL Irpinia.

Since the GAL Irpinia area includes both small-scale urban centers and large rural areas predominantly devoted to agriculture and forestry, the approach will be differentiated and tailored to the characteristics of the territory. This means identifying tailor-made solutions: more advanced infrastructure and services in urban areas; community management models, and widespread facilities in rural areas.

4.1 CircuPuncture Economy Action Plan for GAL Irpinia

The GAL Irpinia area is characterized by a vast and diverse rural landscape, with a strong agricultural and forestry tradition. However, it is currently facing very specific challenges that require innovative solutions for the development of a circular economy.

These challenges are of technical, legislative and organizational nature: the fragmentation of agricultural and agri-food businesses, the lack of synergy between producers, processors, and researchers and, finally, the difficulties associated with the sustainable management of

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agricultural waste and residues. In addition to these critical issues, there are cultural and economic factors, as the benefits of the circular economy are not yet fully perceived by local businesses and communities.

From a geographical point of view, the extent and dispersion of rural settlements hinder the development of structured collaborations: the access to common infrastructure and services for the treatment of by-products and waste are more complex than in the rest of the region. Stakeholders are located at different points in the value chain—from primary production to processing and distribution—with the result that operations are still predominantly conducted according to traditional linear models.

Some local experiences are already showing signs of alignment with the principles of the circular economy, especially in sectors such as wine, olive oil and livestock farming, but these initiatives need to be strengthened through targeted incentives, local promotion activities, and demonstration pilot projects.

In this scenario, GAL Irpinia and the local administrations play a crucial role: although they cannot intervene directly in regulatory matters, they can promote sustainable practices, support processes of aggregation between companies and activate technical and organizational tools aimed at strengthening the competitiveness of supply chains. At the same time, they can stimulate the spread of a culture of sustainability through awareness-raising and training activities aimed at both agricultural entrepreneurs and citizens.

Seminars, workshops, and information campaigns are key levers for spreading practices such as reuse, recycling, and the valorization of agricultural and agri-food waste, contributing to a more sustainable and environmentally friendly lifestyle.

The feedback from the local stakeholders have identified three main challenges to assist the transition:

- the development and modernization of infrastructures for the treatment and recovery of residual plant biomass, sludge, and wastewater;
- the testing of phytoremediation and Phyto-dewatering systems on a local scale;
- the implementation of circular bioeconomy models in the most relevant agricultural supply chains.

Starting from those challenges, the plan is structured around a series of integrated and complementary actions aimed at enhancing local resources, reducing waste, and promoting innovative models for managing agricultural waste and effluents.

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Such actions must be supported by preliminary cross-cutting initiatives to stimulate local development and promote local circular bio-economies, thereby ensuring stakeholder involvement, knowledge dissemination, and the replicability of the proposed solutions.

4.2 Cross-cutting challenges to CSS2 – CSS3

To accompany and strengthen the implementation of the CircuPuncture Economy Action Plan, some cross-cutting actions have been identified: the **Implementation of the Collaboration Agreement**; **Local Community Outreach** and the **Development of Local Circular Bioeconomies**.

These actions respond to the need to ensure preliminary widespread involvement, active participation, and knowledge transfer between businesses, local authorities, plant operators, research centers, and citizens. The goal is to create a territorial ecosystem conducive to the adoption of innovative and sustainable solutions capable of generating long-term economic, environmental, and social benefits.

Territorial animation focuses on dialogue with potential beneficiaries, the establishment of local partnerships, and the promotion of participatory processes, in order to build solid networks and share common objectives.

The development of local circular bioeconomies aims to enhance the value of waste and wastewater flows, encouraging the testing of innovative solutions, the creation of demonstration plants, and the dissemination of replicable models, with the active involvement of businesses and rural communities.

Through these cross-cutting actions, GAL Irpinia strengthens its role as a territorial facilitator and consolidates the path towards a widespread, resilient circular economy rooted in the local rural fabric.

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CSS 2 FOOD AND FEED	
CSS 3 WASTE WATER AND NUTRIENTS	
LEGAL FRAMEWORK (Regional Level)	
C 1.1 **Collaboration Agreement for the application of the FRONTSH1P approach**	
Coordinator	Campania Regional Governement - Directorate-General for Integrated Water and Waste Cycle and Environmental Authorizations (DG 50.17.00)
Implementation Parties	GAL IRPINIA
Timeframe	July 2025 – december 2027
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	- Promotion of the dissemination of best practices for Circular Economy - Support local authorities in drafting municipal regulations - Monitor, with the support of technical agencies, the operating conditions of local supply chains in order to promote a circular and sustainable local economy
Indicators	Implementation of the Circular Economy Action Plan in the GAL IRPINIA area according to the FRONTSH1P approach
AWARENESS AND KNOWLEDGE	
C 2.1 **Local community outreach**	
Key actions	1. Mapping potential beneficiaries and stakeholders 2. Organization of informational and participatory meetings 3. Multi-channel communication and dissemination 4. Support for the establishment of partnerships and collaboration networks 5. Support for the establishment of partnerships and collaboration networks
Coordinator	GAL IRPINIA
Implementation Parties	- Avellino Provincial Federation of Direct Farmers - Italian Confederation of Farmers, Avellino - Local agricultural business associations - Local authorities and wastewater treatment plant operators
Timeframe	1. 0–3 months 2. 3 – 12 months 3. 6 – 18 months

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	4. 0 - 36 months 5. 6–18 months
Financing	Regional Funding (POR2021-2017)
Expected Results	Preliminary widespread involvement, active participation, and knowledge transfer between businesses, local authorities, plant operators, research centers, and citizens
Indicators	Number of potential beneficiaries/stakeholders contacted Number of workshops/meetings organized Number of participants in events Number of networking meetings facilitated by the LAG Partnerships or collaboration networks formally established Number of information materials produced and disseminated Number of visits to the website or dedicated digital channels Number of expressions of interest collected Number of projects/proposals activated
PARTICIPATION AND NETWORKING	
C 3.1 **Development of local circular bioeconomies**	
Key actions	1. Identification of priority waste and wastewater streams 2. Design the innovative solutions 3. Involvement of local businesses 4. Dissemination and capitalization of results
Coordinator	GAL IRPINIA
Implementation Parties	- Campania Region - Local authorities and wastewater treatment plant operators - Research institutions and universities - Cooperatives and farmers' associations - ICT companies and technical consultants
Timeframe	1. 0–6 months 2. 6 – 12 months 3. 6 - 24 months 4. 18 - 36 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	Cross-sectional analysis of agricultural waste streams Development of projects Creation of networks Transforming projects into replicable and scalable models
Indicators	Number of supply chains analyzed and types of waste/effluents mapped Number of innovative projects developed and presented

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	Number of partners involved in the design Number of companies participating in bioeconomic partner ships Number of new agreements or collaborations formalized Number of workshops/seminars presenting the results Number of participants in dissemination events Number of replicable models/guidelines produced and shared

Table 6 Preliminary Cross-cutting actions and solutions related to CSS2 and CSS3

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CSS 2 FOOD AND FEED	
AWARENESS AND KNOWLEDGE	
C 2.1 **Ri.Agri (Riuso Agricolo)**	
Key actions	1. Identification of supply chains and priority areas 2. Establishment of local partnerships (Operational Groups-GO)
Coordinator	GAL IRPINIA
Implementation Parties	- Operations Groups (GO) - Provincial Federation of Direct Farmers Avellino - Italian Farmers Confederation Avellino - Agricultural enterprises
Timeframe	1. 0 – 3 months 2. 2 – 6 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	Facilitate the creation of GOs composed of agricultural companies, research institutions, consultants, ICT companies and civil society actors suitable for circular economy experiments in specific agriculture sectors
Indicators	Number of GOs established and active Number of farms and other partners involved
PARTICIPATION AND NETWORKING	
C 3.1 **RI. AGRI. – Networking**	
Key actions	1. Training and capacity building 2. Rural community involvement 3. Monitoring and feedback gathering
Coordinator	GAL IRPINIA
Implementation Parties	- Operations Groups (GO) - Provincial Federation of Direct Farmers Avellino - Italian Farmers Confederation Avellino - Agricultural enterprises
Timeframe	1. 5 –18 months 2. 5 – 18 months 3. 9 - 24 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027) ~~Regional Funding (POR2021-2017)~~
Expected Results	Raise awareness and involve local actors
Indicators	Number of workshops /training events and participants Number of accesses to the dedicated website, publications and dissemination material distributed

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INFRASTRUCTURE SUPPORT	
C 4.1 **RI. AGRI. - Technical design and selection of innovative solutions**	
Coordinator	GAL IRPINIA
Implementation Parties	- Operations Groups (GO) - Provincial Federation of Direct Farmers Avellino - Italian Farmers Confederation Avellino - Agricultural enterprises
Timeframe	6 – 12 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	Installation of innovative technologies in rural areas, for experimental and demonstration purposes
Indicators	Number of pilot plants or innovative solutions implemented Amount of agricultural/waste waste recovered or reused (tonnes/year) Percentage of waste reused compared to total produced)
SUPPORT FOR CIRCULAR ENTREPRENEURSHIP	
C 5.1 **RI. AGRI. – Financial Support**	
Key actions	1. Tender activation and financial support 2. Capitalization and replicability
Coordinator	GAL IRPINIA
Implementation Parties	- Operations Groups (GO) - Provincial Federation of Direct Farmers Avellino - Italian Farmers Confederation Avellino - Agricultural enterprises
Timeframe	1. 4 – 12 months 2. 18 – 30 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	Funding innovative plats, evaluation of impacts and replicability assessment
Indicators	Number of projects financed Total amount of public resources allocated and % used Number of enterprises reporting reduction in disposal costs

Table 7 Action and solutions related to CSS2, RiAgri

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CSS2 Ri.Agri (Riuso Agricolo – *Agricultural reuse*)

The Ri.Agri Action fits into this context as part of a Community Project financed by GAL Irpinia and aimed at supporting private investments capable of activating rural development processes through circular economy practices. In a logic of environmental protection and sustainability, Ri.Agri promotes the valorisation and reuse of farm processing waste, in particular pruning mowing, reducing waste and negative impacts and supports the implementation of CSS2.

The action provides support to fully cover intervention costs, and up to the amount of **100,000.00 euros**, dedicated to the implementation of projects promoted by partnerships (Operational Groups) aimed at introducing and disseminating innovative bioeconomy processes, in particular in the olive, cereal, livestock and wine supply chains.

The direct beneficiaries are the Operational Groups, composed by:
- agricultural and forestry enterprises (individual or associated) based in the GAL Irpinia area;
- other enterprises operating in rural areas relevant to the achievement of the objectives;
- public bodies and private enterprises active in research and/or training;
- consulting providers;
- other actors in agriculture, food, forestry and civil society;
- enterprises operating in the ICT sector.

Through Ri.Agri and thanks to the agreement with the Campania Region, GAL Irpinia aims to transform innovative experiments and practices into models that can be replicated at a territorial level, strengthening the local cluster of the circular economy and contributing to the competitiveness of production chains, the reduction of environmental costs and the diffusion of a culture of sustainability.

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CSS 3 WASTE WATER AND NUTRIENTS	
AWARENESS AND KNOWLEDGE	
C 2.1 **Wastewater Treatment - Phytoremediation – (DEPURFitodepurazione)**	
Key actions	Animation and capacity building
Coordinator	GAL IRPINIA
Implementation Parties	Campania Region – DG Integrated water and waste cycle (co financing and technical support). Beneficiary municipalities (construction and management of pilot plants). Research bodies and technical advisers (design, monitoring and training). Agricultural business associations (Coldiretti Avellino, CIA Avellino, rural cooperatives). Local communities (citizens and businesses as indirect beneficiaries).
Timeframe	6 – 18 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	Workshops and seminars with municipalities, agricultural enterprises and associations; technical training for municipal staff on plant management
Indicators	Number of workshops and information meetings organized. Number of information materials produced (brochures, newsletters, website). Number of accesses to the dedicated section of the GAL site. Number of events/events with focus on phytopurification.
PARTICIPATION AND NETWORKING	
C 3.1 **Wastewater Treatment – Involvement**	
Key actions	Involvement of local communities
Coordinator	GAL IRPINIA
Implementation Parties	Beneficiary municipalities (construction and management of pilot plants). Agricultural business associations (Coldiretti Avellino, CIA Avellino, rural cooperatives). Local communities (citizens and businesses as indirect beneficiaries).
Timeframe	6 – 12 months

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Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	Information activities for citizens and administrators on environmental and economic benefits
Indicators	Number of participants in training/animation events. Number of municipalities involved in pilot plants.
INFRASTRUCTURE SUPPORT	
C 4.1 **Depur – Pilot Plants**	
Key actions	1. Identification of pilot sites 2. Technical and authorization design 3. Construction of pilot plants
Coordinator	GAL IRPINIA
Implementation Parties	Campania Region – DG Integrated water and waste cycle (co financing and technical support). Beneficiary municipalities (construction and management of pilot plants). Research bodies and technical advisers (design, monitoring and training).
Timeframe	1. 0 – 3 months 2. 2 – 6 months 3. 6 - 12 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	Installation of innovative plants in rural municipalities not served by public sewerage
Indicators	Number of pilot plants built (target: 2). Economic value of investments (270,000 €) % of resources actually used compared to the allocation. Total purification capacity of plants (equivalent inhabitants served).
SUPPORT FOR CIRCULAR ENTREPRENEURSHIP	
C 5.1 **Depur – Circularity Support**	
Key actions	1. Monitoring of environmental performance 2. Capitalization and replicability
Coordinator	GAL IRPINIA
Implementation Parties	Beneficiary municipalities (construction and management of pilot plants).

