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1. Executive Summary

The deliverable was conceived with the aim to describe the starting point in the Łódź Region (Łódź voivodeship) before the design, development and implementation of the Circular Systemic Solution 2 Food and Feed, providing also a description of future activities, objectives and success criteria for WP4

2. Scope and Structure of the Deliverable

Definition of an implementation framework for CSS2. This deliverable will cover the following aspects:

1) Technical and non-technical state of the art, requirements and success criteria to satisfy the implementation of the technological and non-technological solutions required in CSS2;
2) Identification, involvement, needs and expectations from regional stakeholders involved in CSS2;
3) Executive implementation plan of CSS2.

3. About FRONTSH1P and CSS2

A **FRONTrunner approach to Systemic circular, Holistic & Inclusive solutions for a new Paradigm of territorial circular economy (FRONTSH1P)** is a European circular economy project that started on November 1st, 2021. It is funded by the European Union under the Horizon 2020 programme.

The project is centred in the Polish Region of Łódź. A region that on the one hand, traditionally heavily relies on coal extraction, and on the other hand, has pioneered circular (bio)economy since the early 2000s. The region has always been in the forefront of innovation and has become one of the leading regions in the field of circular economy. In the next 4 years, FRONTSH1P will contribute to further the green and just transition of the Łódź region away from its current linear economic foundation, towards the region's decarbonisation and territorial regeneration. It will do so by demonstrating four Circular Systemic Solutions. Each circular systemic solution targets an economic sector that is aiming towards decarbonisation: Wood Packaging, Food & Feed, Water & Nutrients, and Plastic & Rubber Waste. Each developed circular systemic solution will furthermore be highly replicable. A feat that will be proven during the project by

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their implementation in four other European regions: Campania (Italy), Sterea Ellada (Greece), Região do Norte (Portugal), and Friesland (the Netherlands). Through the development of the circular systemic solutions, FRONTSH1P will create Circular Regional Clusters that involve a wide range of local, regional, and national stakeholders, both from the public and private spheres, guaranteeing that no one will be left behind.

The CSS2, strictly interconnected with other CSSs, has key innovations in: i) CO2 assisted pre-treatment of agro-industrial waste combined with biotechnological treatments for the obtaining of Free Fatty Acids (FFAs) as component for foaming biomaterials; ii) Establishment of innovative oil crops cultivations (i.e. sunflower, milk thistle) in marginal and abandoned agricultural areas to obtain vegetable oils that can be transformed in biodegradable biolubricants, insulating materials and locally available animal feed supplements formulations; iii) production of biobased building blocks (diols and dicarboxylic acids) from second generation feedstock (from regional agro-industrial waste rich in sugars) for the formulation of new compostable bioplastics (compostable bags for OFMSW collection).

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4. Technical and Non-technical state of the art: market conditions of CSS2

4.1. Non-Technical state of the art: Current baseline & Market Analysis

4.1.1. Characteristics and properties of the territory

Today, the necessity to manage biodegradable waste which, due to its characteristics and properties, is burdensome material that is difficult to process, constitutes a significant environmental, technical, economic, and legal challenge. On the other hand, biodegradable waste processing offers not only environmental (no environment pollution) but also financial profits (a possibility to sell processing products: compost as organic fertilizer and biogas).

The European Union has changed its approach to compostable waste, which is more and more frequently treated as a resource (raw material) for the economy and a valuable product that can be processed and reused. New regulations further facilitate an effective approach to biodegradable waste.

The Łódź Region (Łódź voivodeship) is located in the center of the country and neighbours the Kuyavian-Pomeranian voivodeship, the Greater Poland voivodeship, the Silesian voivodeship, the Świętokrzyskie voivodeship, and the Mazovia voivodeship (Fig. 1).

The region's surface area is approx. 18,219 km^2, which constitutes 6% of the surface area of Poland, and it is inhabited by 2,416,902 people (Internet 2). The Łódź voivodeship is divided into 177 communes and it has forty-eight cities, including three cities with district rights (Łódź, Piotrków Trybunalski, and Skierniewice). The region is located on the border between the North European Plain and the Polish Uplands. The northern part of the Łódź voivodeship is crossed by the Warsaw-Berlin proglacial valley. The central part of the Łódź voivodeship is a strip of convex landforms – the so-called Łódź Upland. In the northern part of the region, the strip is highest (approx. 260 m) and starts to disappear. This element divides the drainage basin of the Vistula and the Odra, serving as a first-order drainage divide. The highest points are: the natural summit of Fajna Ryba (347 m a.s.l.) in the Przedbórz Commune and the artificial summit of Góra Kamieńsk (386 m a.s.l.) in the Kamieńsk Commune. Approximately 19% of the whole Łódź voivodeship land is located in an Environmental protected area, including eighty-seven nature reserves, seventeen protected landscape areas, and seven natural

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landscape parks. Agricultural land covers approx. 70% of the surface area of the whole Łódź voivodeship. The Łódź Region has the least forest areas of all voivodeships, taking up only 21% of its surface area.

The Łódź voivodeship has hard coal deposits in Bełchatów, Złoczew, and Rogóźno. Moreover, Cretaceous sands are extracted near Tomaszów, while iron ore and limestone are extracted near Sulejów and Działoszyn.

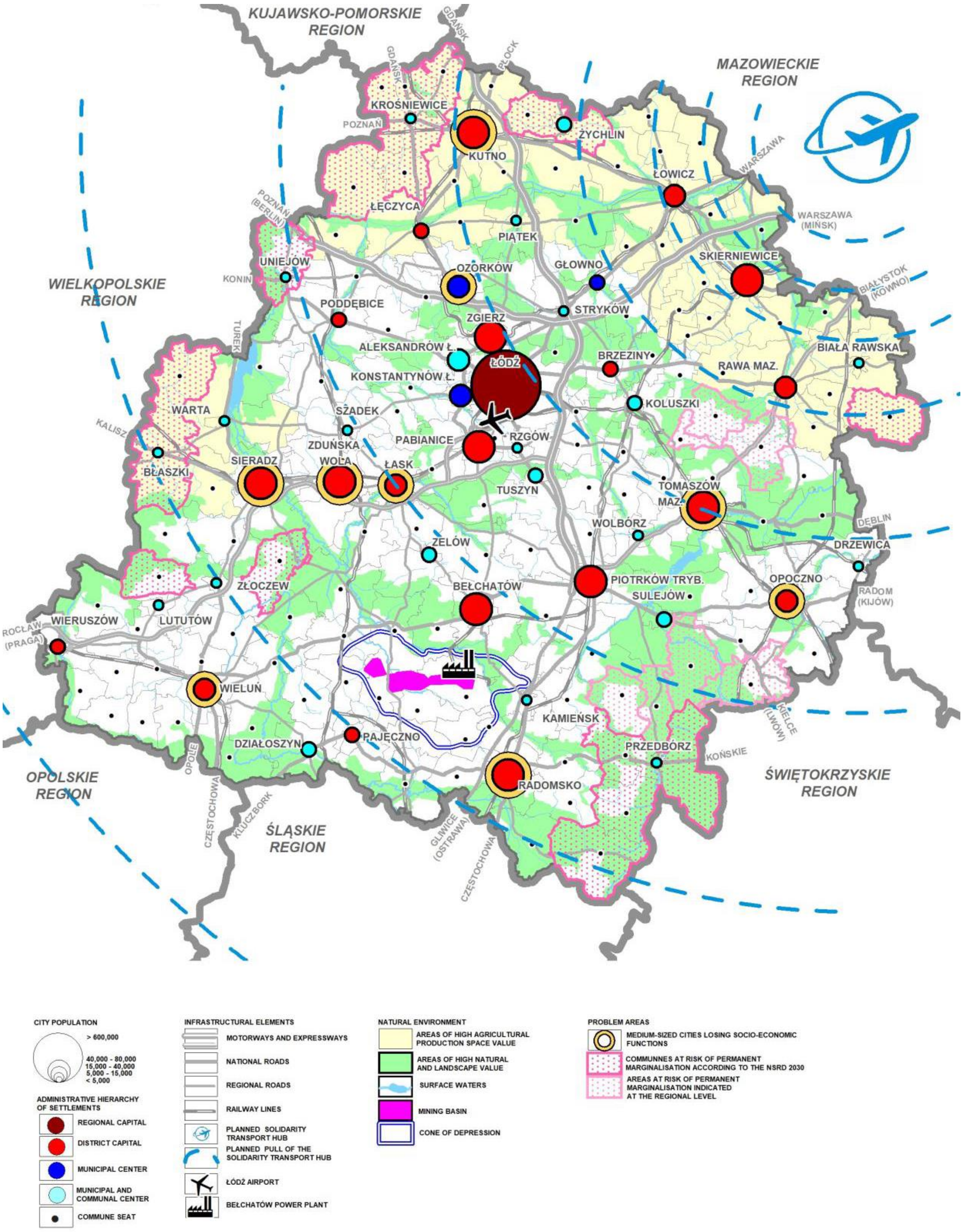

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Figure 1: Key elements of the functional-spatial structure Łódź Region

Source: The Development Strategy of the Łódź Region 2030 is an Appendix to the Resolution No. XXX/414/21 of the Regional Assembly of the Łódź Region, dated 6 May 2021.

The main branches of industry in the Łódź Region include: the energy industry, the machine industry, the food industry, the metallurgy industry, the ph armaceutical industry, and the construction industry. The main products of the region include ceramic tiles, hosiery, hard coal, and cotton fabrics. The largest industrial companies operating in the region are: Bełchatów Power Station, Zakład Energetyczny PGE Łódź S.A., Veolia Energia Łódź S.A. (formerly Zespół Elektrociepłowni w Łodzi and then Dalkia), Łódzki Zakład Energetyczny S.A., and the Łódź Special Economic Zone. The Łódź Region is a scientific and academic center with six public and twenty-two non-public higher education institutions (WIOŚ 2020).

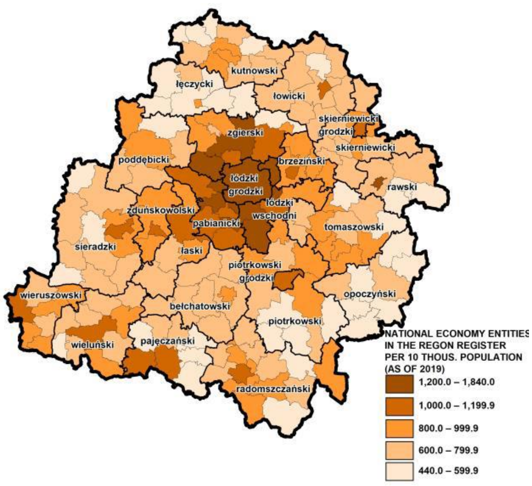

Figure 2: Number of national economy entities in the REGON register per 10,000 population in 2019

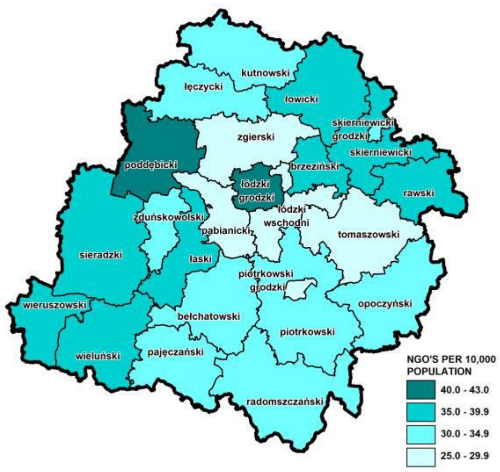

Figure 3 Number of non-governmental organisations per 10,000 population in the Łódź Region districts in 2019

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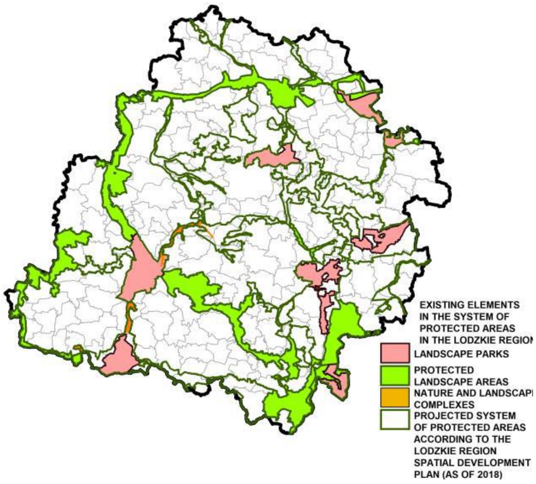

Figure 4: Existing elements of the system of protected areas in the Łódź Region in 2019.

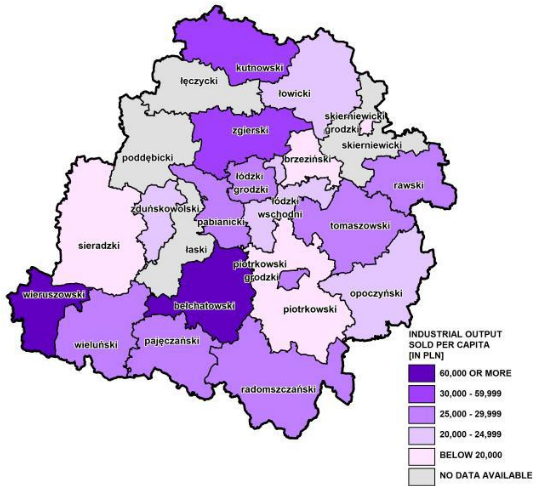

Figure 5: Industrial output sold per capita in 2019

Source: The Development Strategy of the Łódź Region 2030 is an Appendix to the Resolution No. XXX/414/21 of the Regional Assembly of the Łódź Region, dated 6 May 2021.

4.1.2. Potential Resources in Communal Waste – Raw-Material Analysis

Bio-waste – mostly food and garden waste – is the key stream of waste with great valorisation potential, contributing to the creation of a circular economy (CE). It provides valuable materials that improve the properties of soil and fertilizer, and biogas that is a source of renewable energy. 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 Municipal Waste with Separately Collected Fractions, include mostly:

- Kitchen waste as well as expired food and food that is non-suitable 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.

Kitchen waste constitutes a significant fraction in the bio-waste volume. Kitchen waste mostly includes fruit and vegetable peels and cores, fruit and vegetable skins, citrus leftovers, expired food, food leftovers, dumplings, expired yogurts, coffee and tea dregs, expired confectionery products, stale bread, cakes, eggshells etc. Nine million tons of food are wasted in Poland every year, including two tons of waste from

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households. Thus, it can be said that every citizen wastes 53 kg of food a year. To avoid this and not to generate bio-waste, one should wisely choose what they put in their shopping carts (Kozłowska, 2021).

In Poland, bio-waste has been collected separately for a long time, however, initially this mostly concerned green waste from parks and municipal green areas. Subsequently, communes started to implement separate collection among inhabitants, however, also only in connection with garden (green) waste. Only the National Waste Management Plan 2022 included the requirement to introduce systems of separate collection of green waste and other bio-waste at source in all communes by the end of 2021.

Over the last four years, many communes implemented or extended separate collection of bio-waste by kitchen waste. Figure 6 shows the growing share of separate bio-waste collection.

In fact the total potential of bio-waste in the municipal waste volume in Poland is higher than 3500 thousand of ton/year in 2020 (den Boer E., 2021).

