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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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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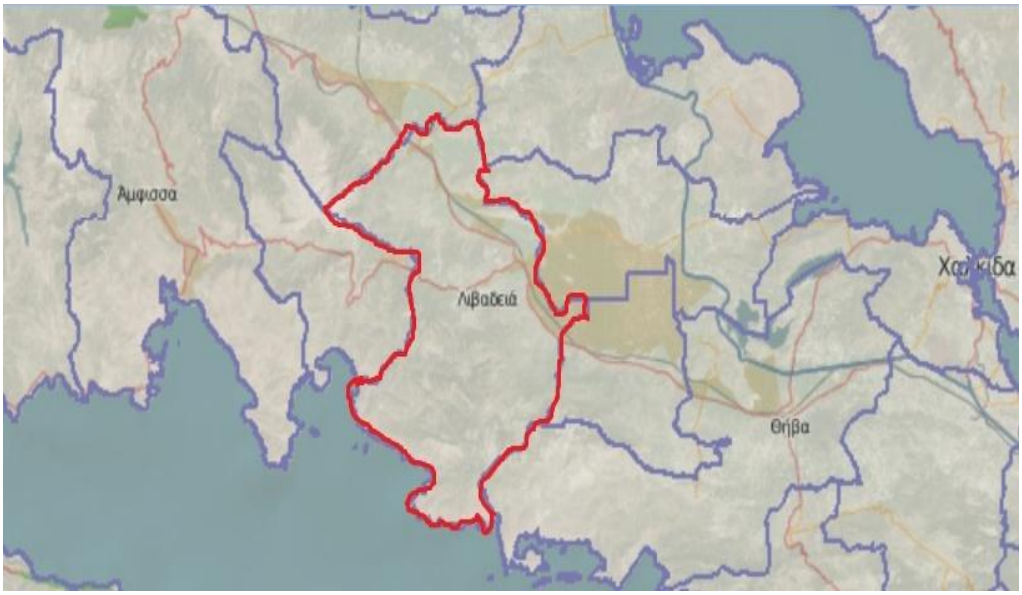

Figure 2 Location of Municipality of Levadia

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.

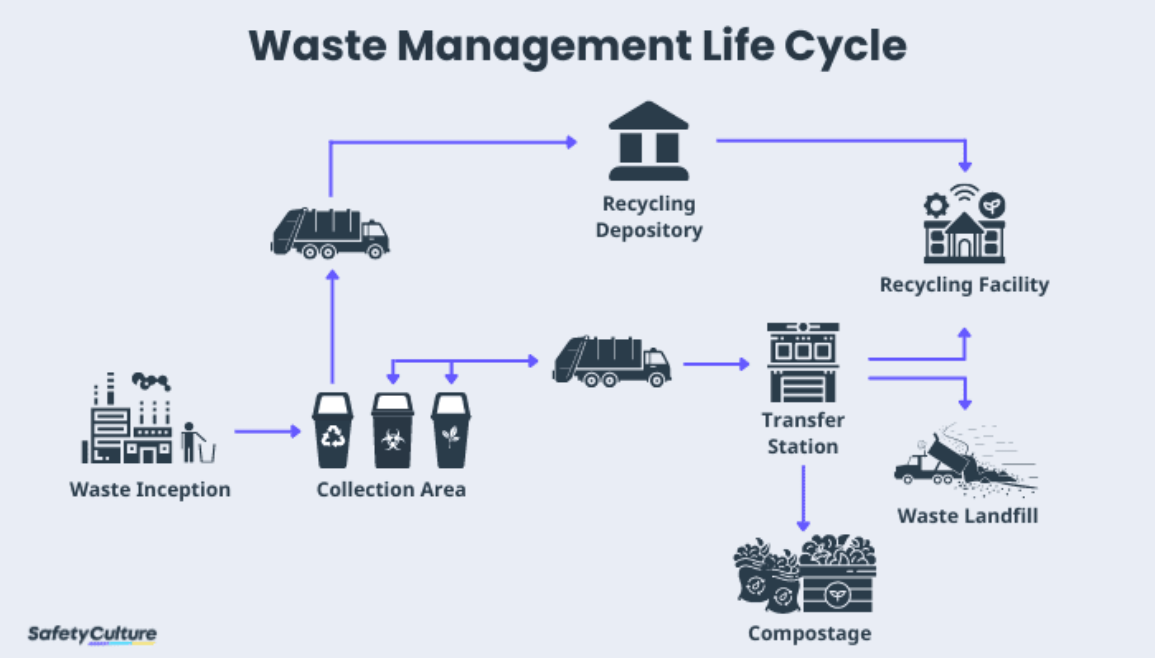

Figure 3 Waste management value chain[7]