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	Agricultural business associations (Coldiretti Avellino, CIA Avellino, rural cooperatives). Local communities (citizens and businesses as indirect beneficiaries).
Timeframe	1. 6 – 12 months 2. 6 – 18 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) + Regional funding (PR FESR 2021 – 2027)
Expected Results	Increase the number of Municipalities declaring benefits in terms of reducing disposal costs; citizens/enterprises reporting positive perception on intervention; increase the satisfaction level of local administrators.
Indicators	Total purification capacity of plants (equivalent inhabitants served). Quality of treated water compared to regulatory parameters (BOD, COD, nutrients). Estimated amount of sludge/wastes recovered or reused (ton/year). Reduction percentage of untreated wastewater. Economic value of additional investments (over the additional 10.19 M€ requested from the Region).

Table 8 . Actions and solutions related to CSS3, DEPUR - (Phytopurification)

CSS3 Wastewater Treatment - (Phytopurification)

The DEPUR interventions are particularly necessary in inhabited rural areas not served by public sewerage, where the management of domestic wastewater takes place through watertight septic tanks and/or leaktight wells. From an administrative point of view, these methods do not constitute actual discharges, but are classified as temporary warehouses pursuant to article 183, paragraph 1, (m), of the Legislative Decree. 152/2006.
To prevent pollution phenomena and mismanagement of liquid waste produced by leak-proof wells and septic tanks (identified with EER code 20.03.04), GAL Irpinia has identified the Depur – Phytopurification action as part of the activities for the CircuPuncture Economy Action PLan.

The action is aimed at the implementation of CSS3 with 2 main objectives: to reduce the production of wastewaters and to prevent water and soil pollution. The action aims at funding the construction of two pilot phytopurification plants for the integrated valorisation of organic matrix waste and sludge from civil or similar waste water, delivered to sub-

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irrigation or surface water bodies. The systems adopted are based on phyto-remediation and bio-remediation techniques, exploiting the natural ability of vegetation and/or microorganisms (individual or in association with plants) to reduce, retain and remove potentially polluting organic and inorganic substances.

Each plant will have a value of 135,000 €, with direct beneficiaries the municipalities involved and indirect beneficiaries approximately 25 equivalent inhabitants for each pilot plant.
The action is integrated by the Collaboration Agreement between GAL Irpinia and the Campania Region: as part of this agreement, GAL has already submitted a request for funding to the Campania Region for a further 13 phytopurification plants, with a total value of 10,190,000 €, capable of serving approximately 1,700 equivalent inhabitants.

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CSS 3 WASTE WATER AND NUTRIENTS	
AWARENESS AND KNOWLEDGE	
C 2.1 **Wastewarer Treatment – Sewage SludgeDEPUR(Fitodisidratazione)**	
Key actions	1. Involvement of the local community 2. Training and technical support
Coordinator	GAL IRPINIA
Implementation Parties	Municipalities– direct beneficiaries of the pilot projects. Purification plant operators (consortia, integrated water service companies, in-house companies, etc.) Research bodies and technical consultants Agricultural associations and citizens
Timeframe	1. 6 – 12 months 2. 6 – 12 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027)
Expected Results	Awareness-raising towards citizens and stakeholders, training of municipal and management entities staff
Indicators	Number of participants in awareness events. Number of technical meetings and workshops held.
INFRASTRUCTURE SUPPORT	
C 4.1 **Wastewater Treatment - Phytodehydration – Pilot Plants**	
Key actions	1. Technical design of pilot plants 2. Construction and testing of the 5 pilot plants 3. Monitoring and evaluation
Coordinator	GAL IRPINIA
Implementation Parties	Municipalities– direct beneficiaries of the pilot projects. Purification plant operators Research bodies and technical advisers.
Timeframe	1. 3 – 6 months 2. 6 – 12 months 3. 12- 24 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027)
Expected Results	Convert existing drying beds into phytodishydration basin
Indicators	Number of phytodehydration pilot plants activated. Amount of sludge treated in pilot plants (tonnes/year). Reduction percentage of sludge to landfill (target: -80%).
SUPPORT FOR CIRCULAR ENTREPRENEURSHIP	
C 5.1 **Wastewater Treatment - Phytodehydration – Circularity Support**	
Key actions	1. Selection of sites and mapping of managing organizations 2. Collaboration agreements with managing organizations

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	3. Capitalization and replicability
Coordinator	GAL IRPINIA
Implementation Parties	Municipalities– direct beneficiaries of the pilot projects. Purification plant operators Agricultural associations and citizens
Timeframe	1. 0 – 3 months 2. 3 – 6 months 3. 18 – 36 months
Financing	GAL Irpinia Funds (CSR 2023 – 2027) ~~GAL Irpinia Funds + Regional Funding (POR2021-2017)~~
Expected Results	Support Municipalities in reduction and management of sewage sludge
Indicators	Total amount of public resources used (€ 352,500.00). % of allocated funding actually spent. Number of beneficiary municipalities N. of municipalities declaring reduction in disposal costs. N. of Municipalities reporting direct environmental benefits.

Table 9 Actions and solutions related to CSS3, Wastewater treatment - (Phytodehydration)

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CSS3 Wastewater Treatment – Sewage Sludge - (Phytodehydration)

An additional environmental issue in the GAL Irpinia territory is linked to the management of sewage sludge, which today represent a critical economic and management burden for rural municipalities. In many cases, the sludge produced is disposed of in landfill with significant costs and with a negative impact on the environment.

To meet these needs, the Plan foreseen the construction of 5 pilot phytodehydration plants, financed with a total budget of €352,500.00, intended for 5 municipalities in the area.
The interventions will allow a reduction of up to ’80% in the volumes of sludge to be disposed of in landfill, improving environmental sustainability and reducing management costs borne by local authorities.

The technology adopted involves the conversion of the existing drying beds of purification plants into vegetated basins (Phytodishydration). A phytodehydration plant is capable of operating for a period of at least 30 years, divided into cycles of 8-10 years.

- Start-up phase (1-2 years): mud loads are modulated according to plant development.
- Operation phase at full capacity (8-9 years): the sludge is introduced discontinuously (weekly cycles alternating with rest periods of 2-5 weeks).
- Final stage (about 1 year): Bed feeding is stopped to promote mineralization and prepare a new cycle.

These interventions represent a concrete strategy to reduce the environmental impact of sewage sludge and initiate sustainable management processes in rural communities.
Looking ahead, the possibility of developing a future research project aimed at valorising stabilized sludge as an agricultural soil improver is envisaged, in full compliance with regulations and with a view to a circular economy.

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Annex 1

Selected indicators of sustainable development relating mainly to economic growth and circular economy in Italy.

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TOOLBOX 2

Selected indicators of sustainable development relating mainly to economic growth and circular economy in Italy

Goal CDG	Goal SDG for Italy	Indicator (units)	To achieved by
Goal 1. No poverty	Reduce the intensity of poverty	1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	2030
		1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than **$1.25 a** day	2030
		1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	2030
		1.b Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions	2030
		1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programs and policies to end poverty in all its dimensions	2030
Goal 2. Zero hunger	Combat food and materia deprivation	2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2030
		2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2030

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		2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2030
Goal 6. Clean water and sanitatione	invest in infrastructure and guarantee the right to water	6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	2030
		6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	2030
		6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	2030
		6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	2030
Goal 7. Affordable and clean energy	renewables, the only energy sector not affected by the crisis	7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	2030
		7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	2030
		7.3 By 2030, double the global rate of improvement in energy efficiency	2030
Goal 8. Decent work and economic growth	among the worst in the EU, an alarming picture worsened by the crisis	8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	2030
		8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training	2020

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		8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human traicking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms	2025
		8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	
		8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries	
		8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to inancial services	
		8.10 Strengthen the capacity of domestic inancial institutions to encourage and expand access to banking, insurance and inancial services for all	
Goal 9. Industry, Innovation and Infrastructure	digitalisation is necessary for every production sector	9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well- being, with a focus on affordable and equitable access for all	
		9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to inancial services, including affordable credit, and their integration into value chains and markets	
		9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020	2020
		9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	2030

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		9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use eiciency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	2030
		9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	2030
Goal 11. Sustainable cities and communities	aumentano abusivismo edilizio e sovraffollamento abitativo	11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	2030
		11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	2030
		11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	2030
		11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	2030
		11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	2030
		11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource eiciency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels	2020

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		11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	2030
		11.a Support positive economic, social and environmental links between urban, peri- urban and rural areas by strengthening national and regional development planning	
		11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	
Goal 12. Responsible consumption and production	the circular economy improves waste recycling	12.2 By 2030, achieve the sustainable management and eicient use of natural resources	2030
		12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	2030
		12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	2020
		12.1 Implement the 10 Year Framework of Programs on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	
		12.c Rationalize ineicient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	
		12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	
		12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	2030
		12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	

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		12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	
Goal 13. Climate action	adapt national objectives to EU targets	13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	
		13.2 Integrate climate change measures into national policies, strategies and planning	
Goal 15. Life on land	we need a national plan for the restoration of natural systems	15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	2020
		15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	2020
		15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and loods, and strive to achieve a land degradation- neutral world	2030
		15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	2030
		15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	2020
		15.a Mobilize and significantly increase inancial resources from all sources to conserve and sustainably use biodiversity and ecosystems	
		15.b Mobilize significant resources from all sources and at all levels to inance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation	
		15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed	

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		15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	2020
		15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	2020
Goal 16. Peace, justice and strong institutions	regulate online communication, fairness and respect are needed	16.1 Significantly reduce all forms of violence and related death rates everywhere	
		16.2 End abuse, exploitation, traicking and all forms of violence against and torture of children	
		16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all	
		16.4 By 2030, significantly reduce illicit inancial and arms lows, strengthen the recovery and return of stolen assets and combat all forms of organized crime	2030
		16.5 Substantially reduce corruption and bribery in all their forms	
		16.6 Develop effective, accountable and transparent institutions at all levels	
		16.9 By 2030, provide legal identity for all, including birth registration	2030
		16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements	
		16.b Promote and enforce non-discriminatory laws and policies for sustainable development	
Goal 17. Partnerships for the goals			

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Annex 2

CONVEGNO

FRONTSH1P – Soluzioni Sistemiche Circolari per il recupero e la valorizzazione degli scarti: un nuovo paradigma di sviluppo territoriale basato sull'economia circolare

Giovedì 30 marzo 2023 – 14:30/16:30

Napoli > Mostra d'Oltremare > Padiglione 5 > Sala Mediterraneo

14:00 Registrazione partecipanti

14.30 Saluti

Intervengono

- Carmine Pascale **STRESS,** Fabio Magrassi **STAM**
  Presentazione generale al progetto
- Carlo Caligiuri **UNIBZ**
  Residui e scarti derivanti da imballaggi legnosi
- Daniele Turati **NOVAMONT**
  Valorizzazione degli scarti urbani e agricoli per la riqualificazione territoriale attraverso coltivazioni a basso impatto
- Alberto Reis **LNEG**
  Acque reflue urbane ed industriali
- Carmine Pascale **STRESS**
  Scarti urbani ed industriali di plastica o gomma
- Fabio Magrassi **STAM**
  Strumenti digitali per l'adozione estesa dell'economia Circolare
- Carmine Pascale **STRESS**
  Azioni strategiche di replicazione - possibili applicazioni in Campania: Valorizzazione delle biomasse agricole* a cura di *GRADED
- Fabio Magrassi **STAM**
  CCRI – La Circular Cities and Regions Initiative

16.15 Dibattito e Conclusioni

Funded by the European Union in the framework of the Horizon 2020 Research and Innovation Programme under grant agreement No. 101037031

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Grant Agreement number: 101037031
Project acronym: FRONTSH1P
Project title: A FRONTrunner approach to Systemic circular, Holistic & Inclusive solutions for a new Paradigm of territorial circular economy
Type of action: Innovation Action (IA)

REGIONAL ROADMAP: FRIESLAND PROVINCE, NETHERLANDS

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Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Table of Figures

Table of Tables

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

Abbreviations

CCRI - Circular Cities and Regions Initiative
CE – Circular Economy
CEAP - Circular Economy Action Plan
CpEAP – CircuPuncture Economy Action Plan
CSS – Circular Systemic Solutions
CTC – Circular Territorial Cluster
ICT - information and communication technologies
LAP – Local Activity Place
LR – Lodzkie Region
NGO – Non-Governmental Organisation
RCT - Regional Cluster Team
SAT – self-assesment tool
SLOM – Stowarzyszenie Łódzki Obszar Metropolitalny (Lodz Metropolitan Area Association)
TRL - technology readiness level

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STAGE I: ANALYSIS OF CONDITIONS

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1 Stage 1: Analysis of Condition

1.1 Designation of the Region

The province of Friesland (also known as Fryslân) is one of the twelve provinces located in the Netherlands. Friesland is the largest province of the Netherlands, but the least densely populated. Friesland ranks low on economic indicators, but high when well-being indicators are reviewed. Nevertheless, there is a unique blend of societal well-being and targeted economic strengths. The main drivers for economic growth within this ecosystem are the scale, short communication lines, the presence of industrial chains and the "so-called "Frisian DNA". The power of this DNA is the ability to form a community, partly driven by shared own language and deep-rooted traditions. The culture is characterized by involvement, reliability and loyalty.

Figure 1 Friesland is located in the Northern part of the Netherlands (source: Britannica)

One of the goals of the region is to be a European frontrunner concerning circularity. There is a commitment to an integrated approach where supply chains are closed, and waste no longer exists. Everyone is invited to participate in and initiate circular initiatives. There is a large focus on a pragmatic, action-oriented approach, which can be best summarized by the Frisian saying "Best Genôch", which loosely translates to "good enough". Friesland has been pioneering toward a circular economy for a while now, where the focus is to become one the most circular region of the world. Due to the so-called "Frisian Model", a strong foundation has been built. This model is powered by a Triple Helix of business, government and academia. The association Circular Friesland plays a central role in aligning these different perspectives and promoting the collective learning process.