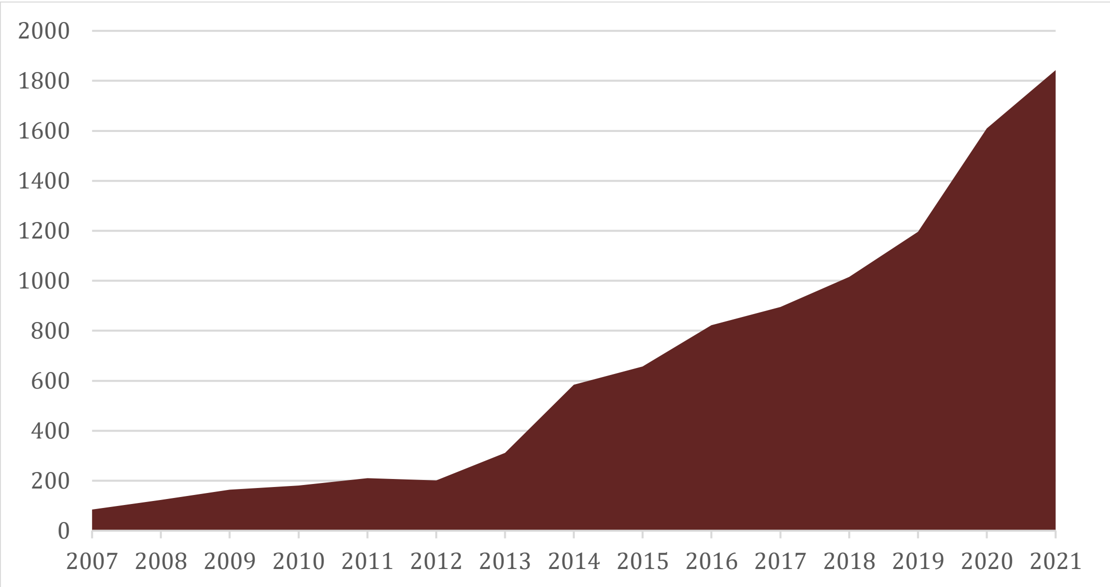

Figure 6: The share of separate bio-waste collection in Poland in tons/year - Source: own work based on GUS – Local Data Bank, 2022.

The present Ordinance of the Minister of Climate and Environment on the method for separate collection of selected waste fractions imposes on communes the obligation to collect bio-waste separately. Pursuant to the law, the whole stream of bio-waste is covered by this obligation. Collection and processing of kitchen and garden bio-waste presents a great challenge to communes today. However, it is not a new task and covering collection of the whole bio-waste with this obligation was only a matter time. As Table 1 indicates, the level of separate biowaste collection is regularly growing.

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Table 1: The level of separate biowaste collection in Poland

Year	2010	'11	'12	'13	'14	'15	"16	'17	'18	'9	'20
	kg/inhabitant										
Unit amounts of separately collected bio-waste in Poland	4,7	5,4	5,2	8,1	15,2	17,1	21,4	23,3	26,4	31,2	42,0

Source: GUS – Local Data Bank, 2022.

Inhabitants of the Łódź Region collect less bio-waste as part of separate collection than the national average, meaning only 41kg/inhabitant (Figure 7). The estimation include: vegetable and fruit peelings, egg shells, coffee and tea grounds, wilted flowers and plants, vegetable food scraps. In other words, biodegradable waste from gardens and parks, food and kitchen waste from households, catering, including restaurants, canteens and mass caterers, offices, warehouses and retail units, as well as similar waste from plants producing or marketing food.

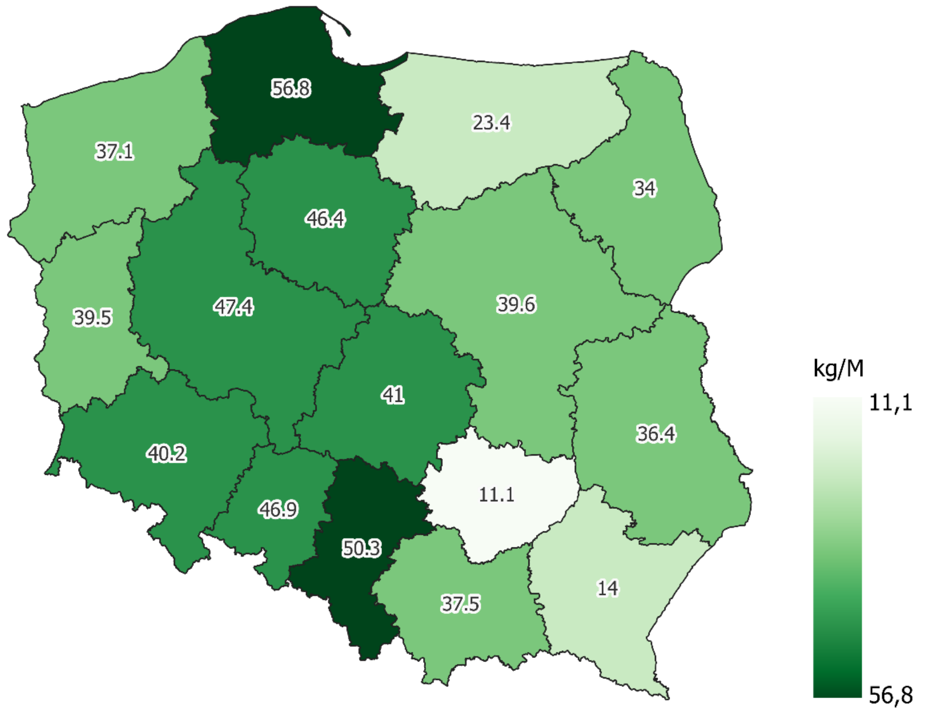

Figure 7: The effects of separate bio-waste collection by inhabitants per voivodeship in 2020 - Source: based on the data of the Statistics Poland, 2021.

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In 2010, the dominant way of municipal waste management was still landfilling, with 73.4% of municipal waste undergoing this process and only 17.8% of the collected municipal waste being recycled.

In 2020, municipal waste collected in Poland was subjected to the following processes:

- Recycling – 3,498.6 thousand tons (26.7%),
- Biological treatment processes (composting or fermentation) – 1,577.9 thousand tons (12.03%),
- Incineration with and without energy recovery – 2,822.6 thousand tons (21.52%),
- Landfilling – 5,217.7 thousand tons (26.7%).

As Figure 8 shows, there is more waste for composting or fermentation in the Łódź Region (14%) than the national average.

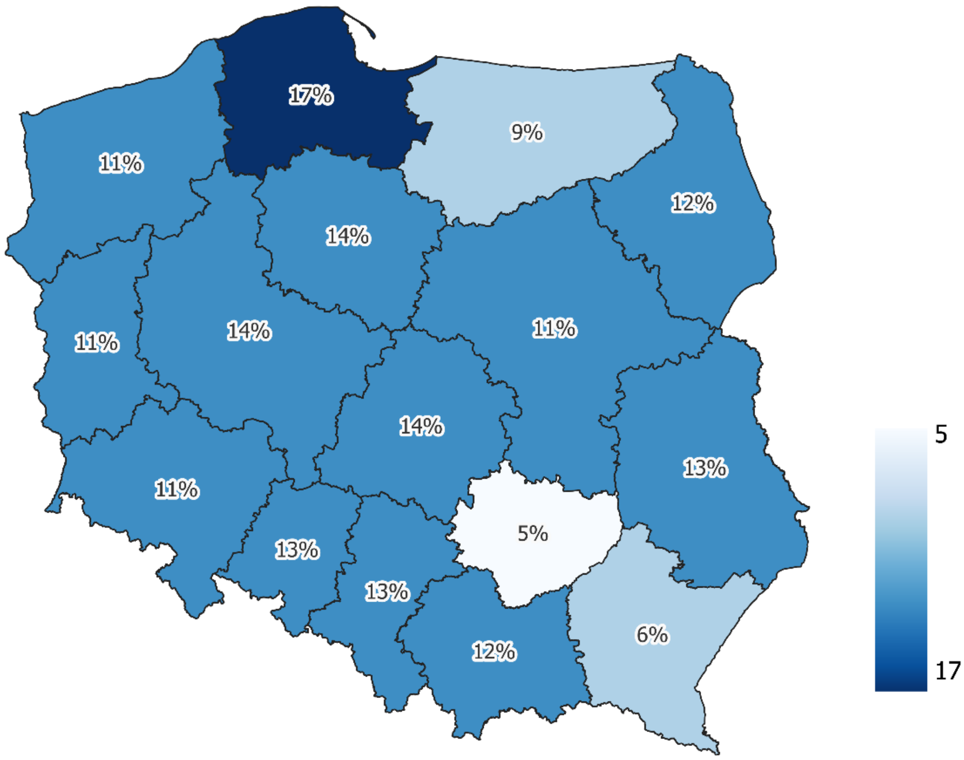

Figure 8: Waste for composting or fermentation according to the voivodeship (average for Poland 12%) - Source: GUS – Local Data Bank, 2022.

Based on 177 reports on the fulfilment of tasks connected with municipal waste management submitted by commune heads and mayors to the Marshal of the Łódź Region and the Łódź Provincial Environmental Protection Inspector, upon their verification and analysis, it was found that in 2017 a total of 718,722 tons of municipal waste was collected from inhabitants (approx. 4% more compared with 2016), in 2018 243,570 tons was collected, and in 2019 276,590 tons of municipal waste was

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collected (source: Provincial Waste Management Plan 2021; Marshall Office Łódź, 2021).

In 2017, 60,681 tons of biodegradable waste (Bio) was collected separately, including 38,152 tons of green waste (source: Provincial Waste Management Plan 2021). In 2018, the volume of municipal waste collected for recycling was 133,916.5 tons, in 2020 – 222,152.3 tons, while in 2021, the volume of municipal waste collected for recycling was 217,453.9 tons.

The volume of biodegradable municipal waste collected in 2017 (Table 2), pursuant to the reports of commune heads and mayors on the fulfilment of tasks connected with municipal waste management for 2017, was 55,810,875 tons. Tables 3 and 4 present results for the years 2018-2021.

Due to amendments to ordinances introducing the requirement of separate bio-waste collection and changes to definitions and terms connected with this group of waste, subsequent reports providing data on the production and processing of bio-waste are inconsistent and difficult to compare.

Table 2: The volume of biodegradable municipal waste collected and processed in the Łódź Region in the years 2015-2017

The code of biodegradable municipal waste collected	The type of biodegradable municipal waste collected	The volume of biodegradable municipal waste collected [ton]		
		2015	2016	2017
20 01 08	biodegradable kitchen waste	17 102,560	13 073,120	10 085,178
20 02 01	biodegradable waste	23 785,190	29 132,190	33 630,508
20 03 02	waste from markets	97,320	426,070	548,710

Source: Provincial Waste Management Plan, 2021.

Table 3: The volume of biodegradable waste collected in the years 2018-2021

The code of biodegradable municipal waste collected	The code of biodegradable municipal waste collected	The volume of biodegradable municipal waste collected [ton]			
		2018	2019	2020	2021
	biodegradable kitchen waste	no data	no data	no data	no data
20 02 01	biodegradable waste	69 358,49	98 975,37	99 978,26	

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20 03 02	waste from markets	no data	no data	no data	no data

Source: GUS – Local Data Bank, 2022.

Table 4: Biodegradable waste treatment in the years 2018-2021

	2018	2019	2020	2021
The mass of municipal waste generated per capita [kg]	319,2	332,9	347,4	361
The mass of collected municipal waste destined for composting or fermentation [ton]	82392	113794	116828,9	120921,4
Biodegradable waste - total collected selectively during the year [ton]	82039,86	14818,66	no data	no data
Biodegradable waste - collected selectively during the year from households [ton]	69358,49	98975,37	99978,26	no data
Biodegradable waste - collected selectively during the year from other sources (municipal services, trade, small business, offices and institutions) [ton]	12681,37	no data	16881,11	12003,36
number of communes where selective collection of municipal waste was carried out - in total	177	175	175	175
the number of communes where the selective collection of biodegradable waste was carried out	124	139	139	160
Waste generated during the year subject to recovery - composted) [ton]	no date	no date	no date	1,7 k

Source: GUS – Local Data Bank, 2022.

Table 5: The forecasted mass of municipal waste generated in the Łódź Region in 2019-2025 with a perspective until 2031, including biodegradable waste.

Type / group waste		Total municipal waste	Mixed municipal waste (20 03 01)	Biodegradable waste, including green waste
Base year	2017	717 706	496 880	55 811
Forecasted mass of generated municipal waste [ton/year]	2023	959 614	535 451	124 798
	2024	1 007 594	524 742	137 277

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	2025	1 047 074	514 247	151 005
	2026	1 099 428	503 962	166 108
	2027	1 143 405	493 883	182 716
	2028	1 189 141	484 005	200 087
	2029	1 236 707	474 325	221 087
	2030	1 273 808	464 839	243 195
	2031	1 312 022	455 542	287 515

Code of waste in group Biodegradable waste, including green waste: 15 01 01 - Paper and cardboard packaging, 15 01 03 - Wooden packaging, 15 01 06 – Mixed packaging waste, 20 01 01 - Paper and cardboard, 20 01 08 Biodegradable kitchen waste -, 20 01 10 - Clothes, 20 10 11 - Textiles, 20 01 25 - Edible fats and oils , 20 01 38 - Wood other than listed under 20 01 37, 20 02 01 - Biodegradable waste, 20 03 02 - Waste from marketplaces, ex 15 01 06 – Mixed packaging waste, ex 20 01 11.- Textiles.

The Łódź Region has the following municipal facilities:

- 7 facilities for mechanical and biological processing of mixed municipal waste;
- 9 landfills of waste other than hazardous and inert waste.

In the Łódź Region, there are also seven facilities for processing green waste and other bio-waste that before the amendment to the Act of 13 September 1996 on maintaining cleanliness and order in communes became effective had had the status of regional facilities for municipal waste processing. These are facilities in the village of Krzyżanówek near Kutno, in Łódź, in the village of Dylów near Pajęczno, in the village of Płoszów near Radomsko, in the village of Pukinin near Rawa Mazowiecka, in the village of Różanna near Opoczno, and in the village of Juków near Skierniewice (Fig. 9).