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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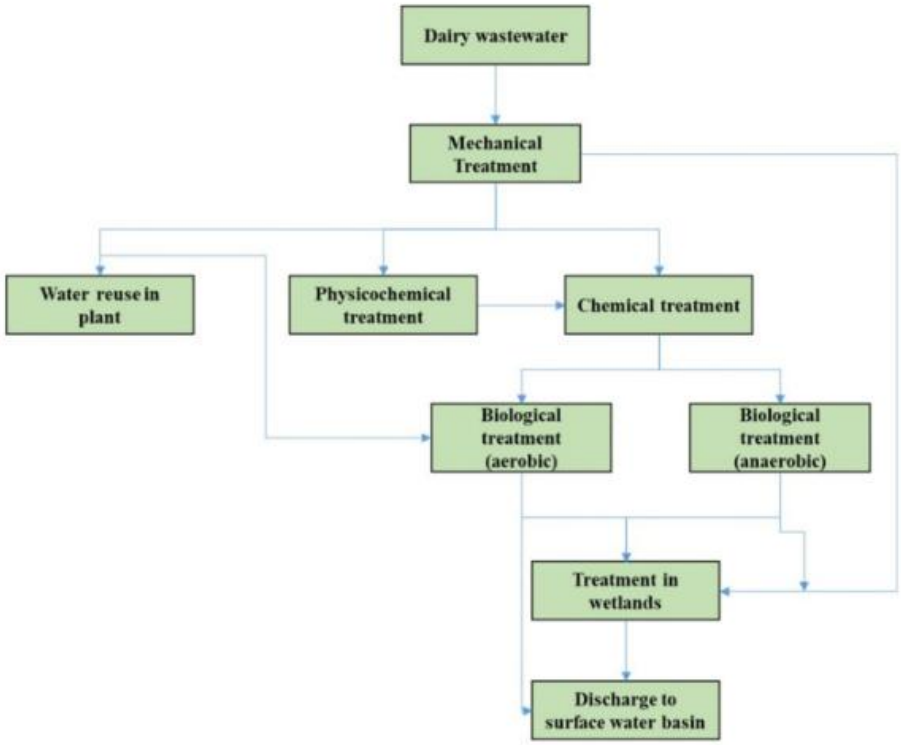

Figure 4 Value chain of management of dairy wastewater [9]

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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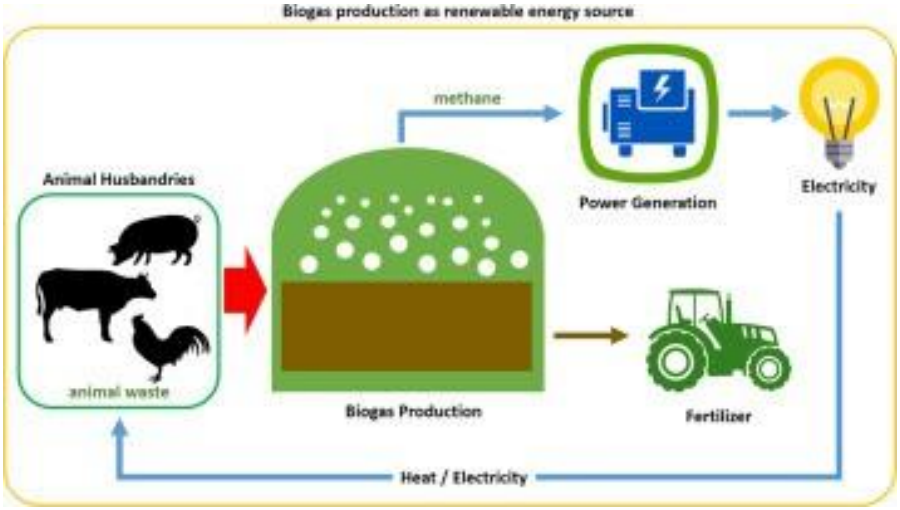

Figure 5 added value products from butchery waste [10]

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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