This transition is pursued at the regional scale. The regional scale is ideally suited for accelerating the circular economy. Nevertheless, a lot of initiatives do not stop at the border of Fryslân. The Frisian model has replicated to other neighbouring provinces of the likes of Groningen, Drenthe and recently Utrecht. These provinces have established a similar association, each with their own

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identity and approach. Specifically, the Province of Groningen and Drenthe have strong ties with Friesland in terms of collaboration.

Overall, the Frisian economic agenda focuses on six key sectors:

1. **Water Technology:** This sector has an important contribution to the broad prosperity of the province. More than half of the water technology employment is based in Friesland, which accounts for 2.600 jobs. With the WaterCampus, Friesland has an important knowledge institution that contributes to innovating and connection.

2. **Agrifood:** This is not only limited to the primary sector agriculture, but the entire chain. It also involves the supplying and processing industries, as well as wholesale, retail and knowledge institutions. Compared to the other parts of the country, this sector is less intensive. The sector comes with the challenge to properly reward circular entrepreneurship and recognizing societal added values. In 2023 there were 31.040 jobs in the sector.

3. **High Tech Systems & Materials (HTSM):** This is a cross-disciplinary sector which is characterized by mostly small, specialized companies. The Frisian HTSM has over 3.500 companies, employing a total of at least 20.600 people. The driving force behind the sector in Friesland is the Innovation Cluster Drachten (ICD).

4. **Circular Materials:** This sector can be subdivided into three different parts: greening, reuse and reducing material use. In Friesland, there is a strong focus on setting up biobased value chains, reuse and circular plastics. In the recycling sector, there are 3.000 jobs. The companies that have potential to apply the circular materials contribute 18.700 jobs to the Frisian market.

5. **Maritime Technology:** Within Friesland, there is a specialisation in yachtbuilding and regular shipping. The sector prefers to operate on the scale of Northern Netherlands, instead of just Friesland. Within Friesland, 5.600 people are working in the sector.

6. **Tourism & Hospitality:** Within the hospitality sector, there are 6.750 companies. The added value per job is relatively low, but the added value of the sector can be better expressed in terms of its contribution to wide prosperity.

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Figure 2 The Frisian Economic Agenda Blue Delta (source: Innovatiepact Fryslân)

In Friesland, circularity does not have one rigid definition. Instead, the region built its foundation on adaptable design principles, which are also known as the "Seven Pillars of Circular Economy". This model serves as a guiding practical tool for business, policymakers and communities. Using this tool, the abstract concept of circularity can be translated into concrete actions that can be applied across different sectors and regional contexts.

The seven pillars are defined as follows:

- **Materials:** It is crucial that raw materials are reused at a high level as long as possible, to minimize negative impacts on nature, biodegradable materials are used as much as possible.
- **Energy:** energy supply from sustainable sources is vital for the circular economy. This includes energy from the sun, water, and wind and other green energy sources. This ensures a system that is clean, reliable and future-proof.
- **Water:** This pillar aims to minimize the use of fresh water and maximize the recovery of energy and nutrients from water. Pollution of aquatic ecosystem must be halted as well.
- **Biodiversity:** When designing products and services, biodiversity should be kept in mind. Preserving biodiversity is essential for maintaining a planet with regenerative capabilities that can sustain life in the long term.

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- **Society & Culture:** The goal is to have a thriving society with self-restoring and regenerative capabilities. This must by a society for everyone, with respect for every culture. Different ideas and perspectives are valued for the resilience and inclusiveness of the system.
- **Health & Wellbeing:** The impact of harmful and toxic substances should be limited. If such substances are used, it is done in a controlled way. This ensure that there is no unnecessary exposure and economic activities do not pose a threat to human health and well-being.
- **Value:** The classic definition of value is broadened. Besides financial value, it also includes social and environmental value. The economy becomes a tool for realizing social and environmental value, which cannot be expressed in monetary terms.

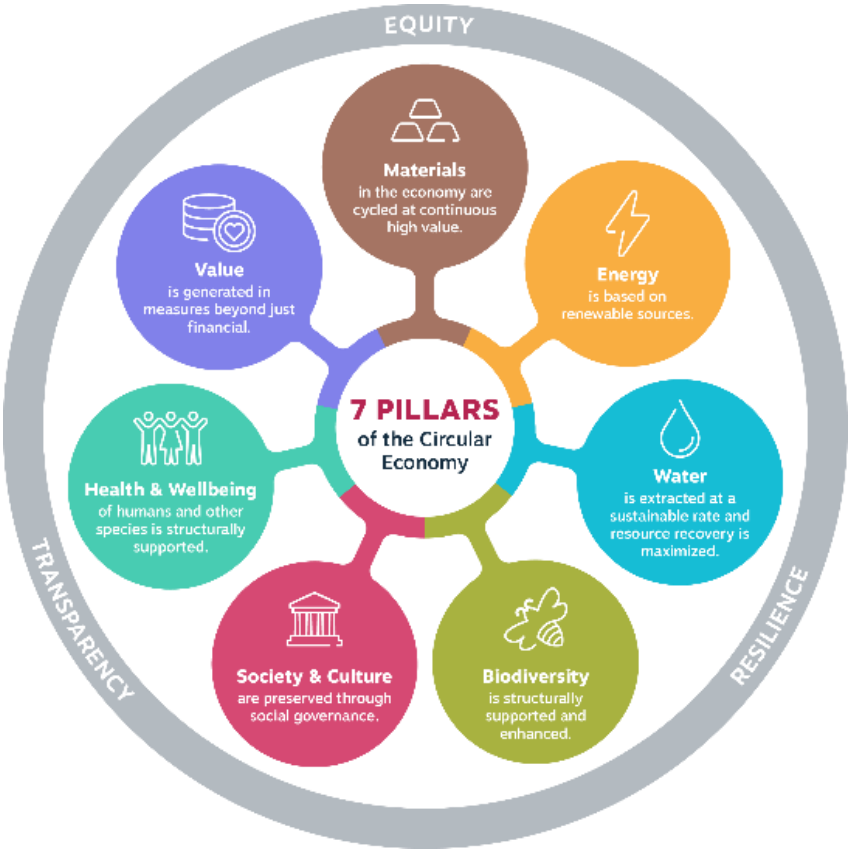

Figure 3 The 7 Pillars of a Circular Economy (source: Circular Friesland)

The strength of the model is it allows for flexible use, by also considering regional characteristics. Nevertheless, there is still alignment with the broader circular economy goals. The model has been applied by several companies in the region to make conscious decisions that benefit a circular economy. Additionally, the seven pillars form the backbone for the association's program and the regional strategy. The focus is on specific tipping points, which include activities to set up new value chains, create ownership for relevant stakeholders and connect the region with national and international policy and funds.

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1.2 Identification of Key Resources for implementing circular economy activities (including the establishment of indicators)

1.2.1 Plastics and Rubber

The strategic direction of Circulair Friesland is rooted in the "Transitie-Doe-Agenda Kunststoffen", which loosely translates to Transition-Action Agenda Plastics (Veele, 2020). With this agenda, the association wanted to inspire the Frisian sector to embrace circularity for plastics. Within the province of Friesland a collection and processing infrastructure has been established via a plastic sorting installation. It is able to handle the largest share of plastic packaging in the Netherlands. Friesland benefits from a unique mechanical sorting and recycling infrastructure operating at an international level. The region boasts a strong knowledge and innovation ecosystem, with the facilities ranging from advanced laboratories to pilot plants. A leading example is the National Test Centre for Circular Plastics (NTCP), where pilot-scale testing can simulate how household plastic waste behaves during sorting and washing processes. These insights contribute to more effective recycling and drive innovation toward fully recycled plastics. Overall, the Netherlands is one of the leaders of Europe in terms of recycling post-consumer waste.

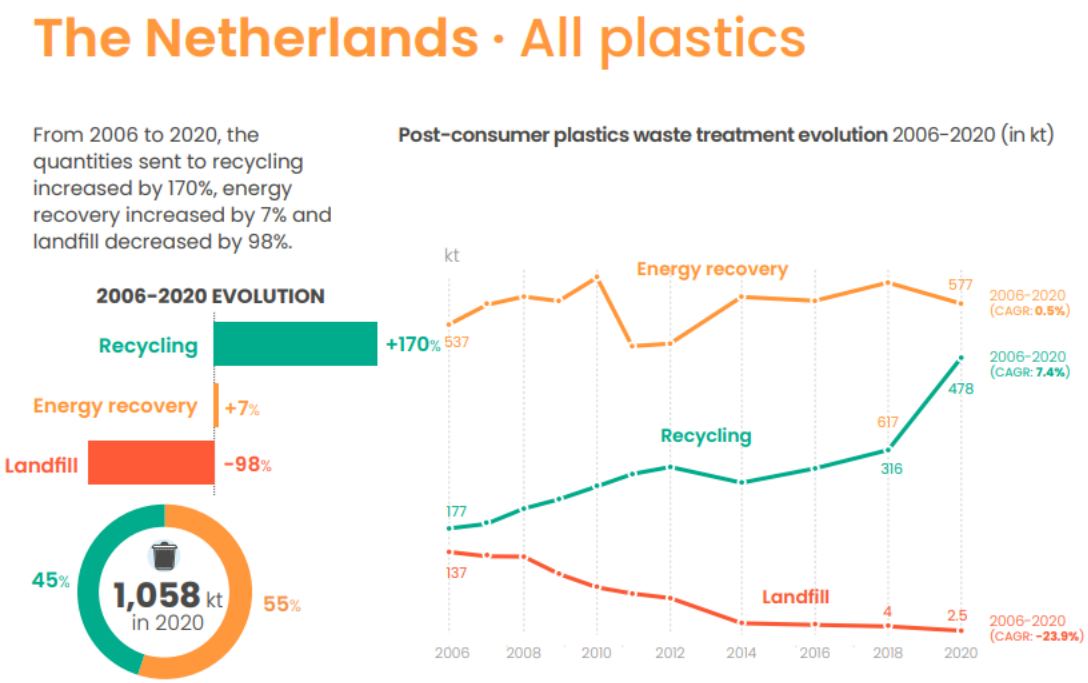

Figure 4 The recycling quantities for the Netherlands (source: Plastics Europe)

Circular Friesland emerged from a material flow analysis of the province carried out in 2015. Within this analysis 5 themes were selected to be investigated. One of this theme's was the plastic value chain. In that time, there was still a lot of room for improvement. Recycling was done by an "open loop". In other words, collected plastic was crushed towards granulate, instead of

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new products. Furthermore, a lot of the biggest recyclers' capacity was outside of the province. The analysis showed the opportunities to be more circular as a province and companies started to have the desire to share their waste streams as feedstock and create (new) products.

After the establishment of the association a lot of developments have been made. Starting in 2019, Circular Friesland and its members have put their signature under the Plastic Pact, which is an agreement to use less plastic, reuse more plastic and make new plastics more recyclable. Furthermore, in 2020 the province had joined the national programme VANG, which aimed to reach 75% waste separation. Furthermore, the Frisian municipalities collaborated to realise closed feedstock loops. As part of the Frontsh1p project, we have been working on updating the "transitie-Doe-agenda" to set a clear focus within the new, Northern collaboration.

An extensive analysis has been performed to classify the companies of Friesland that are active in the sector (Kamminga & Hamstra, 2024). This resulted in a number of clusters, of which the major ones are textiles, rubber, composites, construction plastics, coatings, packaging, foils, injection moulding, waste processing/EOL.

Table 1 The challenges and stregths of each plastic cluster

Cluster	Challenge	Strength
Textiles	Recycling Difficulty	Multidisciplinary
Rubber	Reuse Difficulty	Chemical Resistance
Composites	Recycling Difficulty	Lightweight
Construction Plastics	Long Life Span (Nature Pollution)	Durable
Coatings	Poor Recycling Opportunities	Increases Lifespan
Packaging	Recycling Difficulty	Efficient
Foils	Recycling Difficulty	Protection
Injection Moulding	Use of Recyclage	Flexibility
Waste Processing / EOL	Contamination	Close Loops

Given the developments outline above, it is clear that Friesland has made significant progress in the recent years towards a more circular plastics chain. There is a strong ambition and a solid foundation, active participation between stakeholders and extensive knowledge and experience with plastics across various sectors. At the same time there are still some important challenges that need to be addressed and although challenging, this also offers strategic opportunity. It is therefore a logical a timely choice to introduce a dedicated focus on CSS plastics and rubber within the Frontsh1p project. This focus enables the region to build on the established strengths, address the remaining gaps, and accelerate a transition towards a fully circular plastic economy in the Northern part of the Netherlands.

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1.3 Characterization of the region through the prism of the identified resources

1.3.1 Management of Plastic & Rubber Waste (CSS4)

The last couple of years, the region has made developments to increase the number of recycled plastics, develop biobased plastic, and reduce the number of used plastics altogether. All plastics have inherent value and should be treated as nutrients within a circular economy. While the aim is to design plastics for reuse, recycling, and added value without harming human health or the environment, most plastics are still not engineered for high-quality recycling due to technical and chemical limitations. A robust technological infrastructure is essential, including separate closed-loop systems for biodegradable and non-biodegradable plastics, ensuring that materials retain their quality and value throughout the cycle. Finally, awareness and responsibility among consumers, producers, and governments are crucial. Everyone must contribute to reducing litter, separating waste correctly, and promoting knowledge-sharing and education to enable high-quality recycling. According to Omrin (2023), the plastic house-hold waste was 17 kg per person per year. The amount of post-collection plastic has been increasing year over year from 19.681 tonnes in 2021 to 22.343 tonnes in 2023.