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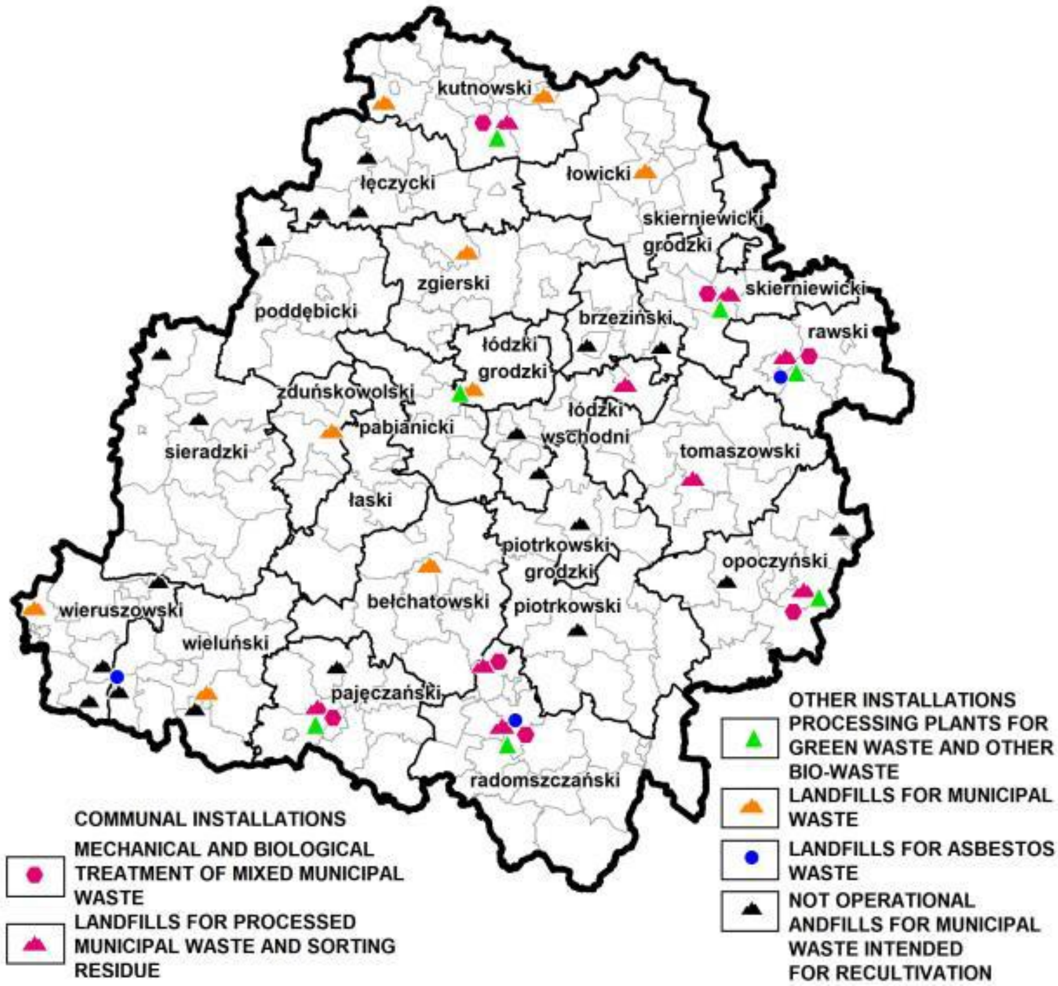

Figure 9: Management of communal waste in the Łódź Region in 2020

Source: own study based on data from: Regional Environmental Protection Agency, draft Waste Management Plan for the Łódź Region for 2019-2025 (including 2026-2031)

The present capacity of facilities for the processing of bio-waste, including green waste, in the Łódź Region is 72,445 tons/year. This capacity was determined based on Chapter 2 of the Investment Plan (Part I. The Existing Facilities), forming an integral part of the Waste Management Plan for the Łódź Region for the years 2019-2025, considering the years 2026-2031. The largest capacity is offered by the facility in Łódź, which is a composting facility located at 70/72 Sanitariuszek Street, operated by Zakład Gospodarowania Odpadami, and the facility in Dylów, which is also a composting facility, operated by EKO-Region with its seat in Bełchatów.

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4.1.3. Potential Resources in Industrial Waste – Raw-Material Analysis

Depending on the source of biodegradable waste and the place it is produced, it can be classified as municipal or non-municipal waste. Industrial and production waste, meaning non-municipal waste, includes:

- 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 economy and industry waste, energy crop waste;
- Sewage sludge from sewage treatment plants;
- 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.

Considering waste codes, biodegradable industrial waste includes a few dozen types of waste classified based on their source into the following groups:

- Group 02 – waste from agriculture, horticulture, hydroponics, aquaculture, forestry, hunting and fishing, food preparation and processing (30 types of waste from subgroups: 02 01, 02 03, 02 04, 02 05, 02 06, and 02 07);
- Group 03 – waste from wood processing and the production of panels and furniture, pulp, paper and cardboard (10 types of waste from subgroups: 03 01 and 03 03);
- Group 19 – waste from facilities and devices used for the management of waste from wastewater treatment plants and from treatment of water intended for human consumption or water for industrial use (13 types of waste from subgroups: 19 06, 19 08, 19 09, and 19 12).

Biodegradable waste from the industrial sector has diverse physical properties and chemical composition. The differences result from different places of waste production, types of materials used, and technological conditions of the production processes. On the other hand, waste produced in the same industry sector usually has similar physical and chemical properties.

In 2017, the Łódź Region produced 445,815,614 tons of biodegradable non-municipal waste. This volume is higher than the volume of biodegradable waste produced in 2016, however, it is much lower than the volume of biodegradable non-municipal waste produced in 2015. Most waste comes from group 19 (waste from facilities and

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devices used for the management of waste from wastewater treatment plants and from treatment of water intended for human consumption or water for industrial use). Figure 6 presents data for the years 2015-2018. There was no data for 2019.

Table 6: The volume of biodegradable non-municipal waste produced

Group of waste	2015	2016	2017	2018
	mass [ton]	mass [ton]	mass [ton]	mass [ton]
02	195 982,488	189 546,615	190 435,994	100 710,51
03	114.141	107,210	93,879	82 875,25
19	341 286. 893	222 184,970	255 285,741	650 497,69
Total	537 383,521	411 838,795	445 815,614	834 083,45

Source: Regional Waste Management Plan 2021; Marshall Office Łódź, 2021.

A system for managing biodegradable industrial waste is based on the producers' responsibility for its proper management. In case a waste producer is unable to manage the waste produced, they are obligated to hand it over to entities that are authorized to collect and process it. In 2015-2018, biodegradable industrial waste from groups 02 and 03 was mostly recovered, while biodegradable industrial waste from group 19, in the period in question, was mostly treated.

Biodegradable industrial waste can be processed in various ways, including through recovery processes in accordance with Annex 1 to the Act of 14 December 2012 on waste (uniform text in Journal of Laws of 2022, item 699, as amended):

- R1 – Use principally as a fuel or other means to generate energy,
- R3 – Recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes),
- R5 – Recycling/reclamation of other inorganic materials,
- R6 – Regeneration of acids or bases,
- R10 – Land treatment resulting in benefit to agriculture or ecological improvement,
- R11 – Use of waste obtained from any of the operations numbered R1 to R10,
- R12 – Exchange of waste for submission to any of the operations numbered R1 to R11,
- R13 – Storage of waste pending any of the operations numbered R1 to R12 (excluding temporary storage, pending collection, on the site where it is produced),

And treatment processes in accordance with Annex 2 to the Act of 14 December 2012 on waste (uniform text in Journal of Laws of 2022, item 699, as amended):

- D1 – Deposit into or onto land (e.g. landfill, etc.),

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- D4 – Surface impoundment (e.g. placement of liquid or sludgy discards into pits, ponds or lagoons, etc.),
- D5 – Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.),
- D8 – Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D1 to D12,
- D9 – Physical-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations numbered D1 to D12 (e.g. evaporation, drying, calcination, etc.),
- D10 – Incineration on land,
- D13 – Blending or mixing prior to submission to any of the operations numbered D1 to D12,
- D14 – Repackaging prior to submission to any of the operations numbered D1 to D13.

In 2017, 1,145,750,340 tons of waste were recovered. This was the largest volume in the analysed years. Most waste from group 02 was submitted to the R3 operation. The trend was similar for waste from group 03, in the case of which the largest volume was also submitted to the R3 operation (Table 7). In group 19, the most frequently used recovery process was R5 (recycling/reclamation of other inorganic materials) (Table 7).

Table 7: The Mass of recycled non-municipal biodegradable waste in 2015 – 2017

Group of waste	Process code	2015	2016	2017	2018	
		mass [ton]	mass [ton]	mass [ton]	Process code	mass [ton]
02	R1	6 659,880	2 457,880	2 681,020	R1, R3, R5, R10, R11, R12,	138 954,90
	R3	344 283,905	382 453.577	388 384,487		
	R5	2 358,000	2 257,326	1 615,964		
	R10	2 477,391	18 253,285	21 247,804		
	R11	38 805,400	1 400,000	0,880		
	R12	3 348,504	16 585,375	14 869,763		
	R13	49 186,130	55 024,117	53 627,635		
03	R1	55 080,000	7 255,807	2 450,090	R1, R3, R5, R11, R12	141 219,68
	R3	128 654,169	102 793,085	96 001,800		
	R4	2,720	0,000	0,000		
	R5	26 273,957	23 299,482	25 252,569		
	R10	0,006	0,000	0,000		
	R11	259,420	276,085	89,280		
	R12	9 494,560	2 604,100	8 531,640		
	R13	0,000	5,660	0,000		
19	R1	11 127,456	36 692,942	69 224,842	R1, R3,	239 959,30

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	R3	74 500,776	126 888,534	161 946,872	R5, R11, R12	
	R4	224,225	25,300	419,161		
	R5	112 556,282	76 608,061	132 530,814		
	R6	0,000	5,000	0,000		
	R10	67 059,491	78 885,770	61 346,198		
	R11	2 100,310	121,900	83,370		
	R12	81 014,200	113 225,260	98 323,520		
	R13	13 238,916	6 620,487	7 122,630		
Total		**1 028 705,697**	**1 053 739,035**	**1 145 750,340**		

Source: Regional Waste Management Plan 2021, Marshall Office Łódź, 2021.

In 2017, 471,608,920 ton of biodegradable industrial waste were treated. Over the analysed years, the amount of biodegradable non-municipal waste treated dropped. Most waste from group 02 was submitted to the D5 operation, i.e. specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.). In the analysed years, the volume of landfilled waste decreased.

Waste from wood processing and the production of panels and furniture, pulp, paper and cardboard (group 03) were only treated with D8 operations (biological treatment not specified elsewhere in Annex 2 to the Act on waste, which results in final compounds or mixtures which are discarded by means of any of the operations numbered D1 to D12).

In the case of waste from group 19 (waste from facilities and devices used for the management of waste from wastewater treatment plants and from treatment of water intended for human consumption or water for industrial use), the most frequently used treatment operation was D5, meaning landfilling (table 8).

Table 8: The volume of treated biodegradable non-municipal waste in 2015-2018

Group of waste	Process code	2015	2016	2017	2018	
		mass [ton]	mass [ton]	mass [ton]	Process code	mass [ton]
02	D5	1 915,380	97,400	162,300	D5 D8 D9	823,93
	D8	1 820,120	2 624,405	2 689,560		
	D9	1 326,866	762,399	1 714,725		
	D14	0,019	0,000	0,000		
03	D8	0,000	0,000	6,800	D8	11,70
	D1	67,200	134,300	25,400		
	D4	20 345,500	0,000	0,000		
	D5	351 276,490	300 785,759	31 872,770		
	D8	47 004,230	103 520,811	93 489,010		
	D9	2 546,013	3 203,605	3 728,325		
	D10	67 750,660	67 569,650	56 920,030		

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	D13	0,023	0,000	0000		
	D14	0,000	0,001	0,000		
Total		494 052,501	478 698,331	471 608,920		

Source: Regional Waste Management Plan 2021; Marshall Office Łódź, 2021.

Biodegradable non-municipal waste is processed in, among others, facilities for the production of alternative fuels – 2, a facility for the production of fuel – 1, facilities for the production of pellets – 1, facilities for the production of pellets, granulate, and briquette –1, biogas plants – 2, and an agricultural biogas plant – 1. A total of eight facilities are available. Biogas plants are located in Kutno (capacity of 11,939,260 tons/year), Bukowiec Opoczyński, Opoczno Commune (capacity of 797,880 tons/year), and Chełmo-Masłowice (capacity of 24,087,00 tons/year).

Within industrial waste, group 02 was identified as waste problematic for the Łódź Region. One of the reasons for this is the fact that the surface area of the agricultural land is approx. 70% of the total surface area of the voivodeship. Moreover, the food industry is among the most important and the most rapidly developing industries in the voivodeship. Apart from industrial plants, there are also small and medium enterprises, such as twenty catering companies and eleven frozen food manufacturers. There are also twenty companies manufacturing food. Ready-to-cook foods are produced by fourteen companies.

Pursuant to the Ordinance of the Minister of Climate of 2 January 2020 on a catalogue of waste (Journal of Laws of 2022, item.10), waste from group 02 is waste from agriculture, horticulture, hydroponics, aquaculture, forestry, hunting and fishing, and food processing.

Waste from group 02 includes the following subgroups:

- 02 01 – waste from agriculture, horticulture, hydroponics, forestry, hunting and fisheries;
- 02 02 – waste from the preparation and processing of food products of animal origin;
- 02 03 – waste from the preparation of food products and stimulants, and waste of plant origin, including waste from fruit, vegetables, cereal products, edible oils, cocoa, coffee, tea, and from the preparation and processing of tobacco and yeast, and from the production of yeast extracts, and from the preparation and fermentation of molasses (excluding 02 07);
- 02 04 – waste from sugar processing;
- 02 05 – waste from the dairy products industry;
- 02 06 – waste from the baking and confectionery industry;

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- 02 07 – waste from the production of alcoholic and non-alcoholic beverages (except for coffee, tea and cocoa).

Most of waste from group 02 is biodegradable waste but not only as, for example, metal waste is also classified into this group. Methods for preventing the production of waste from group 02 include education on waste production minimization and ecodesign concerning environmental aspects when designing products or implementing management systems.

In the years analysed, most waste from group 02 was produced in 2015, with the volume of 209,707,453 ton. The least amount of waste was produced in 2016 – 201,398,693 ton.

Over the years, there is no clear downward or growing trend in the volume of waste. Out of the waste produced, waste with code 02 01 06 – animal manure dominated in 2016. The least amount of waste generated in 2015-2017 was waste with code 02 01 09 – agrochemical waste other than those mentioned in 02 01 08 – 0.418 ton (table 9).

The breeding of animals and agricultural produce processing industry generate great amounts of liquid and semi-solid organic waste. The processing of this waste poses a challenge to the industry, local governments, scientists, and engineers. Organic waste contains precious components that are important for the fertility of soil and the production of crops. After proper processing (e.g. composting), their distribution directly to the cultivated land offers a recycling option with regard to this waste. Generally, however, it is treated using methods opposed by the public due to their effect on the health and quality of life of local inhabitants.

In the agricultural and food processing industry, the largest percentage of unused materials is related to the processing of sugar beets, the production of potato starch, and the production of plant oils and cheeses. The production of food is inexorably linked to the production of waste. For example, in order to produce canned fish, the percentage of raw material volume unused in the end product is 30-65%, in the case of fish fillet production – 50-75%, in the case of cattle slaughter and beef processing – 40-52%, in the case of pig slaughter and pork processing – 35%, in the case of poultry slaughter and poultry meat processing – 31-38%, in the case of yogurt production – 2-6%, in the case of cheese production – 85-90%, in the case of wine production – 20-30%, in the case fruit and vegetable juice production – 30-50%, in the case of plant oil production – 40-70%, in the case of corn starch production – 41-43%, in the case of potato starch production – 80%, in the case of wheat starch production – 50%, and in the case of production of sugar from sugar beets – 86% (Kopik, Orlicki, 2019).