To accelerate the transition to a circular plastic economy, it is essential to scale up best practices in the production and development of high-quality recycled and alternative materials. This includes improving the perception and understanding of recycled plastics and emerging material, such as biobased and biodegradable plastics, through scalable proof-of-concept projects. All this contributes to the reduction of CO2 emissions and is being addressed in the following projects:

Plestic Ready

The main objective of this project is to enhance and accelerate the earning capacity of the circular plastics sector in the Northern Netherlands through a multidimensional approach. This integrated strategy not only supports economic development but also contributes to environmental quality, public health, education, and regional well-being. The approach is designed to accelerate the phase-out of fossil-based resources, reduce raw material consumption, and promote responsible use of materials throughout the value chain. By building a coordinated scaling strategy, the project fosters long-term impact, including increased knowledge development, strengthened regional ecosystems, and improved conditions for entrepreneurship and business establishment in the circular plastics sector.

A key element of the project is the introduction of the plesTic Readiness Level—a conceptual framework that assesses the maturity of circular plastic innovations across all relevant

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domains, including technology, regulation, logistics, and social acceptance. This framework identifies the barriers to market introduction and outlines the steps needed to scale innovations effectively and sustainably. Through targeted R&D projects, new sustainable business models and value chains are created. These efforts also contribute to broader regional development by enhancing education and skills, valorising scientific and applied knowledge, strengthening support structures, and increasing engagement with governments and international networks. In this way, plesTic Ready supports the ambition to position the Northern Netherlands as a Centre of Excellence for circular plastics with the potential for global impact.

Care2Change

The healthcare sector in the Netherlands is responsible for approximately 7% of national CO_2 emissions, 4% of total waste, and 13% of raw material consumption. A major challenge lies in the sector's high carbon footprint and minimal reuse of materials, leading to significant waste volumes—much of which, due to strict regulations, must be incinerated. Plastics play a critical role in this issue, as hospitals rely heavily on single-use plastic products for hygiene and safety, contributing substantially to both emissions and non-recyclable waste streams. In response, all hospitals and knowledge institutions in the Northern Netherlands are joining forces in an ambitious initiative to create a CO_2-neutral and fully circular healthcare sector. This project is among the largest and most impactful circularity efforts in the region and aims to serve as a blueprint for other hospitals in the Netherlands and across Europe. Beyond reducing environmental impact, it also seeks to unlock new revenue models through circular innovation, with plastics as a key focus area for redesign, reuse, and high-quality recycling.

Wad van Waarde & Wad Gaat Om

In the north of the Netherlands lies the Wadden Sea region—a place where salt and fresh water merge, the horizon shifts, and land and sea continuously trade places. This UNESCO World Heritage Site is rich in biodiversity, natural beauty, and cultural life, but it also faces serious challenges: plastic pollution, microplastics entering the sea, pressure from global shipping routes, declining biodiversity, and increasing economic demands. Achieving a plastic-free Wadden region is a complex challenge, too large for any one party to solve alone. Only through joint effort and systemic change can we protect this extraordinary region and ensure its future as a thriving, sustainable landscape.

To address these issues, the *Wad van Waarde* project was launched with a dual mission: to build a local, sustainable value chain connecting (young) farmers, designers, students, entrepreneurs, and makers—and to create circular, locally produced alternatives to plastic products. These products aim to replace current plastic items and ensure they no longer end up polluting the sea. Building on this, the follow-up project *Wad Gaat Om* takes a broader, system-based approach. It focuses on both curative and preventive actions: cleaning up existing plastic pollution while preventing new plastic from entering the region. The program integrates product innovation,

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education, circular value chains, behavioral change, and collaboration across governments, businesses, knowledge institutions, residents, and visitors.

X-Lives

The goal of X-Lives is to promote the transition to a circular and resource-efficient economy. Within X-Lives, Dutch and German partners in North Rhine-Westphalia collaborate as part of the EU Interreg VI programme to stimulate circular innovations in the field of polymer, fiber, and mineral materials. This project includes activities such as the recycling of polymer materials, sustainable production processes, the processing of recycled materials into new products, and the use of renewable raw materials in material cycles. This also applies to fiber composites such as glass and carbon fiber reinforced plastics. The project offers opportunities to support circular innovations through targeted funding (via vouchers) and by embedding innovations into circular business models.

1.4 Analysis of barriers to implement circular economy or green transition solutions

The transition to a circular plastics economy faces persistent challenges that hinder large-scale implementation. While demand for recycled plastics is growing, systemic barriers across the value chain continue to limit progress. These barriers affect not only the production and processing of recycled materials but also their market uptake. The most pressing obstacles include:

Economic competition from low-cost virgin plastics
High capital (CAPEX) and operational (OPEX) costs in recycling
Lack of robust and efficient waste collection infrastructure
Fragmented and complex regulatory landscape
Limited quality and recyclability of current plastic waste
Insufficient market demand and lack of launching customers

The following sections elaborate on each of these barriers,

One of the key reasons that influence the implementation of circular plastics is the large influx of virgin plastic and the accompanying financial viability. Virgin plastics remain significantly cheaper than recycled alternatives, due to the low production costs in mostly China and the United States. Investment in circular infrastructure is risky and capital-intensive (CAPEX), while operational costs (OPEX) such as energy and labor are high in comparison and are not always recovered by returns. As a result, recycled plastics struggle to compete economically, which leads to reduced demand. This instability has caused financial instability within the recycling industry, which causes a lot of them to fill for bankruptcy. In recent years, the Netherlands lost 1/3 of its recycling

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capacity and a major recycler in Friesland has also filed for bankruptcy (Blue Cycle). Moreover, the market lacks sufficient launching customers willing to adopt and pay for circular products. Without mechanisms like true pricing that internalize environmental costs, circular business models struggle to become sustainable.

Another challenge is the lack of robust infrastructure. Collection systems are often small-scale or fragmented. Additionally, long distances between collection and processing sites make logistics economically unviable, as transport costs outweigh the value of the recycled material. Additionally, contamination and mixing of plastic types during collection further reduce recyclability, complicating material recovery and sorting. This is partly caused by poor separation between technical and biological waste streams. Municipalities also have different policies regarding the collection systems, either opting for "bronscheiding" (source separation) or "nascheiding" (post-separation).

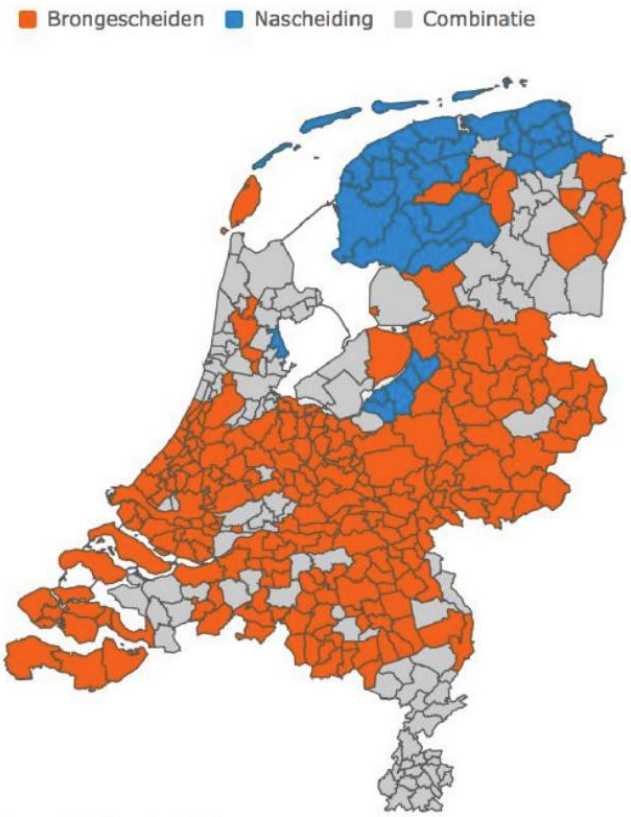

Figure 5 An overview of source separation and post-separation waste policies for different municipalities in the Netherlands (source: Nedvang)

The demand for recycled plastics has been larger than the supply, but inconsistent and fragmented regulation significantly hamper the progress made. European legislation like the PPWR, REACH and the SUP is increasing the demand for recycled content, but it also introduces complexity. The end-of-waste status and chemical safety requirements prevent broader adoption of recycled materials. Additionally, the quality of recycled material is not up to par. Originally,

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plastics were not designed with recyclability in mind. Many materials are composed of complex blends or multilayered structures. Most of the plastic waste in the Netherlands is hard to recycle (foil or mixed content). According to Plastic Europe, in 2022 only 11.2% of the produced plastic in the Netherlands was circular. The sector has set new ambitions for 2050 to no longer use primary fossil fuels. Yet, due the current consumptions patterns, the demand for plastic will only increase. Alternatives like bioplastics, while promising in theory, are faced with scepticism due to inconsistent waste handling performance and end-of-life uncertainty.

1.5 Identification and analysis of the stakeholders (including existing networks and connections between them)

As part of the Frontsh1p project, we have invested in the strengthening of ties by working together on the topic of circular plastics. One of the most important cross-border collaborations is Greenwise Circular Plastics. This is an initiative where the Northern knowledge institutions collaborate with Northern companies, governments, students and citizens on challenges in the circular economy. Furthermore, there are other organisations working to accelerate the transition towards a circular plastic economy, like Chemport Europe and SUSPACC. Both cluster organizations have strong research and development opportunities.

Figure 6 A depiction of the ecosystem on Circular Plastics (source: Greenwise Campus)

The ecosystem is comprised of several companies, government bodies and knowledge institutions. As part of the Interreg Europe project *Plastix*, the province of Fryslân is actively working to accelerate the circular transition of plastics on a regional level. By facilitating knowledge exchange across the entire circular plastics value chain, the province aims to

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strengthen the innovation capacity of SMEs and promote cross-regional collaboration. A key contribution is the development and deployment of a benchmark tool—originally created under the Interreg *Replace* project PLASTIX —now tailored specifically to circular plastics. This tool enables regions to compare performance, identify areas for improvement, and leverage each other's strengths.

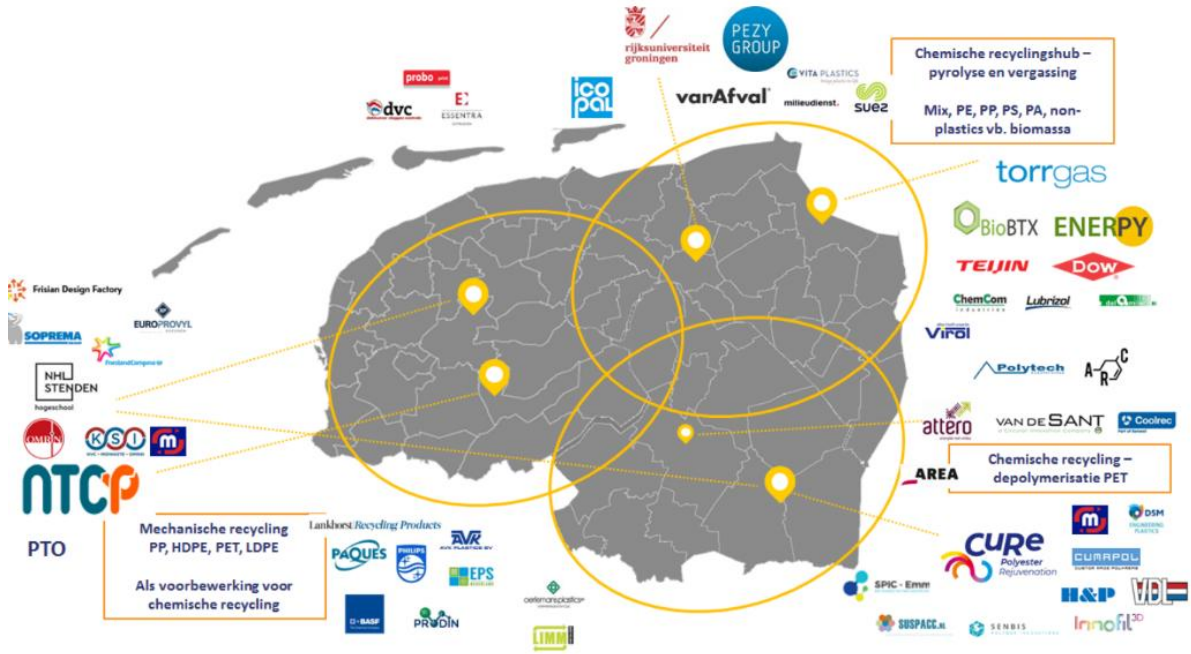

Figure 7 Companies present in the ecosystem (source: Transitie-Doe-Agenda Kunststoffen)

For knowledge institutions, an example within the circular plastics transition is NHL Stenden, specifically through its professorship in Circular Plastics. The mission of this research group is to drive the shift toward a future-proof plastics economy in the Northern Netherlands. By developing sustainable materials and processes, the professorship contributes to reducing resource dependency and environmental impact. Their approach is rooted in biomimicry, drawing inspiration from the planet's own natural systems to create responsible, circular solutions. While knowledge institutions, regional governments, and companies often have limited influence over structural barriers in the plastics chain, they play a crucial role in advancing innovation. NHL Stenden exemplifies how applied research can help bridge this gap by translating ecological insights into tangible, scalable technologies for industry and society.

1.6 Engagement of stakeholders

The association functions as a strategic engagement route for small and medium-sized enterprises (SMEs), acting as a platform that brings together businesses around shared goals and long-term interests. Key activities include facilitating networking opportunities, supporting collaboration across value chains, organizing relevant events, and coordinating targeted lobbying efforts. Visibility and positioning of SMEs within broader regional and national agendas are

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actively pursued. All efforts are business-driven, with initiatives shaped by the practical needs and insights of the companies involved. The association is composed of and supported by companies that not only participate but also contribute to the co-creation of activities and strategies. By operating from the perspective of the business community, the association ensures that its initiatives remain aligned with current and future economic realities.

In addition to supporting internal collaboration, the association represents its member companies in external forums and advisory bodies. Participation in these gremia allows for direct input into policy development and strategic decision-making at various levels. Lobbying efforts focus on putting relevant topics on the political and institutional agenda, particularly in areas such as applied research priorities and the design of education and training pathways. Through this approach, the association bridges the gap between businesses, knowledge institutions, and government bodies, creating an ecosystem where SMEs can thrive, innovate, and remain competitive in an evolving economic landscape.

In the table below, an overview can be found of members of VCF that are active in the plastics and rubber sector.

Company
Boxo
Caparis
Cup-Concept
Europrovyl
EPS Nederland
Happy Cups
Indu-Con
Infoframe
Lampe Technical Textiles
Lankhorst
Nedcam
NNRD
Omrin
Pyrasied
Soprema
UPPACT
ZONklaar

Figure 8 An overview of the members of the VCF

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1.7 Analysis of the supply value chain

In the plastic supply chain, Friesland plays a key role in the recycling stage. After plastic products are discarded, the waste is collected and carefully sorted to separate recyclable materials from non-recyclable ones. In Friesland, advanced sorting facilities and technologies help maximize the recovery of valuable plastics. The recyclable plastics are then thoroughly washed and shredded to prepare them for further processing. This cleaned and shredded material forms the basis for high-quality recyclate or raw material that can be reused in new plastic products. Friesland's strength lies in this part of the chain, where efficient sorting, washing, and shredding ensure that as much plastic as possible is given a second life, contributing to a more circular economy.

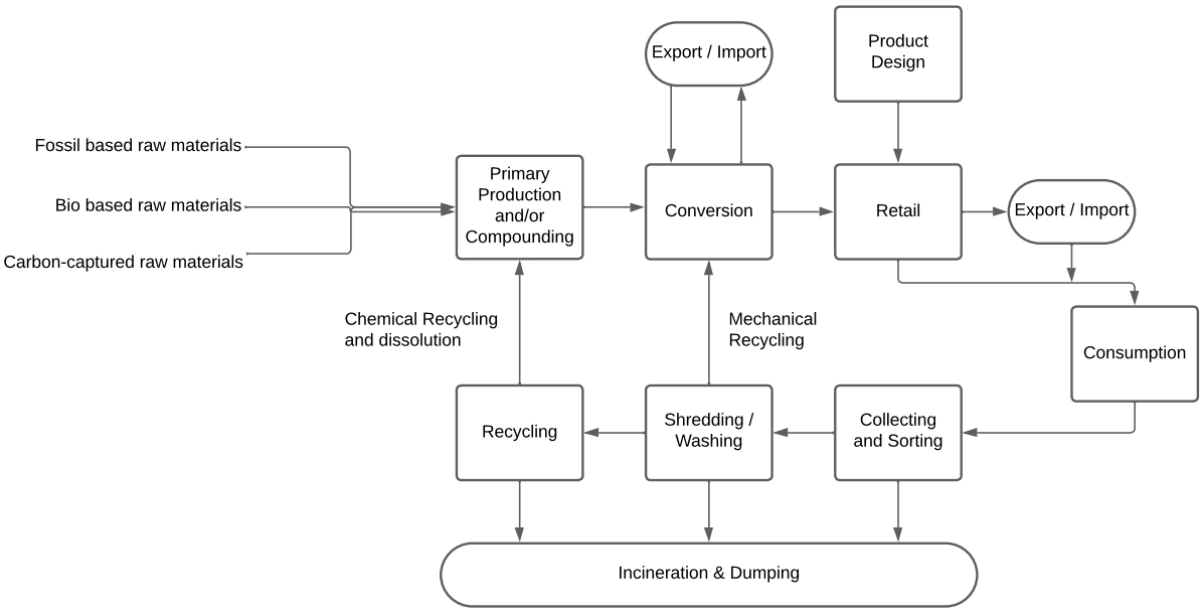

Figure 9 A schematic representation of the plastic value chain (source: adapted from TNO)

Research has shown that the following 5 application groups are most promising in Friesland. Each topic has a different place within the plastics value chain, which is shortly addressed in the table.

Table 2 General remarks on the 5 application groups (source: Kamminga & Hamstra, 2024)

Topic	General Remarks
Coatings	Water-based paints are a more sustainable alternative to traditional paints, which often contain high levels of volatile organic compounds. However, microorganisms can affect the shelf life of water-based paints. They are mainly in the production/conversion phase of the supply chain.

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Construction Plastics	Plastics are essential in construction due to their versatility. Sustainability depends on high-quality recycling and using renewable raw materials for new construction plastics. Construction plastics are produced either from virgin or recycled polymers and processed into building products, spanning from raw material sourcing and recycling (upstream), through production (midstream), to end-use in construction (downstream).
Composites	Composites are hard to recycle because they combine multiple materials. Vitrimers offer a solution by acting like thermosets in use but thermoplastics during recycling and can be bio-based. Research into bio-composites using bioplastics and natural fillers is growing, especially in Northern Netherlands. Composites span production, use, and critical end-of-life phases.
Rubber	The rubber industry is decades behind the plastics industry when it comes to sustainability. It is often assumed that rubber cannot be recycled often or not to a high standard. The Northern Netherlands has a large presence in the rubber industry. The recycling infrastructure for rubber is still limited, so the sector mainly operates within production and use phases.
Water Plastics	Friesland is a frontrunner when it comes to water technology, with Leeuwarden as Capitol of Water Technology. Application are mainly targeted on downstream phases.

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STAGE II. RESOURCES MISSIONS AND CSSs

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2 Stage 2: Resources & Missions Selection

In recent years, Friesland has made significant strides toward creating a more circular plastics chain. The region combines a strong ambition with a solid foundation, marked by active collaboration between stakeholders and deep expertise across various sectors of the plastics value chain. At the same time, key challenges remain—challenges that, while complex, present important strategic opportunities. Against this backdrop, it is both logical and timely to introduce a dedicated focus on CSS 4 for plastics and rubber within the Frontsh1p project. This focus allows Friesland to build on its existing strengths, close critical gaps, and accelerate the transition toward a fully circular plastics economy in the Northern Netherlands. For a more extensive analysis, we refer to part I.

2.1 CSS Definition

Plastics are versatile synthetic materials derived primarily from polymers. They are widely used across sectors such as construction, packaging, healthcare, textiles, and water technology due to their durability, lightweight nature, and adaptability. In the context of circularity, plastics are increasingly viewed not as disposable materials, but as valuable resources that should remain in use through reuse, high-quality recycling, and responsible design. In Friesland, the focus is on maximising recyclability, using renewable raw materials, and developing innovative alternatives such as biobased or biodegradable plastics to reduce environmental impact across the full lifecycle. For a larger deconstruction, we refer to Part I.

Rubber refers to elastic polymer materials, both natural and synthetic, that are essential in a wide range of applications—from industrial products to consumer goods. Compared to plastics, the circular transition for rubber is at an earlier stage, with recycling technologies and infrastructure still developing. The sector faces unique challenges, including the assumption that rubber cannot be effectively or repeatedly recycled and the limited availability of high-quality recycled rubber. In Friesland and the wider Northern Netherlands, efforts are underway to address these gaps, exploring new recycling methods, reuse strategies, and innovations in material design to bring rubber into the circular economy.

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STAGE III. CHALLENGES

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3 Stage 3: Challenges

One of the main strategies for the association Circular Friesland for closing loops and generate circular resources, and adressing the challenges associated with plastics and rubber is the **CIRCO method**. The CIRCO methodology is a practical and action-oriented approach that helps companies and designers transition from linear to circular business models. CIRCO is built on the principle that circularity starts with design. By rethinking products, services, and business models, organizations can reduce waste, extend product lifespans, and create added value through reuse, remanufacturing, and recycling. At the core of the CIRCO approach are three main circular design strategies:

1. **Design for Inner Circles** – prioritizing reuse, repair, and refurbishment to keep products in use longer.
2. **Design for Cascading** – enabling materials and components to be reused in new applications after their initial use.
3. **Design for Pure Material Flows** – ensuring that materials remain identifiable and separable to facilitate recycling.

CIRCO offers structured training programs, known as Tracks, that guide participants through a three-step process:

1. **Inspire & Learn** – Introduction to circular economy concepts, case studies, and relevant design principles.
2. **Business Modeling** – Identifying circular opportunities and reshaping the business model to support them.
3. **Implementation Planning** – Developing a concrete roadmap to prototype and implement circular solutions.

CIRCO has empowered thousands of professionals across industries—from manufacturing to construction, consumer goods, and services—to embed circularity into their innovation processes. It supports collaboration within value chains, enabling companies to co-create sustainable solutions with suppliers and customers. In an era of increasing environmental and economic challenges, the CIRCO methodology provides a clear path forward—combining design thinking with sustainable business innovation to build a resilient, circular future.

PlesTic Readiness Level

Furthermore, within the project Plestic Ready, a new conceptual framework addresses the complex challenges of introducing sustainable polymers and their products on a successful and economically viable scale: the *plesTic Readiness Level*.

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While technical development and innovation are essential, they are only part of the equation. Barriers to implementation can also arise in areas such as legislation and regulation, logistics, or social acceptance, to name just a few. In order to advance innovations in a sustainable way and move toward a closed-loop plastics economy, it is critical to identify the specific obstacles that hinder the transition from innovation to market introduction.

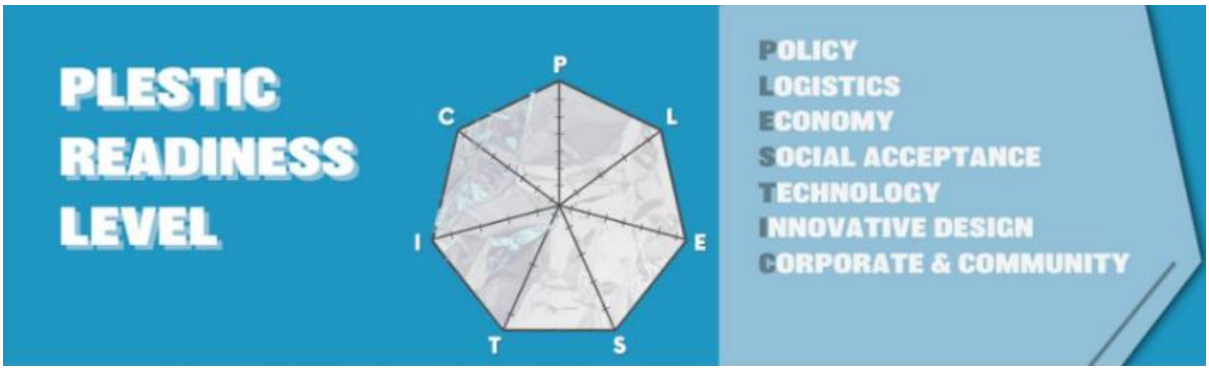

Figure 10 A visualisation of the plesTic Readiness Level. Each lettre stands for an element of the equation.

The plesTic approach assesses the level of 'maturity' or market readiness of an innovation across all domains relevant to plastics. It provides insights into what is needed to further advance the innovation toward commercialization. Whereas the well-known *Technology Readiness Levels (TRL)* measure the state of technological development, the *plesTic Readiness Level* offers a more holistic view—taking into account the broader context necessary for successful market entry of sustainable plastic solutions.

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Stage IV. ACTION PLAN

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4 Circular Economy Action Plan for Friesland Province

The Dutch province of Friesland and the Circular Friesland Association have the ambition to create a circular economy in which plastics are used in a sustainable way to support and strengthen society and to spare the environment as much as possible. This ambition can be made more concrete with the help of the *Trais Materialis*:

- Reduction of material use
- Sustainable implementation of residual material use by means of the use of recycled material and/or biobased material, including design for recycling
- Streams containing virgin material are used as efficiently as possible and designed for recycling

Friesland has specific strengths which position it well to develop circular solutions. At the same time, the regional economy is characterized by a lot of SMEs that often lack the capacity, knowledge or investment to make the transition from linear to circular business models. Collaboration does exist through networks such as the Circular Friesland Association, but broader participation and more effective matchmaking are required to unlock systemic change. Targeted awareness and training programs are needed to help both entrepreneurs and citizens recognize the benefits of circular practices in everyday life and business operations.

This Action Plan sets out the concrete steps and actions that will guide Friesland's transition to a more circular economy. It is to be seen as the successor of the present so called *Transitie-Doe-Agenda Kunststoffen*. This builds on ten years of experience and projects in Friesland and signals our continued commitment to developing circular plastics solutions in the years ahead. The focus for plastics is on maximising recyclability, using renewable raw materials, and developing innovative alternatives such as biobased or biodegradable plastics to reduce environmental impact across the full lifecycle. The circular transition for rubber is at an earlier stage, with recycling technologies and infrastructure still developing.