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Table 9: The volume of waste from group 02 produced in the years 2015-2018

Code of waste	2015	2016	2017	2018
	mass [ton]	mass [ton]	mass [ton]	mass [ton]
02 01 01	35,000	29,000	35,000	38,00
02 01 02	917,773	766,313	975,700	no data.
02 01 03	12 772,042	11 040,794	6 546,402	7 226,30
02 01 04	3,164	4,812	4,415	no data.
02 01 06	34 694,110	52 118,836	47 540,178	no data.
02 01 07	no data.	no data.	no data.	0,00
02 01 08*	0,455	1,137	0,905	no data.
02 01 09	0,010	0,197	0,211	no data.
02 01 10	3,420	5,770	6,505	no data.
02 01 81	70,070	73,514	73,112	no data.
02 01 82	196,818	235,689	45,567	no data.
02 01 99	260,030	2 049,029	1 539,800	no data.
02 02 01	1,550	16,940	300,420	534,22
02 02 02	26 870,841	21 236,769	25 998,595	3 980,40
02 02 03	4 807,391	2 184,172	1 710,880	3 574,83
02 02 04	9 190,399	13 421,183	11 905,808	14 172,93
02 02 81	15 388,388	640,300	616,854	no data.
02 03 01	1 882,630	2 097,690	1 335,510	1 510,37
02 03 03	8,240	6,200	6,600	11,14
02 03 04	4 684,943	3 472,668	4,996,904	2 870,12
02 03 05	9 189,260	10 477,480	18 124,870	668,05
02 03 80	10 299,894	7 447,426	7 006,697	2 726,92
02 03 81	331,854	293,704	206,409	257,96
02 03 82	27,300	42,600	101,800	111,90
02 03 99	2 618,240	379,087	546,585	0,00
02 04 01	2 043,720	2 390,550	13 743,870	no data.
02 04 02	125,460	0,000	0,000	no data.
02 04 80	0,000	0,000	1 012,880	0,00
02 05 01	156,329	150,482	107,255	40,90
02 05 02	4 442,569	6 347,934	7 123,471	12,62
02 05 80	23 496,855	13 262,250	10 066,510	837,20
02 05 99	0,000	68,550	402,750	no data.
02 06 01	1 647,534	2 884,148	7 123,250	10 659,63
02 06 03	2,820	0,000	0,000	498,38
02 06 80	11,486	48,286	16,872	176,90
02 06 99	28,486	372,193	392,392	no data.
02 07 01	559,500	586,900	388,500	35,81
02 07 04	105,734	140,650	93,692	22,83
02 07 05	466,550	162,050	33,750	1,10
02 07 80	41 945,707	46 730,870	33 787,877	7 239.54
02 07 99	55,051	26,290	100,680	no data.
Total	209 707,453	201 396,693	204 521,532	57 208,05

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Source: Regional Waste Management Plan 2021, Marshall Office Łódź, 2021.

A system of management of waste from agriculture, horticulture, hydroponics, aquaculture, forestry, hunting and fishing, and food processing is based on the responsibility of waste producers for its proper management. In case a waste producer is unable to manage the waste produced, they are obligated to hand it over to entities that are authorized to collect and process it.

In the years 2015-2018, waste from group 02 was mostly recovered. In the analysed period, the year in which the highest quantity of waste from group 02 was processed is 2017, with the volume of 450,925,976 tons. In the analysed years, a trend emerged regarding the recovery of waste from group 02. The most frequently used recovery operation was R3 – recycling/reclamation of organic substances which are not used as solvents (including composting and other biological transformation processes). The chemical composition and properties of this waste allow it to be used in nature. The dominant direction of waste recovery is production of organic fertilizers and components for the production of compost (Table 10).

Table 10: The volume of waste from group 02 recovered in the years 2015-2018

Code of waste	Process code	2015	2016	2017	2018	
		mass [ton]	mass [ton]	mass [ton]	Process code	mass [ton]
02 01 01	R5	0,000	0,000	1,900		0,00
02 01 03	R1	0,000	22,140	0,000	R1 R3 R12	88 564,77
	R3	133 103,550	140 234,400	151 023,280		
	R12	0,000	2 550,000	2 270,000		
	R13	24 880,850	27 796,160	30 077, 890		
02 01 04	R3	0,820	5,080	7,740		
	R12	0,000	0,000	0,000		
02 01 06	R3	149 869,710	180 483,090	183 544,710		
	R10	31,800	0,000	0,000		
	R13	24 305,280	26 577,210	23 490,100		
02 01 07	R12	0,000	2 200,000	0,000		150,00
02 01 82	R3	0,000	84,440	82,260		
	R12	0,000	79,800	480,000		
02 01 83	R3	no data	no data	no data	R3 R12	79,54
	, R12	no data	no data	no data		
02 01 99	R3	R3	9,000	7,000		
	R12	R12	0,100	28,740		
02 02 01	R3	317,360	420,420	837,520		534,22
	R3	12 955,630	11 092,600	13 027,340		3 980,40

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02 02 02	R11	21 920,000	0,000	0,000		
02 02 03	R3	432,050	9 710,650	6 241,045	R3	3 574,83
	R12	0,000	0,000	7,954	R12	
02 02 04	R1	1 723,800	2 413,600	2 361,020	R1	14 172,93
	R3	2 102,700	11 721,170	10 050,930	R3	
	R10	198,000	0,000	0,000	R10	
	R12	135,000	1,500	53,100	R12	
02 02 99	R3	76,540	102,070	52,000		
02 03 01	R3	3 424,100	1 698,120	462,280		
	R5	2 358,000	2 150,000	1 445,000	R3	1510,37
	R11	12 000,000	1 400,000	0,000	R5	
	R12	0,000	0,000	11,540	R12	
02 03 04	R3	894,504	1 152,170	1981,030	R3, R5	2 870,12
	R12	12,800	402,980	198,130	R12	
02 03 05	R3	6 889,680	4 057,110	3 056,790	R3	668,05
	R12	82,200	163,200	210,800	R12	
02 03 80	R3	2 307,985	183,260	1 255,690	R3 R10 R11 R12	2 726,92
	R10	273,579	248,750	0,000		
	R11	0,000	0,000	0,000		
	R12	0,000	1,800	1 375,427		
	R13	0,000	530,910	0,000		
02 03 81	R3	193,840	275,785	268,306	R3	257,96
	R5	0,000	1,720	77,260	R5	
02 03 82	R3	20,220	57,340	101,760	R3 R12	111,90
	R12	9,800	19,000	0,200		
	R13	0,000	119,837	19,567		
02 03 99	R3	0,000	639,000	498,250		
	R5	0,000	17,000	27,040		
	R11	2 229,000	0,000	0,000		
	R12	273,970	1,340	42,040		
	R13	0,000	0,000	34,440		
02 05 01	R3	176,490	160,660	40,900		261,20
02 05 02	R3	23,680	2 336,723	12,620		9,16
	R10	1 396,555	0,000	0,000		
	R12	85,000	0,000	0,000		
02 05 80	R3	4 170,740	0,000	0,000		837,20
02 05 99	R3	0,000	0,000	16,400		
02 06 01	R3	28,260	370,932	4 437,212	R3	10 659,63
	R12	99,520	530,553	21,800	R12	
	R3	0,000	179,630	461,210		498,38

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02 06 03	R12	0,000	0,000	4,700		
02 06 99	R12	904,280	3 211,912	45,800		
02 07 01	R3	407,920	738,460	388,470		388,47
02 07 04	R3	121,774	148,668	76,172	R3 R12	22,83
	R12	6,993	0,000	5,600		
	R13	0,000	0,000	5,600		
02 07 05	R3	2,960	0,000	0,000		1,10
02 07 80	R3	13 665,110	11 581,430	10 248,430	R3 R12	7 239,54
	R10	1,487	1,160	358,847		
	R11	2 656,400	0,000	0000		
	R12	25,000	1 408,320	16,060		
02 07 99	R12	0,000	46,880	78,038		
	R13	0,000	0,000	0,038		
	R14	3,421	2,910	0,000		
Total		**426 808,878**	**449 540,99**	**450 925,976**		**131 879,98**

Source: Regional Waste Management Plan 2021; Marshall Office Łódź, 2021.

A small amount of waste from group 02 was also treated. The highest amount was treated in 2017, with volume of 4,566,585 tons. In the analysed years, the amount of treated waste grew. The most frequently used operation was D8, i.e. biological treatment not specified elsewhere in Annex 2 to the Act on waste, which results in final compounds or mixtures which are discarded by means of any of the operations numbered D1 to D12 (Table 11).

In the Łódź Region, there are different facilities that processed waste from group 02 in 2015-2018, including facilities for the production of mushroom logs, a yeast slurry drying plant, facilities for the recovery of foods, facilities for the production of pellets, granulate, and briquette, facilities for the production of alternative fuels, facilities for the production of fuel, biogas plants, an agricultural distillery, composting facilities, fermenting boxes, and facilities for the firing of ceramics.

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Table 11: The volume of waste from group 02 treated in the years 2015-2018

Code of waste	Process code	2015	2016	2017	2018	
		mass [ton]	mass [ton]	mass [ton]	Process code	mass [ton]
02 01 01	D9	0,000	0,960	0,000		
02 01 04	D5	28,040	0,000	0,000		
02 01 06	D5	3,200	0,000	0,000		
	D9	5,800	0,000	0,000		
02 01 08*	D9	18,80	16,647	6,080		
	D14	0,190	0,000	0,000		
02 01 99	D9	12,116	0,532	0,005		
02 02 01	D8	6,000	15,600	0,000		
	D9	6,000	0,000	0,000		
(02 02 03	D9	0,000	0,000	0,170		
02 02 04	D5	53,360	97,400	162,300	D5	2 029,71
	D8	627,000	729,120	777,710	D8	
	D9	0,000	0,000	855,000	D9	
02 02 99	D8	54,370	87,950	250,600		
02 03 01	D8	144,330	184,500	11,000		4,00
02 03 03	D5	78,450	0,000	0,000		
02 03 04	D8	0,000	0,135	0,000	D8	92,52
	D9	0,000	0,000	10,500	D9	
02 03 05	D8	181,500	164,600	0,000	D8	2 462,30
	D9	18,000	0,000	487,720	D9	
02 05 02	D8	467,850	1 249,900	1 171,550		
	D9	853,920	286,300	90,090		
02 05 99	D8	0,000	68,550	382,100		
02 06 03	D9	412,220	457,760	265,160		
02 07 04	D8	48,470	0,000	0,000		
02 07 05	D8	290,600	124,050	33,750		
02 07 80	D8	0,000	0,000	62,850		
Total		**3 310,055**	**3 484,204**	**4 566,585**		**4 588,23**

Source: Regional Waste Management Plan 2021; Marshall Office Łódź, 2021.

Projected mass of generated non-municipal biodegradable waste in the Lodzkie Voivodship for the years 2023 - 2025 (including the perspective for 2031) shows that the mass of the waste will be decrease. It is potentially connected with lower number of inhabitants and increasing awareness of the inhabitants of the voivodeship (Table 12).

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Table 12: Table 12. Projected mass of generated non-municipal biodegradable waste in the Lodzkie Voivodship for the years 2023 - 2025 (including the perspective for 2031)

Projected mass [ton/rok]			
2023	2024	2025	2031
192 553,0	190 627,4	189 674,3	184 054,7

Source: Regional Waste Management Plan 2021.

The directions of activities undertaken in relation to the management of municipal waste, including food waste and other biodegradable waste, require a special approach. A system of bio-waste management should be mostly based on the reduction of the amount of waste produced. How can this be achieved in the case of biodegradable waste? Production of such waste can be limited by:

- Implementing clean (waste-less) technologies in the industry and production;
- Conducting activities with the aim to reduce the production of kitchen waste in households.

In the case of bio-waste, its production can be limited mostly through education raising social awareness and changing everyday food consumption habits. Other significant activities include management of green waste and other bio-waste in rural areas by the inhabitants themselves, for example, in household compost bins or agricultural biogas plants, and in household compost bins in areas of single-family dwellings.

4.1.4. Climatic and environmental conditions

The study of climatic conditions is important for identification of marginal lands and for the definition of proper crops suitable to be used for i) production of animal feed ii) biomass feedstock for free fatty acids preparation.

The area of the Łódź Voivodship in terms of climate belongs to the Central Poland region. A characteristic feature is the high variability of atmospheric pressure and the types of weather. Compared to other regions, this area is distinguished by a large number of days, an average of 38 a year, with very warm weather characterized by moderate cloudy skies and no rainfall, and quite frosty weather with heavy clouds and precipitation, 7 days a year on average. Throughout the year, there are an average of 35–40 clear days and about 140 cloudy days, and the predominant western (20 % frequency among all winds) and south-western winds (10–12 % frequency among all winds). Air flows quite often from the south-east and from the east (more than 10 % of the time), most often in spring and autumn. There are also fairly frequent winds from the northern sector in the spring months.

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Atmospheric precipitation shows a greater spatial differentiation on the scale of the voivodeship. Larger annual sums of precipitation, reaching 620 mm per year, occur in the southern and south-eastern parts of the area and decrease towards the north to 550–500 mm per year (Figure 10). The average annual air temperature values, calculated on the basis of long-term data, range from 7,6°C to 8 °C. Temperature maximums are above 36°C and minimums-30°C recorded. Hot days with a temperature above 25 °C are on average 34-37, and frosty days, when the temperature does not exceed 0 °C throughout the day, about 40. The duration of the seasons for the year is similar, except for winter, which begins faster in and eastern the ends of the voivodship and ends fastest in the west. The average length of the growing season in the Łódź Voivodship is 230 days in the south-west and changes to 225 days in its central and eastern parts (Figure 11). The earliest growing season begins in the western part of the voivodship on average March 22nd, a little later around March 25th in the central and eastern parts. There, the growing season ends earlier on average on November 5th, and in the western part, on November 7th (Woś 1996; Kłysik 2001; Podstawczyńska 2010; Wibig, Radziun 2019, Tomczyk, Szyga-Pluta 2016).

Figure 10: Spatial distribution in the Łódź Region mean yearly precipitation totals (in mm), in years 1961–2015

Source: own study based on Wibig, Radziun 2019.

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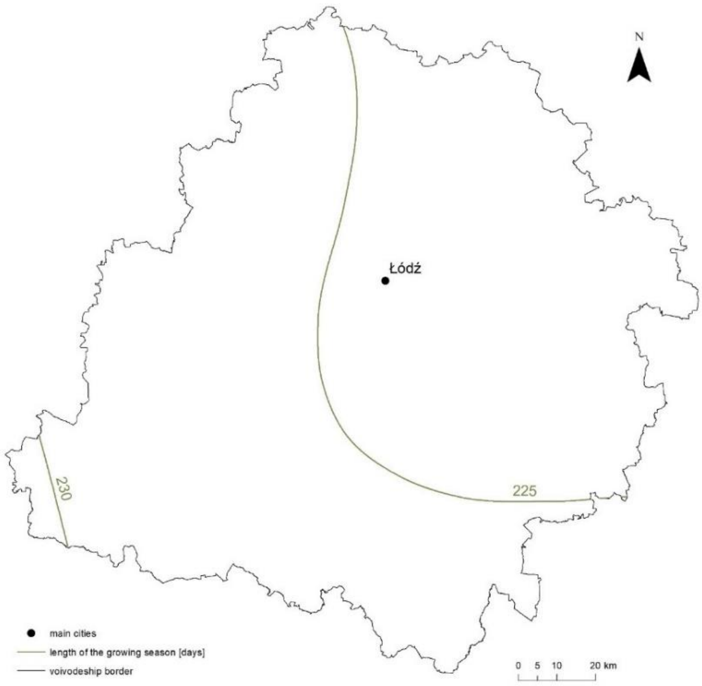

Figure 11: Mean length of the growing seasons in the Łódź Region (in days), in years 1971–2010 - Source: own study based on *Tomczyk*, Szyga-Pluta 2016.

4.1.5. Identification of marginal areas in Łódź Region

The localisation of marginal land in the Łódź Region was analysed using the soil and agricultural map. The map is a part of the Łódź Region Geoportal. On the map there is information about the land use connected with the ordinance of the Economic Development and Technology Ministry, on the register of land and buildings of 27 July 2021 with subsequent changes. The database was sourced from the Department of Geodesy, Cartography and Geology of Łódź Region. The agricultural wastelands are connected with devastated areas and marginal soils with low productivity. This land was excluded from agricultural use.

The information allows presenting land use with the wasteland area (Figure 12). The analysis was connected with filtration of this type of land use and aggregation of data about each land area inside each Łódź Region commune. Statistical analysis used in this report is the primary step to show which commune in the Łódź Region is a leader in the field of wasteland share.