4.1 Action Plan for CSS 4

CSS 4 Plastic and Rubber	
Acting as a platform that brings together businesses	
Key Actions	▪ Facilitating networking opportunities ▪ Supporting collaboration across value chains ▪ Organizing relevant events

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Responsible Parties	VCF, Greenwise Campus, CGD, SUSPACC
Indicators	▪ (Networking) events organized ▪ Collaborations and matchmaking between businesses present at these events
Lobbying efforts	
Key Actions	▪ Putting relevant topics on the political and institutional agenda ▪ Coordinating targeted lobbying efforts ▪ Bridging the gap between businesses, knowledge institutions and government bodies ▪ Lobby's on biocyclate and biobased topics, this is in collaboration with NVCE, Chemport and the Northern provinces ▪ Actively contributing to the correct framing and branding of circular plastic products by setting up and/or participating in (national) partnerships ▪ Create a European wide playing field for plastics ▪ Approaching private financing providers to close the funding gap
Responsible Parties	VCF, Chemport, Provinces, NVCE, Greenwise Circular Plastics, CGD, SUSPACC
Indicators	▪ Improved perception and understanding of recycled plastics and emerged material, such as biobased and biodegradable plastics, through scalable proof-of-concept projects ▪ Collaborative lobby statement ▪ Northern provinces implement the lobby statements/narrative ▪ National/European level politics implement the narrative which has an impact on the Clean Industrial Deal on the European level
Continuing development of the circular plastics ecosystem	

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Key Actions	▪ Collaboration for improving and strengthening biobased applications, mechanical and chemical recycling and product design ▪ Scale up best practices in the production and development of high-quality recycled and alternative materials ▪ Create an ecosystem where SMEs can thrive, innovate and remain competitive in an evolving economic landscape
Responsible Parties	VCF, Chemport, Greenwise
Indicators	▪ Greenwise Circular Plastics ▪ Projectplans from PlesTic Ready, Care2Change, NNLvC2.0, PlastiX, WadGaatOm ▪ The collaboration between the 7 partners of the PlesTic Ready consortium is focused on developing the PlesTic approach and thus strengthening and improving the ecosystem
Facilitating knowledge exchange	
Key Actions	▪ Strengthen the innovation capacity of SMEs and promote cross-regional collaboration ▪ Developing a methodology to make circularity measurable
Responsible Parties	VCF, knowledge institutions
Indicators	▪ Dozens of companies collaborating with research institutions ▪ Valorization ▪ Number of new recycling techniques implemented ▪ Volume of biobased polymer production and applications developed
Innovations	
Key Actions	▪ The National Test Centre for Circular Plastics has been initiated in Heerenveen, ensures that the mixed flows of plastic are maximally recyclable which increases the potential for recycling ▪ Further development of recycling techniques, both mechanical, chemical and thermochemical

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	▪ Developing innovative collection structures and logistical systems that contribute to maintaining the quality of plastics ▪ The further development of biobased polymers production and processing as well as the development of applications to boost the supply ▪ Actively helping regional governments to create market demand through circular procurement
Responsible Parties	VCF
Indicators	▪ Establishment and activity of the National Test Centre for Plastics in Heerenveen ▪ Circular procurement by regional governments contributes to growing the market share of circular and biobased plastics in Friesland.

4.1.1 Noord-Nederland Verdient Circulair

Noord-Nederland verdient Circulair is a program in which entrepreneurs in the three northern provinces of the Netherlands (Groningen, Friesland & Drenthe) are encouraged to pursue more circular business practices. We achieve this by removing existing barriers and forging new connections between stakeholders, thus forming clusters. Within the program partners organize events focusing on knowledge sharing, tools, networking and workshops. This allows entrepreneurs to gain relevant knowledge and information, meet new network contacts and discover where and who can help with specific questions.

Actions part of the Noord-Nederland verdient Circulair program

Activation and development programs for SMEs

- CIRCO has developed a training program for organizations and individuals who can and are entering businesses.
- CIRCO supports entrepreneurs and creative professionals to (re)design circular products, services and business models.

Strive for better coordination of activities in the northern CE innovation ecosystem

- To strengthen networks, supply chain collaboration and the innovation ecosystem, we are activating and organizing several value chains in line with the *Transition Agenda Plastics*. We are identifying frontrunners and other companies in these value chains and bringing them together in a series of Roundtable sessions.

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Develop a monitoring system which gives insights into the circular developments in the northern region

- Several monitoring systems are being developed to map the transition to a circular economy. The northern provinces, with the help of Metabolic, are developing a methodology to monitor the progress of the transition in the northern Netherlands.
- *Rijksuniversiteit Groningen* will conduct the first monitoring and will report this by the end of 2022.

Develop an approach to stimulate circular purchasing

- VCF will experiment with stimulating circular procurement in two semi-public sectors: healthcare and education. Organizations within these sectors will be invited and challenged to engage in circular procurement.
- Also experimenting with establishing circular procurement in the private sector focusing on the plastics chain in the northern Netherlands as structured within The Clean North/Chemport Europe.
- We are mapping the SME landscape for biobased and circular plastics and organizing several workshops to bring SMEs and the industry together. We are also using the input from SMEs to further shape the northern Netherlands proposition.

Communication, lobbying and PR

- The project is supported by a wide variety of partners and stakeholders. These parties all have their own communication channels; the goal is to bundle these channels and add an overarching channel to achieve broad awareness and strong lobbying.

<u>Expected results of the Noord-Nederland verdient Circulair program</u>

CIRCO-Tracks

- The Circular Friesland Association operates the CIRCO-tracks and entrepreneurs and organizations build more circular products/business models.

Circular Economy Round Tables

- Circular Economy Round Tables on priority areas to identify new value chains and link ecosystem services.

Monitoring system

- A monitoring system for the transition to a circular economy in the northern Netherlands.
- A functioning Circular Transition Council for the northern Netherlands.

Circular purchasing development

- Experimenting with two (semi) public focused circular procurement and tendering processes.
- Experiment with one private-focused circular procurement and tendering process.
- Strengthening northern collaboration within the circular economy innovation ecosystem in the field of circular procurement and tendering for public and private parties.

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Communication strategy

- A marketing, lobbying and PR plan are developed. Corporate identity, website and the social media channels must be developed and continuously updated with content.
- Lobbying will be determined in close consultation with the Supervisory Board, the Transition Council and other stakeholders.

4.1.2 PlesTic Ready

The main objective of this project is to enhance and accelerate the earning capacity of the circular plastics sector in the northern Netherlands through a multidimensional approach. This strategy not only supports economic development but also contributes to environmental quality, public health, education and regional well-being. The approach is designed to accelerate the phase-out of fossil-based resources, reduce raw material consumption and promote responsible use of materials throughout the value chain. Each letter of PlesTic stands for a different relevant domain to the transition: Policy, Logistics, Economics, Social acceptance, Technology, Innovative design and Corporate/Community.

Actions part of the PlesTic Ready program

Innovation projects

- Business developers engage in discussions with knowledge institutions, companies and non-profit organizations to gather and develop relevant ideas, bring people together and put the idea on paper. The stimulator brings people together and facilitates the conversation to develop projects, stimulate collaborations and establish the chain.
- Develop and implement research and development projects. By encouraging organizations and parties, we are speaking with at least 30-40 organizations that initiate projects.

Developing a model-based approach

- Readiness levels are defined for each letter, to accelerate the market introduction of promising sustainable plastics technologies and materials. To develop this approach, several promising innovations will be analyzed using the PlesTic approach.
- Conducting an actor analysis and providing expertise and knowledge for developing and testing the PlesTic approach and further developing it into a usable tool.
- Organizing and conducting think tanks/round-table discussions on the letters of the plesTic approach.

PlesTic projects

- Stimulating, developing and implementing 15 projects using the various letters aimed at removing barriers and/or making other concrete positive contributions to accelerating and/or more successfully bringing promising technologies or materials in the field of circular plastics to the market.

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Communication

- Organizing events focused on internalizing the PlesTic approach at three regional locations throughout the project. The ambition is for at least one of these to be a large-scale, national event. This will bring people together, stimulate networking and provide opportunities for collaborative development of new projects.
- The targeted use of communication tools to disseminate the project's results. A dissemination and communication plan will be developed for this purpose.

Expected results of the PlesTic Ready program

Increased knowledge development

- 10-15 technical research and development projects. Both stimulating the parties and research and development projects have led to the creation of 10 new partnerships between companies and/or between companies and knowledge institutions.
- Systemically sharing knowledge about circular plastics and the PlesTic approach provides a framework and contributes to a uniform working method, allowing knowledge players and stakeholders to respond accordingly.

PlesTic Readiness Level

- A conceptual framework that assesses the maturity of circular plastic innovations across all relevant domains, including technology, regulation, logistics and social acceptance.
- Identifies the barriers to market introduction and outlines the steps needed to scale innovations effectively and sustainably.
- Supports the ambition to position the northern Netherlands as a Centre of Excellence for circular plastics with the potential for global impact.

PlesTic projects

- Three innovations were tested and (further) developed using the PlesTic approach at the end of the project.
- 15 projects are being carried out based on one or more letters from the PlesTic approach to gain extensive experience with the approach.

Strengthened regional ecosystems

- Three events were organized in the regions of Delfzijl, Emmen and Heerenveen. This regional distribution contributes to achieving long-term impact more quickly and strengthening the connection between these regions.

4.2 Monitoring & Evaluation

As part of the Noord-Nederland verdient Circulair program, a monitoring system is developed to systematically track progress and outcomes. Within the PlesTic Ready program, this monitoring

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and evaluation framework is grounded in the Theory of Change. This ensures that activities are continuously linked to the overarching goals of the circular economy transition.

The system will be applied once or twice a year, providing structured moments to review progress, assess whether activities are on track and identify areas that require adjustment or additional support. This process is not limited to measuring outputs but also considers the broader impacts and systemic changes that the program seeks to achieve. By integrating monitoring and evaluation into the governance of this project, it ensures that decision-making remains evidence-based and adaptive. This supports transparency toward stakeholders, strengthens accountability within the consortium and fosters a culture of learning by sharing insights across the regional ecosystem. Over time, this will also enable benchmarking with other regions and contribute to a clearer understanding of effective pathways for circular economy development in practice.

Apart from this, the Circularity Gap Report Friesland provides an important starting point for monitoring. It shows how circular the province Friesland currently is and where the biggest opportunities lie. Plastics are one of the material streams highlighted, which means we already know what progress is needed. The report is not a monitoring tool itself, but it provides a strong basis that we can use to measure change. By combining these insights with the monitoring system from Noord-Nederland verdient Circulair and PlesTic Ready, we can make sure that the progress is not only tracked year-by-year but also connected to the bigger picture.

4.3 Risks & Mitigation

Table 3 Risk and mitigation actions

Risk	Description	Mitigation
Pricing difference between virgin and secondary plastics	The pricing difference between virgin and secundary plastics continues for too long which means that companies who are investing in circular plastic solutions will go bankrupt before they are strong enough to sustain themselves	We mitigate this through lobbying with a focus on the reliability of policy on circular economy goals
Companies doing too many "stand-alone" innovations	There is a risk of companies not collaborating with other organizations within the region	We mitigate this by forming strategies together and organizing meetings to bring organizations together
Consortium collaboration	Misalignment of goals and lack of cohesion within consortium	Cooperation agreements signed at the project start; regular consultations; built-in monitoring & evaluation system
No or too low funding	There is a funding gap. Parties who need funding are often start-ups who	A new regional innovation strategy and influencing the

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	need cofinancing from private financing providers. There is a Mitch match between public and private funding.	subsidy instruments from the region. Looking at other European projects to make funding available and approach private funders.
Progress & Timeline	Delays in project execution or failure to achieve objectives	Clear governance; strong project/WP management; parallel execution of activities; adaptive monitoring and evaluation system
Embedding PlesTic in ecosystem	PlesTic approach is not embedded or sustained in the regional ecosystem	Greenwise Circular Plastics as structural vehicle; dissemination of knowledge; promotion of new business models to increase adoption
Young ecosystem players	Short project timeline may prevent newer actors from scaling up quickly	Stronger partners assist or temporarily take over tasks
Limited SME engagement	SMEs may show insufficient interest to join	Low-threshold entry points; outreach & promotion; active involvement in circular economy ecosystem rollout

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Best Practices for Regional Replication in Europe

This section consolidates insights gathered through structured interviews with the replication regions participating in the FRONTSH1P project: Portugal (North Region), Italy (Campania Region), Greece (Central Greece and Municipality of Levadia), and Netherlands (Friesland Province).

Aside from the four replication regions, Poland (Łódź Region) was also included in the interviews to identify best practices, challenges, and lessons learned from regional implementation of circular economy approaches and Circular Systemic Solutions (CSSs), in line with the methodology defined under D8.1 – Replication Strategies Model.

The interviews, conducted between July and September 2025 were designed to capture local experiences, actions that worked and did not work, and the contextual conditions enabling successful replication of circular economy initiatives. The video interviews with the replication regions, as well as Łódź region will be made available in FRONTSH1P social media channels and website.

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Best Practices per Regions

Poland – Łódź Region

This region includes multiple replication actors: the Association of the Łódź Metropolitan Area (SLOM), Parzęczew Commune, and the Inter-Municipal Union "Bzura". Together, they represent complementary scales of Circular Economy implementation – metropolitan, municipal, and inter-municipal.

The Association of the Łódź Metropolitan Area (SLOM)

SLOM represents 30 municipalities and focused on the development of the **D8.1 Replication Strategies Model**, supporting regional cooperation. Activities primarily target waste management and public awareness, with challenges including limited funding and fragmented coordination.

Parzęczew Commune

Parzęczew's actions centre on community education and behavioural change. Key initiatives include the CIRCULAB Educational Campaign and the Circulab Festival. Despite limited resources, inclusive communication and school engagement enabled high participation and visibility of results.

Inter-Municipal Union "Bzura"

Comprising 19 municipalities, Bzura leads the Bzura Circularity Centre initiative, integrating waste processing, education, and engagement. Best practices include the Circular Municipality competition and a biogas pilot installation. Success factors include education, cross-sector cooperation, and municipal collaboration.

Together, these three complementary entities within the Łódź Region demonstrate a multi-level approach to circular economy implementation, linking regional strategy, municipal practice, and community engagement.

Regional Context and Coordination

SLOM functions as an Integrated Territorial Investment (ITI) association encompassing 30 municipalities. Its work focuses on strategic planning, knowledge exchange, and the development of the ŁOM 2030+ Supra-Local Strategy, which integrates Circular Economy objectives in waste and resource management. While SLOM itself does not directly implement CSSs, it plays a facilitative role by connecting municipalities and promoting harmonised approaches to Circular Economy across the metropolitan area.

Local Implementation and Community Practices

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At the municipal level, the Parzęczew Commune has emerged as a frontrunner in educational and participatory approaches to Circular Economy. Through initiatives such as CIRCULAB – Educational Campaign on the Circular Economy, the Circulab Festival, and thematic campaigns like Green Bank and Give Back E-Waste, the commune successfully engages residents of all ages. These activities combine education with culture, creating an inclusive model that transforms CE into a community value rather than a regulatory obligation.
Despite facing financial and legal barriers, Parzęczew overcame initial low participation through transparent communication and cooperation with schools, associations, and local businesses. The result is a replicable example of how small rural municipalities can foster behavioural change through creativity, partnership, and continuity.

Inter-Municipal Collaboration and Innovation
The Inter-Municipal Union "Bzura" focuses on environmental education, waste management, and innovation at a supra-municipal scale. It coordinates the "Circular Municipality" competition, promoting CE practices among member municipalities, and conducts annual educational campaigns that involve families and schools.
A notable best practice is the biogas pilot installation in Parzęczew, developed through FRONTSH1P collaboration, which processes school canteen waste to produce biogas and compost for greenhouse use. This initiative effectively demonstrates how local resources can be utilised to close material loops while providing hands-on learning for children and communities.
Bzura also published the practical guide Circular Economy in the Municipality – A Handbook for Local Governments and launched the Circularity Manifesto (2025), a voluntary declaration signed by municipalities, businesses, and academia to integrate Circular Economy principles into local operations.

Challenges and Barriers
Common challenges across Polish stakeholders include **limited financial resources**, **complex administrative procedures**, **and persistent behavioural barriers among residents**. Municipalities often struggle to achieve national recycling targets and to secure funds for infrastructure modernisation. However, these obstacles are mitigated through cooperation, education, and cross-sector partnerships.

Best Practices Identified
The Polish replication cases highlight several practices of strong replicability value for other European regions:

- **Integrated Governance**: Multi-level coordination between SLOM, Bzura, and Parzęczew enables consistent CE policy alignment from strategic to local level.

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- **Education as a Catalyst**: Continuous environmental education, especially targeting schools and families, has proven effective in embedding circular habits and awareness.
- **Community-Led Engagement**: Parzęczew's model demonstrates how combining education, culture, and public participation fosters long-term behavioural change.
- **Inter-Municipal Cooperation**: The "Circular Municipality" competition and Circularity Manifesto showcase how collaborative frameworks can drive innovation and shared responsibility.
- **Pilot Demonstrations**: The biogas installation represents a concrete, scalable solution for local resource valorisation, linking technology, learning, and sustainability.

Future Outlook

Going forward, the three stakeholders will continue to cooperate under the ŁOM 2030+ Strategy and the Bzura Circularity Centre, consolidating the region's position as a frontrunner in CE education and inter-municipal collaboration. The alignment of strategic planning, practical implementation, and citizen engagement in Łódź offers a model of multi-scalar circularity that other European territories can adopt and adapt.

Portugal – North Region

Regional Context and Focus

The Norte Region of Portugal, coordinated by the ***"Comissão de Coordenação e Desenvolvimento Regional do Norte"*** **(CCDR-N)**, is one of the country's most industrialised and export-oriented areas, combining strong agricultural and forestry sectors with a dynamic industrial base. It is home to 3.7 million inhabitants and represents over half of Portugal's national workforce. In the framework of FRONTSH1P, the region focuses on two Circular Systemic Solutions (CSSs):

- CSS2 – Food and Feed Waste Valorisation, and
- CSS4 – Plastics and Rubber Waste Valorisation.

These were selected based on the regional industrial profile, where agri-food, plastics, and rubber activities play a central role in resource use and waste generation.

CCDR-N joined the FRONTSH1P project to strengthen regional cooperation in circular economy, identify value chains and local stakeholders, and exchange knowledge and best practices with other European territories. The project also provides an opportunity to embed CE principles into regional policies and align them with EU-level sustainability goals.

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Current Initiatives

The Norte Region hosts a wide range of CE initiatives across multiple sectors, including agri-food, plastics, and manufacturing. These initiatives involve pilot projects on industrial symbiosis, waste valorisation, and sustainable production, supported by universities, business clusters, and local authorities. Workshops and knowledge-sharing events organised within FRONTSH1P have brought together SMEs, academic partners, and associations to explore synergies and develop new Circular Economy networks. Regional actors have also promoted innovation through applied research and the introduction of eco-efficient industrial processes.

Challenges and Barriers

The main barriers identified in the region are regulatory, financial, and cultural. Regulatory complexity and administrative delays hinder the implementation of innovative circular initiatives. Financial limitations, particularly for SMEs, constrain the adoption of new technologies, while limited awareness and risk aversion slow down behavioural change. Overcoming these challenges requires consistent coordination between policy frameworks, funding mechanisms, and education programmes.

Stakeholder Engagement

Stakeholder participation has been a cornerstone of the region's circular economy efforts. Through seminars, consultations, and collaborative workshops, CCDR-N successfully engaged SMEs, academia, and business associations, fostering a spirit of partnership and knowledge exchange. The active role of universities and research centres has been instrumental in linking scientific expertise with industrial needs and policymaking.

Success Factors and Impact

The main success factor identified is the collaborative model adopted between public institutions, universities, and industry clusters. Discussion forums, coordinated by associations and academia, provided structured environments for co-creation, peer learning, and consensus-building on circular strategies. This participatory governance approach has enhanced the region's capacity to integrate CE into existing policy instruments and value chain development.

Knowledge Sharing and Reflection

Knowledge exchange was prioritised through dialogue and partnership between regional actors. The process revealed that cooperation and shared ownership are essential to the success of CE actions. CCDR-N acknowledges that continuous stakeholder engagement and cross-sector communication are crucial for sustaining momentum. The experience also highlighted the importance of flexibility in adapting CE approaches to local contexts.

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Future Outlook

CCDR-N foresees the continuation of circular activities through the implementation of the Regional Circular Economy Action Plan, building upon FRONTSH1P outcomes. The establishment of a Regional Dialogue Council is envisioned to monitor progress, ensure accountability, and support the integration of CE principles into future regional development programmes. By aligning education, innovation, and governance, the Norte Region aims to consolidate a long-term, systemic approach to circularity that reinforces its position as a frontrunner in sustainable territorial development.

Italy – Campania Region (GAL Irpinia)

Regional Context and Focus

The **Local Action Group GAL Irpinia**, located in the province of Avellino, in the Campania Region, represents a rural area with a strong agricultural and agri-food vocation. With around 100,000 inhabitants, the area is known for high-quality production in cereals, wine, olive oil, and chestnuts, complemented by livestock and artisanal meat processing. Within FRONTSH1P, GAL Irpinia has focused on two Circular Systemic Solutions (CSSs):

- CSS2 – Food & Feed,
- CSS3 – Water & Nutrients

The region aims at addressing the valorisation of agricultural by-products, waste reduction, and innovative water and nutrient management systems. The participation in the project was motivated by the ambition to launch an integrated and replicable model of circular economy for rural territories, combining environmental protection with socio-economic development.

Current Initiatives

GAL Irpinia has launched several key projects to foster CE in the agri-food sector:

- **Ri.Agri Action**: a €400,000 initiative supporting partnerships of farms, institutions, and consultants introducing innovative bioeconomy and waste reduction processes in the olive, cereal, livestock, and wine sectors.
- **Depur Fitodepurazione**: the construction of two pilot phytodepuration plants for the recovery of organic waste and wastewater treatment.
- **Depur Fitodisidratazione**: five phytodewatering plants designed for sludge recovery and production of agricultural soil improvers.

These initiatives bridge traditional agricultural knowledge and modern environmental innovation, offering concrete examples of how rural areas can achieve circularity.

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Challenges and Barriers

The main challenges identified relate to the economic burden of introducing innovative processes, as high initial investment costs deter small and medium-sized enterprises (SMEs). Additional barriers include:

- Limited awareness of the long-term economic and environmental benefits of CE,
- Regulatory complexity and lengthy authorisation procedures,
- Cultural hesitation towards deviating from traditional practices, and
- Organisational difficulties in managing complex multi-stakeholder partnerships.
- GAL Irpinia addressed these barriers through targeted communication, continuous technical support, and institutional cooperation with the Campania Region.

Stakeholder Engagement

Stakeholder participation has been central to GAL Irpinia's strategy. Engagement was achieved through:

- A broad network of local actors including farms, public bodies, consultants, and associations;
- Thematic workshops and exhibitions, used to share solutions and economic evaluations;
- A dedicated website and information materials for continuous dissemination; and
- Events and awareness campaigns integrated into existing regional activities.

Stakeholders were motivated by tangible benefits, such as access to funding, training opportunities, and the potential to establish new partnerships. This participatory approach transformed knowledge exchange into a process of co-creation and shared innovation.

Success Factors and Impact

GAL Irpinia's success derives from a combination of technological innovation, stakeholder participation, and institutional cooperation.

In **Food & Feed**, the valorisation of agricultural by-products (e.g., garlic waste and olive residues) provided replicable examples of waste-to-resource transformation.

In **Water & Nutrients**, pilot projects demonstrated the feasibility of natural-based wastewater reuse and sludge recovery.

The Collaboration Agreement with the Campania Region (DG 50.17.00) formalised regulatory and financial support for circular projects, ensuring long-term continuity.

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Impact is measured through participation levels, partnerships formed, website engagement, and feedback from workshops and calls for proposals. These indicators reflect both quantitative outreach and qualitative stakeholder empowerment.

Knowledge Sharing and Reflection

Through FRONTSH1P, GAL Irpinia identified key lessons transferable to other regions:

- Early and structured stakeholder involvement enhances adoption and sustainability.
- Valorising local resources and by-products fosters innovation and reduces environmental costs.
- Dedicated public funding and technical support are crucial for replicability.
- Continuous communication increases awareness and engagement.
- Pilot testing provides tangible data and demonstrates replicable success.

In retrospect, GAL Irpinia would prioritise early communication, clearer monitoring indicators, and stronger emphasis on economic viability to accelerate stakeholder uptake and model transferability.

Future Outlook

Post-project sustainability will be ensured through several pillars:

- Consolidation of the regional cluster of businesses, research entities, and institutions promoting CE.
- Activation of financial instruments and regional calls, continuing Ri.Agri and Depur programmes beyond the project's lifecycle.
- Replication and dissemination of successful pilots via workshops and communication materials.
- Ongoing training and awareness campaigns to embed CE practices among farmers and consultants.
- Integration into regional and rural development plans, ensuring CE becomes an integral part of long-term territorial strategies.

GAL Irpinia's experience demonstrates how rural regions can serve as laboratories of innovation, blending tradition, environmental responsibility, and cooperation to achieve systemic circular transformation.

Greece – Central Greece and Municipality of Levadia

Regional Context and Focus

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037031

The Region of Central Greece, located in the heart of the country, comprises five regional units: Fthiotida, Evia, Viotia, Evrytania, and Phokida, with a population of approximately 500,000 inhabitants. The region's geographical diversity, combining extensive coastlines, mountainous areas such as Mount Oiti, and major river systems including the Spercheios, shapes both its cultural heritage and its economic profile, which is strongly linked to agriculture, livestock, forestry, and agri-food processing.

The Municipality of Levadia, located within the Viotia regional unit, complements this regional perspective by bringing local-level experience and direct engagement with citizens, cooperatives, and small enterprises.

Within the FRONTSH1P project, the Region of Central Greece and the Municipality of Levadia focus on two Circular Systemic Solutions (CSSs):

- CSS1 – Wood Packaging and Processing, targeting waste reduction and the valorisation of wood residues; and
- CSS2 – Food & Feed, promoting circular use of agricultural and food by-products.

Participation in FRONTSH1P is driven by the shared objective of turning environmental challenges into economic opportunities, strengthening institutional capacity, and promoting inclusive and sustainable regional development.

Current Initiatives and Case Studies

The Region of Central Greece's participation in FRONTSH1P represents its most significant circular economy initiative to date, aligning local industrial potential with European sustainability objectives. At the regional level, the project supports the replication of CSS1 and CSS2 through mapping and engagement of relevant stakeholders, including the agri-food, forestry, and bioenergy sectors. At the local level, the Municipality of Levadia provides practical examples of circularity in action:

- Separate collection of packaging and green waste, with part of the latter reused for heating purposes;
- Reuse of olive kernel waste as biofuel or biogas feedstock;
- Conversion of olive pomace into organic fertiliser and animal feed; and
- Small-scale valorisation of wood residues from carpentry and sawmills for energy production or reuse as biomass.

These examples demonstrate how circular approaches can generate both environmental and economic benefits, particularly when local initiatives are supported by broader regional frameworks.

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The Region also participates in complementary European projects such as SILVANUS, RAW4RES, LILAS4SOILS, MCAP, and NATALIE, which strengthen capacity in climate adaptation, renewable resources, and sustainable land management—thus reinforcing the circular transition.

Challenges and Barriers

Both the Region and the Municipality identify similar challenges in advancing circular economy (CE) practices:

- **Funding-driven engagement**: Many businesses are motivated primarily by short-term financial incentives rather than long-term sustainability objectives.
- **Limited resources and tools:** The absence of pre-existing questionnaires, communication materials, or engagement frameworks initially led to fragmented outreach and slower progress.
- **Cultural resistance:** Companies are often reluctant to share operational data, viewing circular initiatives as competitive threats rather than collaborative opportunities.
- **Regulatory inconsistencies**: National policy frameworks sometimes create disincentives—for example, higher VAT rates on bio-based fuels and delays in implementing "pay-as-you-throw" mechanisms.
- **Infrastructure and capacity gaps**: Smaller enterprises often lack access to the technology, expertise, or logistics required to close resource loops effectively.

Despite these challenges, FRONTSH1P has helped to establish a learning process within the region, gradually building trust, awareness, and collaboration between public institutions, academia, and local stakeholders.

Stakeholder Engagement

Stakeholder participation is a cornerstone of the region's approach. The Region of Central Greece and the Municipality of Levadia, working with the National Technical University of Athens (NTUA), have adopted a multi-level engagement model that includes:

- Mapping of actors across municipalities, industries, NGOs, and civil society, categorising them by readiness level (hesitant, potentially engaged, or advanced);
- Workshops and advisory committees to facilitate dialogue, co-creation, and technical exchange;
- Bilateral meetings and awareness events adapted to sectoral realities;
- Development of communication materials and dedicated questionnaires tailored to specific industries; and
- Online dissemination of project activities and results.