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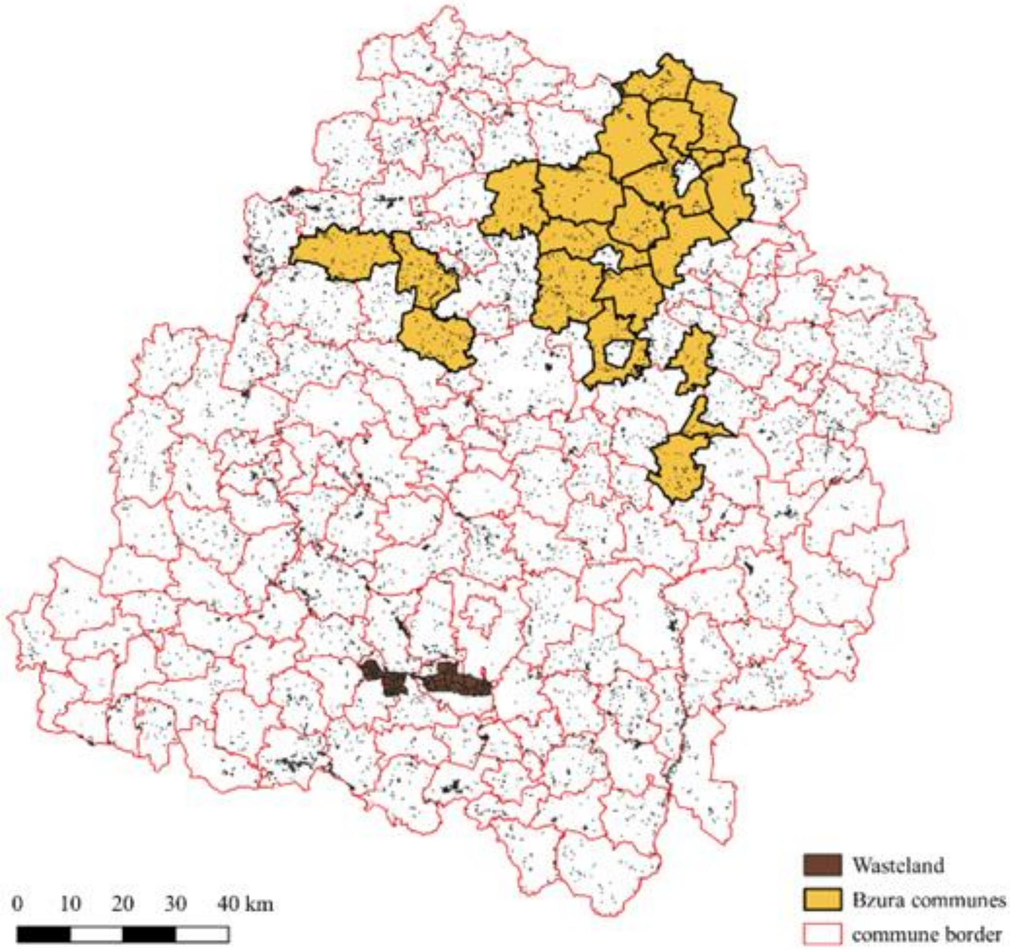

Figure 12: Localisation of wasteland in the Łódź Region - Source: Own work based on the soil and agricultural map Department of Geodesy, Cartography and Geology of Łódź Region.

The information about the wasteland shows that Łódź Region's communes are divided into two groups. The communes containing more than 5 % of wasteland are connected with the opencast mining. In the second group, there are communes with less than 5 % of wasteland area. In this group are all communes of Bzura (Figure 13).

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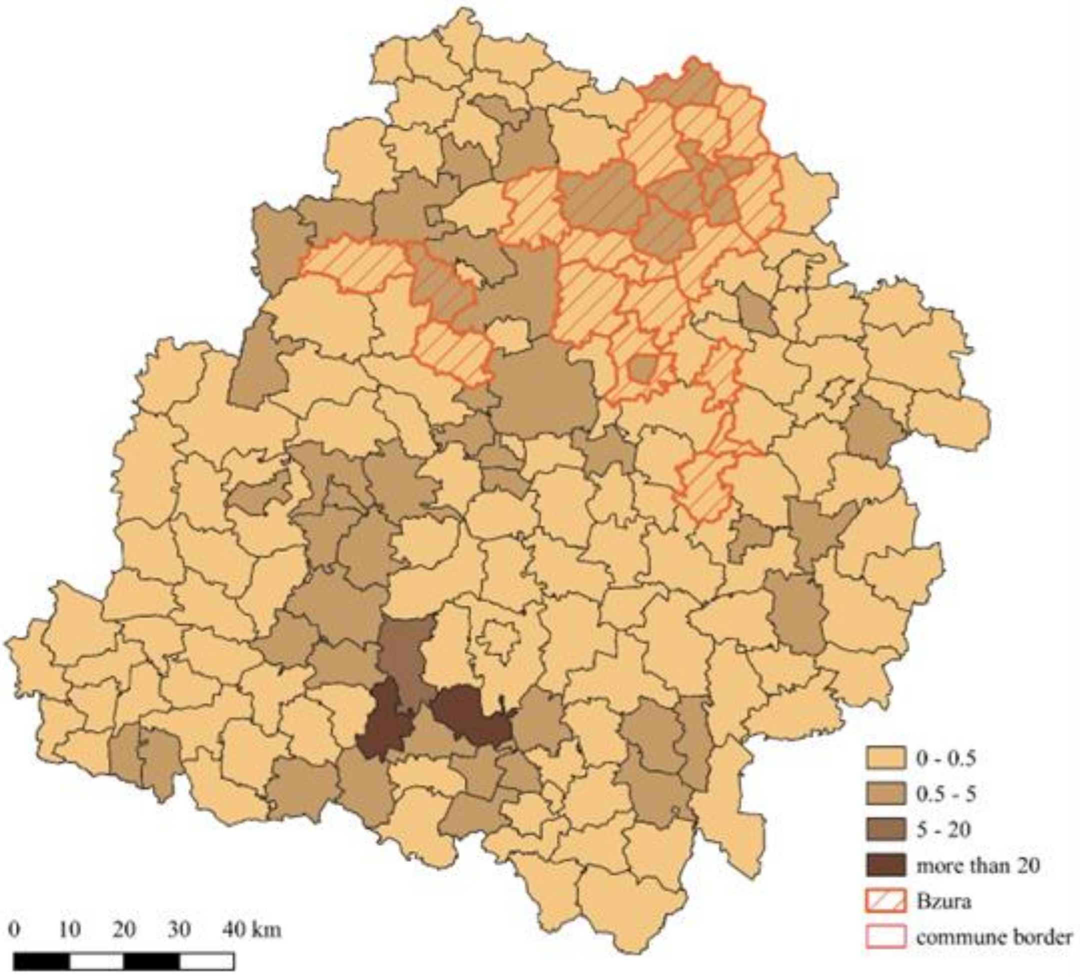

Figure 13: Share of wastelands in the commune area in [%] - Source: Own work based on the soil and agricultural map Department of Geodesy, Cartography and Geology of Lodzkie Region.

In the case of Poland, the owners of the lands may be identified if they belong to public entities. The five communes in the Bzura have got a share of the wasteland of more than 0.5%. There are Domaniewice (1.27 %), Kiernozia (1.07 %), Parzęczew (0.81 %), Bielawy (0.67 %) and Łowicz (0.65 %). The other communes in Bzura have a share of wasteland from 0.05 to 0.31 %.

The analysis contains information about the area in hectares in each commune in the Łódź Region. The median area of wasteland is 29.83 hectares. The analysis allows identifying the lowest value of this measure in the Czastary commune (1.09 ha) (Appendix 1).

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4.2. Identification, involvement, needs and expectations from regional stakeholders involved in CSS2

4.2.1. Legal framework

Taking into consideration the norms and obligations stemming from the rules of European law, matters relating to the food trade are governed by legal acts in Poland. The fundamental laws governing the food industry and food safety are as follows:

1. Act of 11 May 2001 on health conditions of food and nutrition (JL 2001 No 63 pos. 634 with subsequent changes) The Act regulates: 1) requirements for the health quality of food, permitted additives and other food ingredients and substances that assist in processing, excluding matters concerning the commercial quality of agri-food products; (2) the conditions of production and marketing and the requirements for compliance with hygiene rules in the production process and in the marketing of foodstuffs or substances referred to in point 1 and materials and articles intended to come into contact with food in order to ensure the good health quality of the food; (3) the rules for carrying out official controls on food.
2. Act of 21 December 2000 on the commercial quality of agri-food products (JL 2001 No 5 pos. 44 with subsequent changes) The Act regulates the commercial quality of agri-food products and the organization and principles of operation of the Inspection of Commercial Quality of Agricultural and Food Products.
3. Act of 25 August 2006 on Food and Nutrition Safety (JL 2006 No 171 pos. 1225 with subsequent changes). The Act defines the requirements and procedures necessary to ensure food and nutrition safety in accordance with the provisions of European law. The Act also specifies 1) health requirements for food in the scope not regulated in EU law and 2) requirements for compliance with hygiene rules in selected areas, as well as 3) the competence of authorities to carry out official food controls and 4) requirements for carrying out official food controls. The Act also regulates: 1) the rules for the sale, advertising and promotion of foodstuffs and 2) the requirements for child and adolescent nutrition as part of the company's nutrition.
4. Act of 16 December 2005 on products of animal origin (JL 2006 No17 pos. 127 with subsequent changes). The Act defines: 1) the competence of the authorities in the field of hygiene of products of animal origin, as well as food containing both foodstuffs of non-animal origin and products of animal origin, in the agricultural retail trade, specified in the provisions of European law, 2) the

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requirements to be met by products of animal origin placed on the market, 3) the requirements to be met in the production of products of animal origin and by those products to the extent not regulated by Union legislation, including the requirements to be met for the production of meat for personal use. The Act also defines the competence of the authorities of the Veterinary Inspection.

5. Act of 14 December 2012 on waste (JL 2013 pos. 21 with subsequent changes) regulating the obligations of municipal waste producers to separately collect this waste the impact of waste generation and management, and by reducing the overall impact of resource use and improving the efficiency of such use, with a view to moving towards a circular economy.
6. Act of 19 July 2019 on Counteracting Food Waste (JL 2019 poz. 1680 with subsequent changes), which defines the rules for dealing with food and the obligations of food sellers to prevent food waste through a free donations to non-governmental organizations. The Act also obliges food sellers to conduct educational and information campaigns on rational food management and counteracting food waste in the trade unit.

Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on waste of 19 November 2008. The main aim of the change was to create a truly circular economy. The Directive also includes provisions concerning bio-waste.

The definition of bio-waste was changed, and now bio-waste refers to: biodegradable garden and park waste, food and kitchen waste from households, offices, restaurants, wholesale, canteens, caterers and retail premises, and comparable waste from food processing plants. Also a new definition of food waste was provided to include all food as defined in Article 2 of Regulation (EC) No 178/2002 of the European Parliament and of the Council that has become waste. Article 22 of the Directive (also amended) states that Member States shall ensure that, by 31 December 2023 (…) bio-waste is either separated and recycled at source, or is collected separately and is not mixed with other types of waste. Member States may allow waste with similar biodegradability and compostability properties which complies with relevant European standards or any equivalent national standards for packaging recoverable through composting and biodegradation to be collected together with bio-waste. Member States shall take measures (…) to: encourage the recycling, including composting and digestion, of bio-waste in a way that fulfills a high level of environment protection and results in output which meets relevant high-quality standards; encourage home composting; and promote the use of materials produced from bio-waste.

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Pursuant to the Act of 14 December 2012 on waste (uniform text in Journal of Laws of 2022, item 699, as amended), whenever the Act mentions (Art. 3.1) biodegradable waste, it shall be construed as waste that undergoes aerobic or anaerobic decomposition using microorganisms (item 10), and whenever the Act mentions bio-waste, it shall be construed as biodegradable gardens and parks waste, food and kitchen waste from households, restaurants, canteens, caterers, offices, wholesale and retail premises, and comparable waste from food manufacturing or marketing plants. An example of waste classified as biodegradable waste, which is not bio-waste or green waste, is biodegradable packaging waste.

It has to be emphasized that the legal definition of green waste was in force until 30 June 2021. At the moment, the definition in question cannot be found in the legislation, which naturally does not mean that green waste is no longer produced. Pursuant to the Act of 13 September 1996 on maintaining cleanliness and order in communes (Journal of Laws of 2022, item 1297, as amended), communes ensure selective municipal waste collection, including at least paper, metals, plastic, glass, multi-material waste, and bio-waste (Art. 3.2.5), while to municipal waste in the form of parts of plants from green area or cemetery maintenance or marketplaces provisions concerning the treatment of bio-waste constituting municipal waste apply (Art. 1b).

The first Ordinance of the Minister of the Environment on the detailed method for the separate collection of selected waste fractions was published on 29 December 2016 (Journal of Laws of 2017, item 19). The Ordinance determined the detailed method for the separate collection of selected waste fractions, such as paper, glass, metals, plastic, and biodegradable waste, including in particular bio-waste, and when the requirement on separate collection is deemed met. It also stated that the fraction of biodegradable waste, including in particular bio-waste, is collected in brown waste bins labeled “Bio”. After the Ordinance had been published, biodegradable waste, including in particular bio-waste, was mostly identified with green waste. The original text of the Act of 14 December 2012 on waste (Journal of Laws of 2013, item 21) included a definition of green waste (Art. 3.1, item 12), according to which green waste was municipal waste in the form of parts of plants from the maintenance of green areas, gardens, parks, cemeteries, and from marketplaces, excluding street and square cleaning waste. Then, on 28 December 2018 and 7 October 2019, two amendments were introduced to the Ordinance, but none of them concerned bio-waste. On account of the introduction of an amendment to the Waste Directive in 2018, Ordinance of the Minister of Climate and Environment of 10 May 2021 on the method for separate collection of selected waste fractions was published (Journal of Laws of 2021, item 906, issued pursuant to Art. 4a sec. 1 of the Act of 13 September 1996 on maintaining cleanliness and order in communes (Journal of Laws of 2022, item 1297, as amended)). The Ordinance stated

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that paper, glass, metals, plastic, multi-material packaging material, and bio-waste would be collected separately. The bio-waste fraction was to be collected in brown bins or bags labeled “Bio”.

Growing concerns about global warming, the phase-out of gasoline and diesel vehicles and transportation, and the scarcity of resources at landfills may prompt changes in many sector laws that might catalyse the transition to a circular economy (Upadhyay et al., 2021). The sectors like packaging, plastics, wastewater, agriculture, energy are covered by plenty of laws, ordinances, restrictions, and uncertainties. This leads to a disjointed and complicated legal system at the European, national, and municipal levels (Hina et al., 2022; Khajuria et al., 2022). It is worth mentioning the legal guidelines which aim for a model, where a product is treated as waste in its ultimate stages, most often after being recycled or "down-cycled" into goods have less of an impact on the environment (Jaeger and Upadhyay, 2020). In this regard the company has not yet achieved all it can with implementing circular economy. The subject of people's involvement in the CE approach is also raised and should be imposed by law (Charef, Ganjian, and Emmitt, 2021). Governmental policies, laws, and regulations have a significant impact as it transitions from linear to CE as corporate environmental management, the participation of the government is crucial to advance CE procedures, (Kazancoglu et al., 2021). However, limitations that have been identified, such as a lack or ineffectively implemented of environmental rules and regulations, a lack of environmental management certifications and systems, and a lack of favourable tax policies to support circular models are at least influencing the transformation (Mangla et al., 2018; Ranta et al., 2018).

The confrontation of the role of local government units among individual project partners is especially important due to the importance that the European Commission attaches to eco-design. It seems that the development of eco-design, supported by the initiative of the Commission in the scope of relevant directives, may lead to the formation of many simple relations in the future between the owner of the waste (raw material), i.e. a citizen or entrepreneur, and another entrepreneur interested in its purchase.

The first important element of identifying the involvement, needs and expectations of regional CRC stakeholders was the verification of the perception of legal institutions in the CSS2 area. The diagnosis of formal errors and legal barriers is also information about the reasons for a specific state of involvement. It is also indirectly identifying the expectations of stakeholders towards the legal framework for the functioning of the CSS2 market. Two research methods were used to identify legal and formal barriers: online survey and participant observation.

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The survey addressed to selected local government units. The questionnaire was addressed to the municipalities that are part of the Inter-Communal Association of Bzura and neighbors in close proximity - potential members of the developing CRC. A total of 15 responses were obtained. The study was conducted in the period from 01/03/2022 to 03/03/2022. The questionnaire was carried out online. The results show that among the main difficulties of effective involvement of the municipality in selective collected waste are:

- Low level of circular market development and sector diversification,
- The lack of appropriate skills among officers, citizens, scientist and entrepreneurs in building circular market,
- Lack of cooperation between local government units in area of waste management - lack of gaining scale effect,
- Limited access to databases with information about waste and raw materials collected on regional level,
- Lack of databases with market information addressed to companies and society,
- The unserviceable waste management databases,
- Lack of cooperation and integrated activities between companies, society, local non-government organisations and academy,
- Lack of regional networks exchange of good practice in scope of waste management,
- Limited access to sources financing CE for local government,
- Limited knowledge of innovative technologies in field of implementing CE,
- Few companies on regional market of waste management (oligopoly market).

To sum up, important issue is local law (i.e. act on order and cleanliness in the municipality) regulating waste management. Those acts are created separately in every municipality. The better solution will be preparing one act for many municipalities. It lets to build the legal framework for Circular Regional Cluster. Creating one act for group of municipalities is allowed by Polish law. In practise the interpretation of this law is different. National entities that control the activities of municipalities (provincial office) impose nationwide, standard, simplified solutions in this regard (separated local acts and limited flexibility of local governments).

The following detailed conclusions regarding the research carried out have been formulated:

- **Vaguely defined municipalities' responsibilities** for waste management and the organization responsible for waste management;
- Low diversification of the municipality revenue sources in the municipal and industrial waste management system;

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- **Circular economy regulations are scattered in many legal acts**;
- No consequences of the legal regulations of the central level: for example, there is a legal obligation to segregate green waste, but there is no obligation to sort it by residents using biodegradable bags or directly in containers without plastic bags;
- The environmental impact of products and services is not included in the sales price;
- The problem with the enforcement of penalties.

These conclusions are strongly connected with circular economy elements based on all materials: packaging, plastics, food, water and nutrients analysed in FRONTSH1P project.

4.2.2. Awareness of the needs of stakeholders in the field of building CEE

The Łódź Region has 2,426,806 inhabitants, of which 52.4 % are women, and 47.6 % are men. From 2002-2021, the number of inhabitants decreased by 6.9 %. The average age of the inhabitants is 43.3 years, slightly higher than the average age of the entire Polish population. The projected number of inhabitants of Łódź in 2050 is 1,999,131, of which 1,031,519 are women, and 967,612 are men (GUS – Local Data Bank, 2022).

In the Łódź Region, a negative natural increase of population is recorded, amounting to -14 916. This situation corresponds to the natural decrease of -6.09 per 1000 inhabitants of Łódź. In 2020, 20,891 children were born, including 48.9 % girls and 51.1 % boys. The demographic dynamics index, i.e. the ratio of the number of live births to the number of deaths, is 0.58 and is much lower than the average for the entire country. In 2019, 36.3 % of deaths in Łódź were caused by cardiovascular diseases, 25.1 % of deaths were caused by cancers, and respiratory diseases caused 7.9 % of deaths. There are 14.62 deaths per 1000 inhabitants of Łódź. (GUS – Local Data Bank, 2022) It is much more than the average for Poland.

In 2020, were registered 19,670 new citizen and 21,482 deregistration; as a result, the balance of internal migrations for the Łódź Region was -1,812. In the same year, 445 people checked in from abroad, and 305 deregistration abroad were registered – this gives the balance of foreign migrations amounting to 140. The structure of people in Łódź Region is: 58.3 % of the inhabitants of Łódź have a working age, 17.1 % have pre-working age, and 24.7 % of the inhabitants have post-working age (however, it is necessary to take into account the current changes caused by the war in Ukraine and

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the significant number of refugees who they also settle in the Łódź Region (GUS – Local Data Bank, 2022).

Analyses show that the search for potential in the production of waste related to the food and feed sector may be associated with the density of buildings and, thus, the density of address points. Readers should note that the density of address points and the density of the population depend on the administrative and legal status of the commune. This situation is connected with the clustering of people, regardless of the size of the city. Nevertheless, one should note that activities related to the food and feed sector are focused primarily on rural areas (Figure 14).

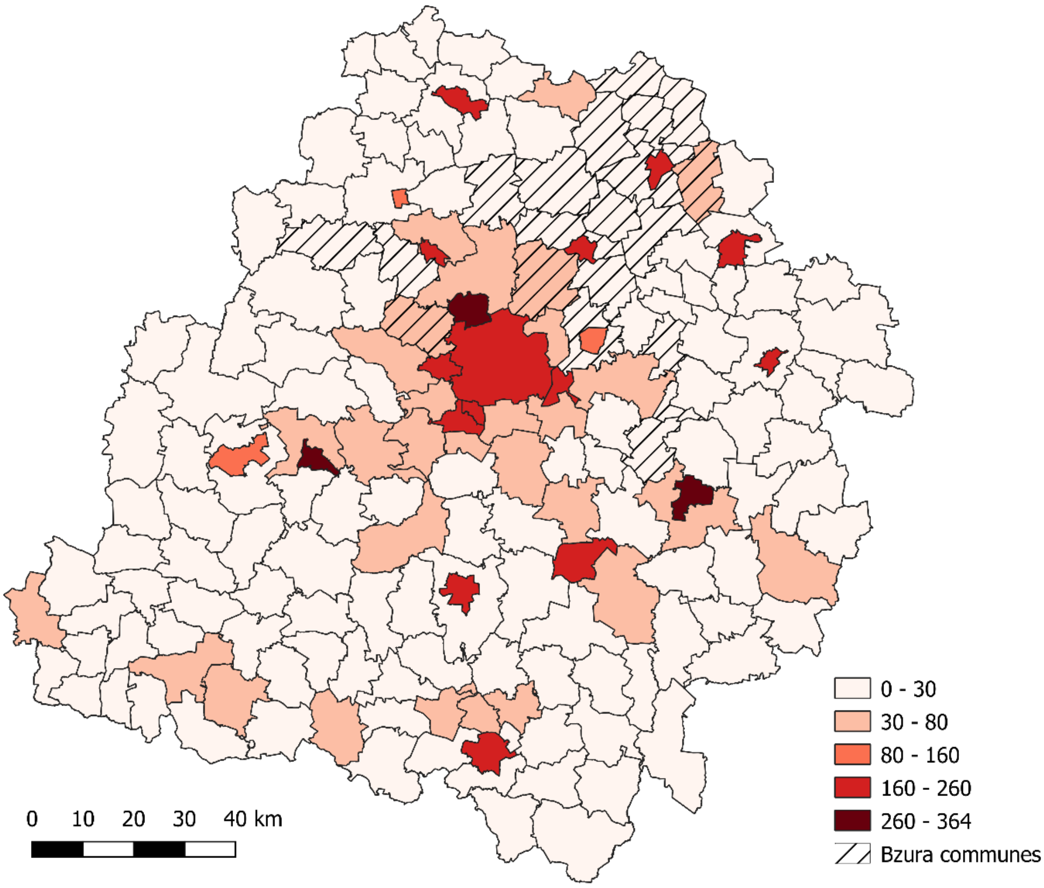

Figure 14: The density of address points on each square kilometre – Source: own work based on data from Head Office of Geodesy and Cartography (GUGiK).

The same situation is also observed analysing the density index of the number of address points in geodetic areas. In the case of areas outside cities, the higher density of address points per square kilometre is characterized by the precincts associated with the seats of municipalities and units that constitute suburbs. These units have increased potential for providing recyclable materials linked to priority areas of circular economy based on packaging, plastics, food, water and nutrients, both in the case of entrepreneurs and residents.

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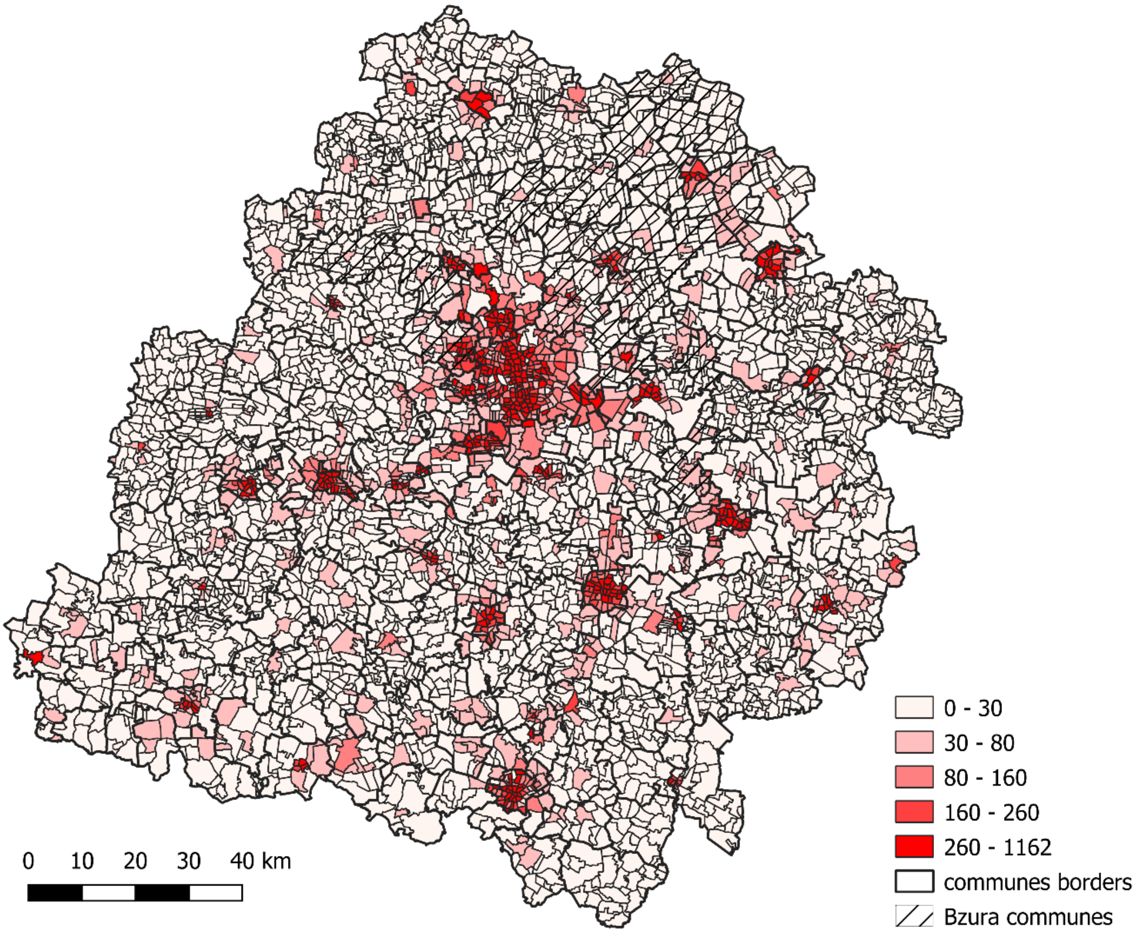

Figure 15: The density of address points on each square kilometre Source: own work based on data from Head Office of Geodesy and Cartography (GUGiK).

There are approximately 5,800 different NGOs in the Łódź Region. Most of them are registered as associations (4,100), followed by foundations (0,8). Among the NGOs, the dominant ones focus their main activities on supporting and promoting the sport, recreation, tourism and hobbies. There is also a large group of NGOs whose activities focus on culture and the arts. Compared to the whole of Poland, in the Łódź Region, a relatively large proportion of NGOs operate in the area of supporting local and socio-economic development.

In the rural areas works the Local Action Groups (LAGs). They are responsible for allocating funds from the LEADER program to the area of operation of individual action groups (Figure 16). Each municipality can only belong to one LAGs. In the case of communes from the Bzura association, they belong to the following LAGs called: Mroga, Ziemia łowicka, Polcentrum, Prym and Gniazdo.

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Figure 16: Local Action Groups in Łódź Region – Source: KSOW of Łódź Region, http://lodzkie.archiwum.ksow.pl/fileadmin/user_upload/lodzkie/grafika/aktualnosci/LGD/MAPA_LEADER_LODZKIE_2018.JPG, (accessed 9.27.22).

The most popular categories of market failure are public goods, externalities, imperfect competition, market incompleteness, and asymmetric information (Randall, 1983, Stiglitz, 2004, Moreau, 2004, Jackson, Jabbie, 2019). Others add incomplete proprietary rights to this list (including Perman et al., 2003, Acheson, 2006). Redmond (2018) presented market failure from a different point of view. A different approach has been presented in evolutionary economics, where the market is perceived as dynamic, chaotic, and constantly changing rather than heading towards equilibrium (Nelson & Winter, 2002, Nelson, 2008, Schmidt, 2018). From this point of view, the market failures typical of the neoclassical economy are not failures.

In this report, we look at market failures from the perspective of a circular economy. In the circular economy, barriers derailing or slowing the transition to CE are often identified (Kirchherr, 2017). The most common categories of barriers are: technological, economic, institutional and social. De Jesus and Mendonça (2018) introduced an

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additional classification for the above barriers. They divided them into hard and soft. Challenging barriers are related to the techno-economy, and soft ones are related to regulatory and social issues.

The economy of the Łódź Region is still in the process of transformation to CE – Circular Economy. Therefore, we decided to identify "*classic*" market failures that are universal for all areas and entities operating within the circular economy. In the case of CSS 2 Food and feed, we can identify five major market failure categories: public goods, externalities, imperfect competition, market incompleteness, and asymmetric information. Our research aimed to identify market failure in the circular economy and to assess the level of their occurrence in Łódź Region. The research was conducted among four groups: business, government, academia and society, who we consider as main actors in the market. To achieve the aim, we conducted two-stage research:

1. Quantitative stage: Survey – online survey conducted among representatives of four mentioned groups. A separate survey sheet was prepared for each group.
2. Qualitative stage: Focus Group Interview (FGI), conducted among representatives of mentioned groups, with the same respondents. FGI research allowed verification of survey results and their interpretation.

For the development of a circular economy and a circular cluster based on industrial symbiosis, using, among other things, food and feed as secondary raw materials in the Łódź Region, there are unclear legal regulations supporting this type of solution. It concerns both regulations created at the national and local level (market failures - public goods). These laws should be thoughtful, relatively unchanging, and adequate to enforce. Currently, there is also a lack of a developed comprehensive system for collecting this type of secondary raw materials on the market (incompleteness of the market) and market trends for products using secondary raw materials being a side effect of the food processing process (externalities).