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This approach has progressively evolved from ad hoc consultations to a more structured framework that aims to formalise engagement through a Stakeholder Council, serving as a permanent platform for consultation and feedback.

Stakeholders are primarily motivated by clear examples of economic benefit, practical pilot cases, and access to capacity-building activities. The participatory process has thus transformed engagement from mere consultation into a model of co-creation and local ownership.

Success Factors and Impact

Key factors of success in the Region of Central Greece and Municipality of Levadia include:

- **Sector-specific engagement**: Tailored communication for wood processing, agri-food, and feed sectors enabled clearer understanding of benefits and challenges.
- **Pilot-oriented demonstration:** Concrete examples, such as olive by-product reuse or biomass valorisation, were essential in building credibility and trust.
- **Partnerships with academia**: Collaboration with NTUA has provided scientific support, methodological consistency, and capacity-building.
- **Gradual trust-building**: Early dialogue and transparent communication helped overcome scepticism and foster long-term cooperation.
- **Regional cooperation**: Integration with European and national projects has expanded access to funding, expertise, and networks.

Impact is measured through a combination of quantitative and qualitative indicators, including participation in events, stakeholder feedback, waste reduction trends, and the number of new collaborations initiated. The overall outcome reflects a growing awareness of CE principles, particularly in agri-food and wood-related industries.

Knowledge Sharing and Reflection

The experience of Central Greece offers valuable insights for other European regions:

- Start with stakeholder mapping and tailored communication, recognising different awareness levels and adapting approaches accordingly.
- Invest in practical tools early, including presentation materials and concise questionnaires, to support coherent and credible outreach.
- Build trust through continuous dialogue rather than short-term incentives, demonstrating tangible economic and environmental benefits.
- Acknowledge local culture and expectations, addressing political or social dynamics that may influence stakeholder behaviour.

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- Allocate sufficient resources for dedicated staff and continuous monitoring, ensuring consistent engagement and evaluation.

If starting again, the Region and Municipality would prioritise earlier preparation of communication tools, formal establishment of a Stakeholder Council, and more immediate inclusion of pilot demonstrations to illustrate practical benefits and accelerate acceptance.

Future Outlook

The Region of Central Greece and the Municipality of Levadia view the FRONTSH1P project as a foundation for long-term circular transformation. Sustaining momentum beyond the project's lifecycle will rely on several key actions:

- Institutionalisation of stakeholder engagement through a permanent Stakeholder Council;
- Integration of circular principles into regional development and environmental planning documents;
- Capacity-building within public administration, with dedicated staff for CE coordination;
- Leverage of future funding opportunities for scaling up pilot projects in the wood and agri-food sectors; and
- Promotion and replication of successful practices, such as olive waste valorisation and biomass reuse, across other regional units.

By embedding circularity into governance structures, economic planning, and community life, the Region of Central Greece and the Municipality of Levadia aim to make circular economy practices a permanent and self-sustaining feature of their regional identity.

The Netherlands – Friesland Province

Regional Context and Focus

The Province of Friesland, located in the north of the Netherlands, is one of the country's largest provinces by area but remains predominantly rural in character. Despite its dispersed population, Friesland is widely recognised as a frontrunner in the circular economy (CE) at both the national and European levels. The circular transition is firmly embedded in regional policy, driven by a coalition of businesses, public authorities, and knowledge institutions.
Within the FRONTSH1P project, Friesland's role has been twofold:

- To advance its own Circular Systemic Solution (CSS) focusing on circular plastics, and
- To act as a mentor and knowledge-sharing region, supporting replication and capacity-building in other European territories.

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The region's guiding philosophy is that "circularity is not a competition against each other, but with each other", highlighting its commitment to cooperation, inclusivity, and shared learning.

Current Initiatives and Case Studies

Friesland's circular economy is organised through the Circular Friesland Association, founded a decade ago by a consortium of leading companies. The association now includes over 180 members, encompassing all regional authorities, educational and research institutions, and a broad network of businesses. The model's success has led to replication in neighbouring provinces — Groningen and Drenthe — where similar associations now count more than 100 participating companies.

Key ongoing initiatives include:

- **Circular Plastics Programme**: Developed within FRONTSH1P, focusing on the valorisation, reuse, and recycling of plastic materials across industrial and consumer applications.
- **Circular Benchmark Tool (CBT):** A regional benchmarking and monitoring system that allows for the assessment and comparison of circular performance across European regions. The CBT serves as a replicable tool for knowledge exchange and performance tracking.
- **Regional Circularity Gap Report (CGR Friesland):** The world's first regional-scale gap analysis, quantifying material flows and circularity rates to guide policy and investment.
- **Circular Procurement Academy:** A collaborative platform for public authorities to enhance circular procurement practices, develop monitoring mechanisms, and jointly tender for sustainable products and services.

In addition, Friesland hosts the annual Circular Summit, which gathers more than 150 representatives from European regions to exchange knowledge and strengthen interregional cooperation.

Challenges and Barriers

While Friesland's transition is well advanced, several structural and contextual challenges remain:

- **Market demand and policy consistency**: Ensuring stable demand for circular products and predictable policy frameworks is essential for long-term private-sector investment.

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- **Regulatory limitations**: National and European legislation can create unintended barriers to innovation; to address this, Friesland established the Frisian Ambition Table for Legislation and Regulation, which liaises with higher authorities to identify and mitigate such obstacles.
- **Procurement inertia**: Shifting public procurement practices towards circular standards requires significant institutional coordination and capacity-building.
- **Cultural and behavioural barriers**: Sustaining engagement across such a broad stakeholder ecosystem requires ongoing communication and leadership.

Friesland's approach to overcoming these barriers combines entrepreneurial initiative with institutional support, ensuring that both private and public sectors share ownership of the circular agenda.

Stakeholder Engagement

Friesland's CE ecosystem is grounded in collaborative governance. The Circular Friesland Association acts as the primary coordination and engagement platform, connecting businesses, government bodies, and knowledge institutions. The model is built upon three key principles:

- **Business leadership:** Private enterprises drive circular innovation, setting the pace and direction of change.
- **Public sector facilitation**: The regional government provides resources, organisational capacity, and supportive policies.
- **Knowledge integration**: Universities and vocational institutions contribute research, innovation, and skills development.

This structure ensures that stakeholder engagement remains continuous, inclusive, and productive, with an emphasis on practical outcomes over theoretical debate.

Success Factors and Impact

Friesland's success can be attributed to a set of clear, actionable principles:

- **Empowering business leadership**: Circular initiatives are developed where momentum exists — in sectors and companies ready to take action.
- **Trust-based cooperation:** The region's government places confidence in private actors, enabling them to lead while providing the necessary institutional support.
- **Ambitious yet achievable targets**: Friesland set a long-term goal of reaching 35% circularity by 2035 (from the current 10%), establishing clear milestones and accountability.

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- **Evidence-based monitoring**: The Circularity Gap Report and CBT provide measurable indicators of progress, helping to track impact and identify areas for improvement.
- **Cross-regional learning**: Friesland actively shares knowledge and methods with other provinces and European partners, reinforcing its role as a mentor region.

Impact is measured through the number of circular enterprises, the expansion of sectoral initiatives (plastics, construction, water technology), and progress tracked via the Circular Benchmark Tool and Circularity Gap Report.

Knowledge Sharing and Reflection

Friesland's approach offers key lessons for other European regions seeking to strengthen their circular economy frameworks:

- Put businesses in the lead — success is highest when private actors are empowered to drive innovation.
- Build trust in public–private partnerships — governments should focus on enabling rather than directing.
- Celebrate success — visible progress strengthens momentum and attracts new participants.
- Identify local ambassadors — influential entrepreneurs can champion circularity within their networks.
- Integrate monitoring early — establishing a feasible framework from the outset ensures measurable outcomes and policy credibility.

These insights underscore the importance of combining ambition with pragmatism — advancing circularity through cooperation, data, and tangible achievements.

Future Outlook

Friesland's post-FRONTSH1P vision is defined by continuity and expansion. Key priorities for the coming decade include:

- Strengthening and expanding the Circular Friesland Association, ensuring long-term collaboration across sectors;
- Fostering interregional partnerships within the Netherlands and across Europe to enhance knowledge exchange and joint initiatives;
- Advancing sectoral agendas, particularly in circular plastics, biobased construction, and water technology;
- Scaling monitoring and benchmarking tools such as the CBT and Circularity Gap Report to enable comparable data across regions; and

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- Raising circular performance to at least 35% by 2035, transforming Friesland into one of Europe's leading circular regions.

Through its blend of entrepreneurial leadership, cooperative governance, and evidence-based policy, Friesland continues to serve as a model region for systemic circular transformation, demonstrating that progress is most effective when regions work with one another rather than in isolation.

Conclusions

Cross-Regional Insights, Success Factors and Lessons Learned
The analysis of the five regional experiences — Poland (Łódź Region), Portugal (Norte Region), Italy (Campania Region – GAL Irpinia), Greece (Central Greece and Municipality of Levadia), and the Netherlands (Friesland Province) — reveals a shared commitment to advancing circular economy principles through collaboration, innovation, and local adaptation. While each region operates within distinct socio-economic and institutional frameworks, several common patterns emerge that define the pathways to successful replication and long-term sustainability of Circular Systemic Solutions (CSSs).

Common Success Factors

Across all regions, successful CE initiatives are grounded in a combination of multi-level governance, stakeholder participation, and practical demonstration.

- **Collaborative and participatory governance** – Effective coordination between regional authorities, municipalities, academia, and private sector actors has proven essential. In Poland, the interplay between SLOM, Bzura, and Parzęczew exemplifies multi-scalar governance; in Greece and Portugal, public–academic partnerships strengthened credibility and knowledge transfer; while in Friesland and Campania, structured networks and associations provided continuity beyond project boundaries.
- **Stakeholder engagement and co-creation** – All regions highlighted the importance of early and continuous stakeholder involvement. Engagement was achieved through workshops, educational campaigns, advisory councils, or formal clusters. Successful engagement relied on tailoring communication to the level of stakeholder awareness and aligning circular practices with local economic priorities.
- **Demonstration and pilot initiatives** – Pilot projects such as Parzęczew's biogas unit, Irpinia's phytodepuration systems, and the circular plastics programme in Friesland proved instrumental in translating CE concepts into tangible outcomes. Demonstrations build trust, facilitate learning, and provide replicable models for future scaling.

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- **Education and awareness** – Particularly evident in the Polish and Portuguese cases, sustained education and public outreach activities established a cultural basis for circularity. Integrating CE into schools, community events, and public communication fostered behavioural change and long-term societal support.
- **Institutional and policy support** – The formalisation of CE within regional strategies, such as the ŁOM 2030+ Strategy, the Campania collaboration agreement, and Friesland's Circular Benchmark framework, demonstrates how embedding CE objectives in policy instruments ensures durability and alignment with wider EU goals.
- **Monitoring and evidence-based approaches** – The introduction of tools like Friesland's Circularity Gap Report and Circular Benchmark Tool provides a replicable model for measuring circular progress. Systematic monitoring not only validates results but also reinforces accountability and learning.

Common Barriers and Challenges

Despite progress, the regions collectively face persistent structural and behavioural obstacles:

1. **Financial and economic constraints** – High upfront investment costs remain the most cited barrier, particularly for SMEs in Italy, Portugal, and Greece. Limited access to tailored funding schemes hampers the adoption of innovative technologies and circular infrastructures.
2. **Regulatory complexity** – Fragmented or inconsistent national and EU regulatory frameworks, lengthy authorisation procedures, and fiscal disincentives (e.g., VAT treatment of bio-based fuels) create uncertainty for investors and innovators.
3. **Cultural and behavioural resistance** – In several regions, stakeholders view circularity primarily as a compliance requirement or funding opportunity, rather than an economic advantage. Hesitancy to share data or collaborate across sectors further limits progress.
4. **Institutional capacity and resource limitations** – Many regional and municipal administrations, particularly in Greece and Poland, face shortages of skilled personnel and operational tools, affecting their ability to sustain engagement and monitoring activities.
5. **Market demand and continuity** – As highlighted by Friesland, the stability of demand for circular products and predictable policy signals are essential for long-term investment by businesses. Without consistent markets, the economic viability of CE remains fragile.

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Lessons Learned and Recommendations

The cross-regional comparison yields several transferable lessons that can inform replication and upscaling of circular practices across Europe:

1. **Start from existing strengths and networks** – Leveraging local industrial traditions or community networks provides a foundation for tailored circular solutions, as seen in Irpinia's agri-food chains and Levadia's olive by-product valorisation.
2. **Empower business leadership and public facilitation** – Regions such as Friesland demonstrate that private sector leadership, supported by enabling public policies, yields faster and more durable results than top-down interventions.
3. **Prioritise education and communication** – Continuous awareness-raising, practical training, and transparent dialogue are indispensable for building trust and maintaining engagement across social groups.
4. **Integrate monitoring from the outset** – Embedding measurement frameworks early in the process ensures data continuity and facilitates benchmarking, replication, and impact assessment.
5. **Create multi-stakeholder governance platforms** – Councils, associations, and clusters institutionalise collaboration and knowledge exchange, providing the structure needed for long-term circular transition.
6. **Celebrate achievements and replicate success** – Recognising and communicating milestones encourages participation, fosters pride, and attracts new actors into the circular transition.

Final Remarks

The FRONTSH1P replication experience confirms that circular economy transformation is most effective when regions pursue inclusive, data-driven, and locally grounded approaches. Although the pace and scale of progress differ, all participating regions demonstrate that circularity can be achieved through collective action, mutual learning, and alignment of environmental and socio-economic goals.

The lessons derived from these regional experiences form a coherent knowledge base for good practices for regional replication in Europe, supporting the broader ambition of FRONTSH1P to foster systemic, replicable, and sustainable circular transitions across European territories.

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