Among the main market failures relating to individual groups of participants in the circular economy, the following can be indicated:

– For entrepreneurs, the problem is primarily the high level of food processing, limiting the possibility of their re-use even for energy production (incompleteness of the market). **Also, there is a lack of a dedicated waste collection system that would enable obtaining raw material from the producer of 42% of all food waste**, such as households (incompleteness of the market, possibly public goods) (EEA, 2014). Furthermore, very difficult in terms of the availability and functionality of database information on the types and sizes of components that make up the food and feed fraction (information asymmetry). For entrepreneurs who want to use agricultural waste, the problem is primarily

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the low availability of this raw material on the market. It happens because farms (especially small, non-specialized, and dominant in Poland) try to use it on their own and for their own needs (externalities and imperfect competition). It must be emphasized, however, that this is not a bad thing in itself, as it is an example of a circular economy on a microscale;

- Also, in the case of the community, a significant barrier is the lack of food and feed (incompleteness of the market) segregation system adapted to the needs of the prosumer and a producer using recycled material. In the case of multi-family housing, there is not even a separate bio-waste fraction. Due to the lack of awareness of the benefits of using food and feed waste (externalities and information asymmetry), the level of community involvement in segregation processes (incompleteness of the market) should also be neglected;
- In the context of power, one can speak of a market failure consisting of a limited area of land that could become a source of raw materials for entrepreneurs (incompleteness of the market). Another failure is the incomplete and functionally limited databases on secondary raw materials from food and feed, whose administrators are public institutions (information asymmetry). An extremely significant mistake is also insufficient promotion of attitudes and externalities;
- From the point of view of the academic community and other R&D institutions, there are two fundamental market failures related to an insufficient adjustment of the offer to market needs and the consequent low absorption of solutions developed under the projects implemented (incompleteness of the market). The result of this state of affairs should be seen, among others, in limited activities related to the monitoring by research and scientific units of current market needs and forecasting future (information asymmetry).

4.3. Requirements and success criteria to satisfy the implementation of non-technological solutions required in CSS2

The requirements and success criteria to satisfy the implementation of the required non-technological solutions relate to various areas, including in particular:

- the scope and appropriateness of applying incentives,
- identification of areas requiring intensification of the integration processes of regional stakeholders' activities,
- the availability and interoperability of databases related to CSS2 activities.

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The research aimed to identify the operating **incentives** in the area of the circular economy. It was based on the use of the qualitative method. The advantages of which are widely emphasized in the literature on the subject: a more in-depth understanding of social phenomena, through active participation in the studied processes, the researcher has a chance to get to know the context and the process of development of phenomena (happening over time). The next ones are a holistic perspective, recognizing many nuances in attitudes, behaviours and conversations with the respondents; Most of the fieldwork, therefore, yields data that cannot be easily reduced to numbers and would be invisible, unforeseen, and immeasurable in those numbers. Qualitative research, thus, provides a new quality of knowledge and information. (Babbie, 2004). There is a hidden belief in this approach that the function of research is not only to generate knowledge but also "a tool for education and awareness development and mobilization to act" (Gaventa, 1991).

It was also decided to use a triangulation approach, which consists in collecting data using various techniques and research tools. Then comparing and combining the results, it is possible to test the same hypothesis and reduce the error burden resulting from the limitations and disadvantages of individual research techniques (Denzin, 2006). The triangulation approach gives research a new dimension by introducing interpretative research attitudes based on social views and experience, which provides greater flexibility in research techniques and tools used.

As part of the qualitative method, it was decided to use three different research techniques:

1. Open participant observation[1].
2. Individual (free) interviews with a standardized list of information sought (IDI - Individual In-Depth Interview), where scientific and research instructions were the research tool, i.e. the list of information sought by the researcher[2].

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[1] The first observation was carried out on April 6, 2022, at Municipal Waste Disposal Plant (Zakład Unieszkodliwiania Odpadów Komunalnych) "Orli Staw" premises in Prażuchy Nowe, visiting all facilities related to the site and getting acquainted with the technologies and the overall idea of the plant's operation. The authors collected photographic material, documents, and auxiliary materials during this time. Interviews were conducted with key and, at the moment - potential respondents, who were then invited to in-depth interviews. Ultimately, it is planned to have at least three such visits combined with participant observation.

[2] As part of the research, four interviews were conducted with key people in the field of the circular economy. The responders were officials representing: the Director Department of Environmental Protection at the Marshal's Office, the Head of the Provincial Inspection for Environmental Protection, the director of the "Orli Staw" Municipal Waste Disposal Plant

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3. Analysis of qualitative data consists of the value of observations made thanks to the use of participant observation. Analysis of the content of the collected materials and conducted qualitative interviews, as well as the analysis of the literature on the subject (scientific articles, reports, EU studies), made it possible to reveal the functioning system of incentives within the implementation of circular economy in the Łódź Region and beyond.

This study aimed to discover the regularity of the phenomenon through the following characteristics, typical for the analysis of qualitative data: frequency, intensity, structure, processes, causes, and consequences of the process (Lofland and Lofland, 1995).

The incentive system to support the implementation of CE can be considered for specific groups of waste:

a) Plastics and Rubber,

b) Water and Nutrients,

c) Food and Feed,

d) Wood Packaging.

Support instruments can be dedicated and used directly by entrepreneurs (and other entities) operating in industries specific to a given waste group and be universal, independent of the type of waste. The surveyed respondents diagnosed two kinds of incentives, claiming that a tiny part is dedicated, and most are universal incentives for waste (raw materials) in general. An example of such a universal incentive is, for example, the NFOSiGW and WFOSiGW subsidy and loan system for the implementation of tasks in the field of environmental protection, including those aimed at implementing CE, provided that a specific task is included in the priorities set for a given year in the resolution of the Fund's management board. These funds may be applied for by natural persons, entrepreneurs, social organizations, local government units and state budget units.

(ZUOK) and entrepreneur - founder of the Ekotechnologie company, which develops and implements new generation technologies. We are talking about an innovative and environmentally friendly method of producing the Biorol natural fertilizer, which was developed for implementation as part of the project: Support for innovation favouring resource-efficient and low-emission economy "SOKÓŁ Interdisciplinary - Implementation of innovative environmental technologies. The respondents played the role of experts in the topic under study and were selected on purpose.

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However, considering the division into the four waste groups and specificity, recommendations for each during the conducted procedures are recommended. The Waste Act allows animals to be fed some municipal waste in terms of organic waste. In terms of food, an important regulatory role is played by the Act on Counteracting Food Waste (19 July 2019), which defines the rules for dealing with food and the obligations of food sellers to prevent food waste through a free donations to non-governmental organizations. The Act also obliges food sellers to conduct educational and information campaigns on rational food management and counteracting food waste in the trade unit.

When it comes to not wasting food, all kinds of social activities work well: Eateries, community refrigerators, and food banks run by various institutions. The management of agricultural waste is the responsibility of the farmer. They are not municipal waste. Therefore PSZOK does not accept them. With the large production of farm waste and the high cost of its collection, this waste is a big problem for farms. The biggest problem is agricultural foils, strings and agro textile. One of the incentives that facilitate the costly collection of waste by farmers is the four-year project of the National Fund for Environmental Protection and Water Management (2019-2023) entitled "Removal of agricultural films and other waste from agricultural activities", which allows for obtaining subsidies for this purpose. The program's beneficiaries are local government units and their unions, and the final recipients are owners of agricultural film waste, nets and twine, and fertilizer packaging.

The process of encouraging (to implement the assumptions of circular economy), i.e. giving and receiving incentives, can be presented using and analogically to the communication model functioning in the literature (Griffin, 2000; Dobek, 2002; Drzazga, 2004). Sender (Source) and recipient (auditorium), and the message will be synonymous with a specific incentive. The conducted research reveals six types of models of encouraging (communication) processes:

1. one-way and two-way communication model: one sender - one incentive - one recipient;
2. mass communication model: one sender - one incentive - several recipients;
3. sectoral communication model: one sender - one incentive - sectoral recipients;
4. communication model of a multitude of senders: many senders - one incentive - one recipient;
5. model of communication of a multitude of senders and incentives: many senders – many incentive - one recipient;
6. communication model – multiple incentives: one senders – many incentive - one recipient.

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The sender of the incentives will be mainly the Government, but also, in a few cases, other actors of the cluster: Society, Company and Academy. On the other hand, the incentive recipients are mainly the Company (understood as an entrepreneur), Society, and marginally Government and Academy. It should be noted that each incentive indicated in the table creates a single encouraging process, conforming to a specific model with individual conditions (context, understanding, channel, noise, feedback).

Referring to the identification of areas requiring the intensification of the **integration processes of regional stakeholders' activities**, attention should be paid to the specific type of network organization to be created. The implementation of the circular economy requires the involvement of all four groups of partners responsible for creating CRC: company, academy, society and government. This involvement requires monitoring and coordination. Such coordination should be the domain of public authorities at both the local and regional levels. Integration of activities induces synergy processes and is therefore a function of the speed of change and the dynamics of regional development processes. This element is particularly important when talking about systemic changes - the evolution of a free market economy operating under a linear production model into a circular economy. However, it should be highlighted that integration of activities on a regional scale (CRC) does not necessarily mean direct cooperation between partners. It is most important that the activities of individual partners affect the resolution of the challenges of the other partners to the greatest extent possible. In other words, partners do not have to be directly bound to each other by formal agreements - it is important that "the sailors in the boat row in the same direction and with solidarity commitment". Hence the importance of the study, which aims to identify the scope of impact of the projects implemented by individual CRC stakeholders on the realization of the challenges and objectives of the projects of the other regional partners.

The Leopold Matrix method was used to achieve this goal. The method makes possible to assess the level of relations between regional partners as measured by the degree of the synergy of their projects. In Frontsh1p, this method was modified to identify the levels of integration between 4 sets of partners: company, academy, society and government. The study analyzed: 187 projects.

The research allowed to identify four types of impacts: intra-sectoral interaction (specific impact), cross-sectoral interaction (between two sets of partners), cross-sectoral interaction (between three sets of partners) Integration (simultaneous integration between all collections of partners) (Figure 17).

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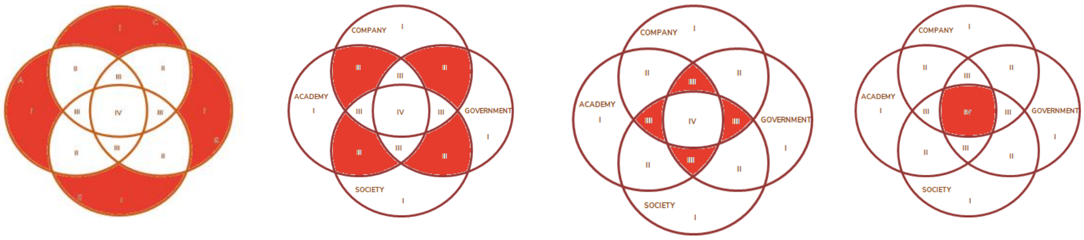

[I] intra-sectoral interaction (specific impact)	**[II] cross-sectoral interaction (2.level)**	**[III] cross-sectoral interaction (3.level)**	**[IV] Integration**

Figure 17: Types of interactions between projects and indicators - Source: own compilation.

Analysis of the synergy of aims and results of CRC stakeholder activities in the Lodzkie Region at the beginning allows concluding that projects have been identified in each group that strengthens CE building. However, the sum of such projects is small: 187 projects, implemented in the period 2014-2021 (Company and Academy) and 2019-2021 (Society, Governance). Thus, one can speak of a low level of project involvement of CRC stakeholders in Lodzkie Region in strengthening CE.

The number of projects that strengthen CE building varies due to the availability of information in the databases and the size of the projects. Nevertheless, it can be noted that in the Company (28) and Academy (28) groups, the selected projects directly relate to activities involving green technologies and are related to environmental protection in various aspects. On the other hand, in the Society (99) and Governance (32) groups, the majority of projects involve activities indirectly related to strengthening CE. Most often, these are projects that strengthen the sense of responsibility, level of participation and social activation, sharing of things, services or reduction of consumption. Less often, these projects involve processes related to recycling and reusing things. The three times higher number of projects in the Society group is due to their fragmentation and small scale of activities. Nevertheless, projects of this type are characteristic of activities undertaken by residents and local community groups. To sum up, projects undertaken directly by local authorities (Governance) and the local community (Society) are rarely about empowerment or inclusion in the Circular Value Chain.

Analysing the findings on the interactions between the regional partners' project activities, it is important to note the relatively large variation in the average ratings for each impact category (Figure 18).

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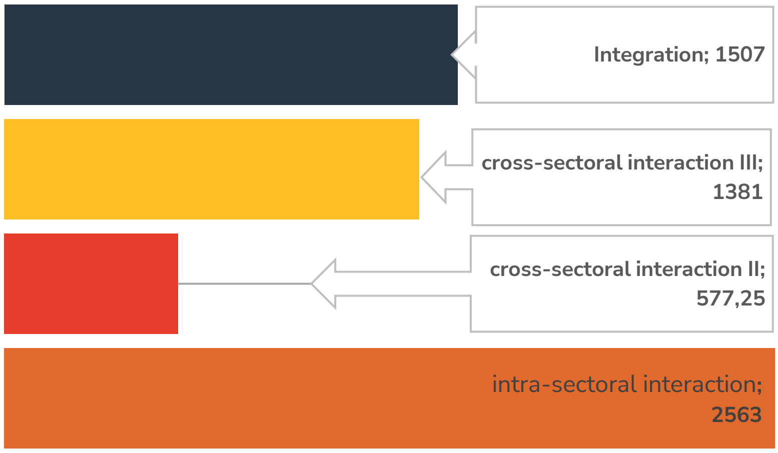

Figure 18: Average ratings of synergistic interactions between stakeholder groups - Source: own compilation.

The vast majority of implemented projects by CRT stakeholders are sectoral (2563). These projects do not affect the achievement of results by other partners. They are important from the point of view of strengthening the sector's internal competitiveness, but their synergistic effects on the local and regional environment are marginal. Optimally, the quantities identifying the different levels of impact should be high and balanced. The lack of this level of sustainability is especially underscored by the fact that the assessment of interaction impacts is five times lower (577.25), concerning partnership relations between two groups of stakeholders.

It is difficult to speak of a sustainable level, nevertheless, it is worth noting that there were cross-sectoral projects in the region that effectively achieved their goals and contributed to the achievement of results in three groups (1,381) or all stakeholder groups (1,507).

The most important image illustrating the scope and needs for coordination of integration activities is given by the analysis at the detailed level (Figure 19). This diagnosis indicates the weaknesses and strengths of particular partnerships between regional stakeholders. It is also important to remember that it is not the existence of formal partnerships. Often, in this case, the strength of synergistic effects depends on the level of awareness and tacit knowledge in the CRC.

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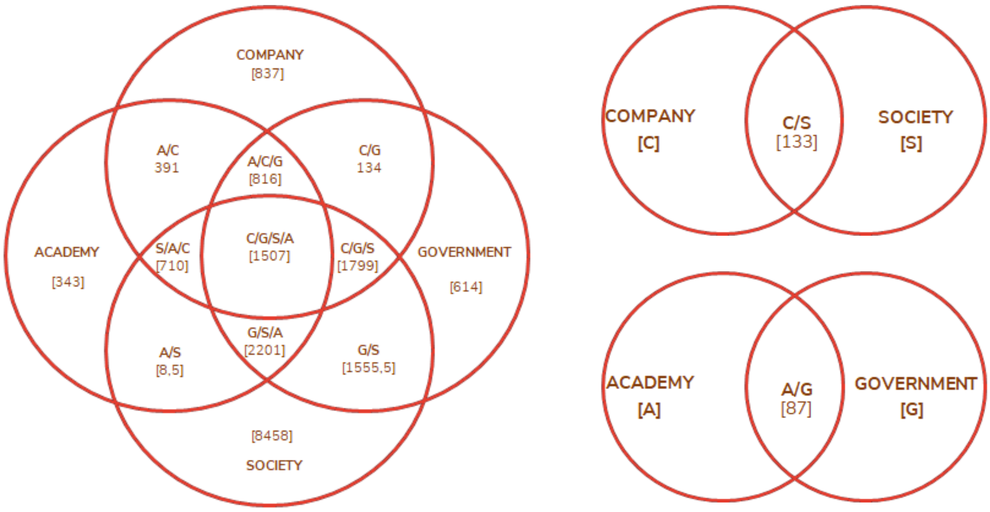

Figure 19: Scope and levels of synergistic effects among CRC stakeholders in Lodzkie Region - Source: own compilation.

In intra-sectoral interaction, the highest level of self-management of development processes within the sector is observed in the Society group (8458). On the one hand, this is good information. On the other hand, the height of this indicator can be interpreted as a closure of the sector to interactions with other sectors. This conclusion is supported, in particular, by the values of second-level interactions between Society and Company (133) and Society and Academy (8.5), which are practically non-existent. The convergence of the Society sector's internal goals is mainly due to the effect of copying the ideas of neighbours and the specificity and monoculture of non-governmental institutions at the local level. In the Government and Company sectors, the ratios are significantly lower, respectively: 614, 837. Nevertheless, it can be considered that these values are at the average level. In this case, the interaction between the objectives of the projects was determined primarily by the availability of project funding sources. It is about the orientation of the subject matter of the projects by the terms of the grants. The lowest value of the intra-sectoral interaction index is identified in the Academy sector (343). This is related, on the one hand, to the low budget 0for R&D in Poland, sectoral closure and individualism determined by the low degree of territorialisation of academic sector entities in the Lodzkie Region. Sectoral closure usually means the implementation of partnership projects but based on industry similarity of partners, rarely spatial proximity.

The situation at the second level interaction is also a challenge. There is a lack of cross-sectoral sustainability. On the one hand, four areas of neglect can be identified: Academy/Society (8.5), Academy/Government (87), Company/Society (133) and Company/Government (134). The processes of synergistic effects between these areas hardly occur. On the other hand, one can see a positive picture of project relations

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between the Academy/Company sectors (391). This is not an indicator of a particularly high value, but nevertheless, this scope of cooperation is particularly desirable and difficult in Polish conditions, so it is worth highlighting. On the other hand, the value of the indicator of relations between sectors is high: Government/Society (1555.5). This means that local authorities influence the behaviour of residents to a large extent and can carry out coordination activities with great effectiveness.

Particular attention should be paid to the Third level of interaction and integrated impacts. It can be seen that in projects implemented in the group of Government or realizing its goals, the interaction has a balanced and relatively high level (from 1507 to 2201). In another case, for example, in the sets: Society/Academy/Company (710) the value is less than half. We can conclude that the goals of projects that coincide with local or regional development policies have a significantly higher potential for synergistic effects. This also means that an extremely important role has to be played by local and regional Government in the transformation of the traditional economy to a circular economy in the Lodzkie Region.

In Lodzkie Region in particular in the CRC, care should be taken to strengthen the synergies obtained through public, private and social investments. Projects undertaken by all regional partners, above all, should be implemented far more often in scopes related to the formation of CE. This effect can be achieved not only by increasing investment budgets but, above all, by targeting resources more precisely to the goals of CE implementation. In this regard, it is also worth emphasizing the importance of Green Public Procurement, which is used to a minimal extent. In contrast, the potential of targeted public spending is high.

Data interoperability cannot be equated with data integration, which aims to synthesize data from different, independent sources into a unified schema. Data interoperability requires the implementation of both data integration and exchange, so the stakeholders must have access to databases. Interoperability is not a purely technical matter. It is connected with: the organizational level, semantic level and technical level (Pagano et al., 2013, pp. 19-25; Masud, 2016, pp. 127-135). The technical level is the most important because it allows for developing the remaining interoperability components.

The methodology of research concerning databases is based on the desk research method. The aim of the study was: the identification of databases containing information related to the circular economy in the region, in particular in the area of Circular Systemic Solutions of the project; identification of gaps in database characteristics; and identification of the level of database interoperability at the technical level.

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The desk research allowed us to identify ten databases with information connected to the Fronsh1p project. These databases owners were: Statistics Poland (three databases), the marshal's office in Lodz (2 databases), the Ministry of Climate and Environment (two databases), the Head Office of Geodesy and Cartography (one database), the Ministry for Education and Science (one database) and the Patent Office of the Republic of Poland (one database).

In the case of CSS2, the databases with some spatial references, such as the Registry of an Entity of National Economy, allows identifying some agriculture entrepreneurs and other firms who use some products generated in CSS2 for agriculture production. In the case of spatial databases, it could help identify the marginal areas where oil crops (rapeseed, milk thistle) can grow.

The problem is that the information about food waste must be collected by the entities looking for this type of data. Another way for information about the food waste in the regional ecosystem is to build the geosystem, which allows for real-time interaction between the chain elements and creates different types of databases, both spatial and statistical.

4.4. Technical state of the art: Current baseline & Market Analysis

4.4.1. From agricultural wastes into FFAs for new eco-designed circular biobased products

State of the art

One of the most challenging objectives of the FRONTSH1P projects is the valorisation of marginal streams and by-products in innovative circular biorefineries. Sugars are one of the most attractive streams, which can be valorised in multiple bio-products. Therefore, the implementation of any biochemical-based biorefinery centred on the so-called "sugar platform" requires the prior hydrolysis of its constituent polysaccharides, i.e., of cellulose and hemicellulose fractions, in order to obtain the respective monomers (mostly glucose and xylose). This hydrolysis can be promoted by chemical, thermal or biological methods. Enzymatic hydrolysis is advantageous due to its greater intrinsic specificity, with the consequent absence of formation of degradation products (potentially produced from sugars and lignin) and increased potential yield, reduced energy consumption due to the moderate reaction conditions and its non-corrosive and

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non-polluting nature (involving less investment in equipment and maintenance costs). However, most sources of lignocellulosic materials are structurally rigid and compact, and therefore their polysaccharides are not easily accessible to enzymes. This recalcitrance of lignocellulosic biomass is mainly due to two factors: the low accessibility of microcrystalline cellulose fibres, which prevents the efficient action of cellulases, and the presence of lignin (mainly) and hemicellulose on the surface of the cellulose, which prevents effective access of cellulases to the substrate.

Thus, lignocellulosic materials, and in particular residual forest and agricultural biomass, unlike saccharose and starch-based (1st generation) raw materials, need to be subjected to mechanical comminution and pre-treatment before applying an enzymatic process, which poses an added challenge in the development of the technology to be implemented. The pre-treatment aims to release the cellulose and hemicellulose fractions from the lignin, reduce the cellulose crystallinity and increase the porosity of the material. Given the high recalcitrance of lignocellulosic biomass, this initial stage of the process is considered one of the key points, being the most complex step from a technical point of view, and with the highest cost, of the conversion technology of lignocellulosic biomass into fermentable sugars. The literature reports show that pre-treatment may constitute more than 40 % of the total cost of cellulosic bioethanol production, limiting the implementation of new advanced commercial biorefineries.

Since this pre-treatment step is common to all value chains for the conversion of biomass into sugars and is of critical importance, advanced biorefineries that use lignocellulose as a raw material can be differentiated based on the different technologies applied as pre-treatment. Pre-treatment technologies are grouped by type of process, having been applied - at laboratory, pilot and demonstration scales - biological, physical, chemical and physico-chemical processes. Use of CO_2 as the adjunctive element of the hydrothermal treatment demonstrated the potential to reduce the pre-treatment time and temperature contributing to lower energy and carbon-footprint of this stage (Morais, et. Al. 2015). Nevertheless, the pre-treatment of the biomass requires, however, an efficient integration with the subsequent step of enzymatic hydrolysis. There are currently very robust cellulases on the market, acting very efficiently even when applied at a low dose, which in combination with enzymes produced by the fungus *Talaromyces amestiolkiae* can enrich the cocktails in β-glycosidases to provide 2G monomeric sugars (namely glucose and pentoses, such as xylose and arabinose).

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Progress beyond state of the art and success criteria

To achieve efficient process intensification, coupled to the liquefaction and subsequent enzymatic hydrolysis, the fermentation of the obtained concentrated sugars stream into lipids must be done with a high yield. The fermentation of sugars to lipids can be performed using recombinant cell factories of e.g., the oleaginous bacterium *Rhodococcus opacus* and the oleaginous yeast *Yarrowia lipolytica*. In this way, the main products are mainly C16-18 triglycerides. Either oleaginous bacteria or yeasts, able to naturally metabolize glucose, can be engineered to assimilate at the same time the pentoses (i.e., xylose and arabinose) present in the hydrolysates. Thus, this can turn the production of free fatty acids from the agriculture wastes carbon, energy and cost-efficient.

Three oleaginous yeast strains (*Rhodosporidium toruloides* PYCC 5615, *Thrichosporum oleaginosus* DSM 11815 and *Rhodosporidium babjevae* DVBPG 8058) are being tested, in order to select the best one, in terms of lipid content, concentration and productivity. These species have been mentioned in literature as good oil producers when grown on lignocellulosic hydrolysates, having been reported 31 % w/w, 3.8 g/L and 0.11 g/L h of lipid content, lipid concentration and lipid productivity, respectively, for *Rhodosporidium toruloides* PYCC 5615 (unpublished data); 51 % w/w, 3.8 g/L and 0.04 g/L h of lipid content, lipid concentration and lipid productivity, respectively, for *Thrichosporum oleaginous* DSM 11815, and 65 %, 18 g/L and 0.19 g/L h of lipid content, lipid concentration and lipid productivity, respectively, for *Rhodosporidium babjevae* DVNPG 8058 (Brandenburg et al. 2021). Shaigani *et al.*[4] tested several yeast strains in shake flasks, Brandenburg et al. developed the tested stains in 500 mL bioreactors and *R. toruloides* PYCC 5615 was tested in 7L- bioreactor. As expected, the yeast cultures developed in bioreactor attained higher lipid productivities, since this system, due to the more efficient mixing, allows better homogenization, thus higher mass transference rates, and medium pH control, than shake flasks. It is expected to achieve similar lipid production when developing the selected strain in a 7-L bioreactor, after optimizing the growth conditions.

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4.4.2. From food industry waste into compostable bioplastics for enhancing urban biowaste separate collection and valorization into compost and biomethanes

State of the art

Circular products are those that are designed not to become waste at the end of their life cycle, by either being re-used, recycled or composted. The circular bioeconomy is crucial in promoting this ecodesign concept.

By applying the circular bioeconomy approach, through the identification and valorisation of agricultural residues or food industries waste and by products, there is an opportunity to use valuable products in substitution of industrial streams (such as sugars) in order to fed biorefineries for the production of high value monomers and biomaterials.

Different EU funded research and development project related to the valorisation of such streams have been carried out, in order to lay down the base for a feedstock differentiation. Furthermore, patented technologies for the production of monomers through fermentation of sugars have been developed.

The produced biomaterial can be used for circular applications, such as bags for organic waste separate collection, in a soil to soil circular approach.

For instance, if organic fraction of municipal solid waste is suitably treated they can become a valuable source of organic matter, such as compost. This high value product represent an important solution for two types of problems: on the one hand, providing valuable soil improvers that can improve crop productivity, minimizing the use of fertilizers, and on the other hand, preventing organic waste from ending up in landfill, which will be prohibited in Europe from the end of 2023.

These agricultural and marginal soils, can be used for the production of biomass sources suitable to extract renewable raw materials needed for the production of bioproducts and bioplastics. These materials can be used to close the loop in waste collection.

For these reasons national, regional and local programmes have been developed to facilitate organic waste collection in order to transform it into quality compost, thanks to the use of compostable bioplastics.

National and international research and development projects have been financed on the study and monitoring of organic waste, and projects of ecodesign and bioplastic interception systems, including initiatives to combine different recycling technologies,

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such as composting, chemical recycling and mechanical recycling and to develop paper-backed packaging, which can be disposed of in both collection flows.

In Italy, as an example, the close collaboration between industries, local authorities, multi-utilities and the Consorzio Italiano Compostatori (Italian consortium of composters) has been essential in developing examples of excellence that are ready to be expanded and disseminated. Thanks also to this model, Italy is currently the European leader in organic waste recycling, collecting 47 % of organic waste compared with an average of 16 % across the continent.

The Italian model was taken as an example for the implementation of national and international successful programmes, such as the development of separate collection systems for organic waste using biodegradable and compostable bags in Turin, Milan, Paris, Barcelona, Monaco, Copenhagen and New York.

Progress beyond state of the art and success criteria

Food industry waste rich in sugars and/or oils provided by industries of the Lodzkie Region (such as producers of fruits juices, producers of fried food, etc…) will be exploited. Such streams will be pre-treated to valorise the waste/residual streams into fermentable sugars and oils which will be then processed in combination with additional sugars streams to produce biobased monomers obtained through engineered microorganisms, to be further processed into polymerization and reactive extrusion to obtain compostable biomaterials fulfilling the applications requirements. Optimal process conditions will be transferred to industrial converters present in the Lodzkie Region to upscale films production in order to obtain finished bioproducts (compostable bags for OFMSW collection).

The production of compostable bioplastics from food industry waste will be scaled-up at TRL7 to be applied for the production of compostable bags for the separate collection of organic fraction municipal solid waste;

4.4.3. From oil crops in marginal lands to biodegradable biolubricants for agricultural and industrial applications

State of the art

The development of innovative products from bio-based feedstocks can be one of the main contributions of bioeconomy to sustainable development, because their carbon is biogenic («bio-based»), meaning a reduction in oil dependence. Nonetheless, this contribution can be effective only through the construction of integrated agro-industrial value-chains based on the sustainable use of biomass, promoting regional biodiversity.

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There is a need of sustainable development models that are rooted in local areas in a circular bioeconomy perspective. No deforested or natural virgin soils need to be exploited for the production of renewable raw materials for the bioeconomy industry.

Territorial regeneration means having a positive impact, returning value to communities, not just through economic but also social and environmental development, creating jobs, promoting multidisciplinary projects in the field, revitalising less-developed marginal areas and transforming uncompetitive or abandoned industrial and research sites. The construction of integrated industrial and agricultural value chains is one of the central elements of the model to promote the sustainable use of biomass, ensuring that the model for bioplastics production is successful and sustainable from all perspectives.

As a matter of fact, renewable raw materials do not represent the solution to all the problems of pollution and to declining oil supply: agricultural crops are not all alike and even the same crops can have a completely different impact depending on the geographic area in which they are grown. It is therefore important to promote regional biodiversity, multiplying the opportunities coming from the study of different plant raw materials and local waste products, minimizing transportation and maximising the creation of knowledge circuits and multidisciplinary projects with the various local stakeholders (universities, research institutes, high schools, voluntary associations, the agricultural sector, institutions and small and medium-sized companies).

To this scope, it is crucial to promote value-chain projects targeted at various areas based on their specific characteristics, starting with experimentation of unconventional dryland crops with low environmental impact and reduced water consumption, along with research and innovation to transform waste and by-products into new applications. To achieve these goals, a strong collaboration between industries and the academic world is required in order to identify and study oleaginous dryland crops (e.g. cardoon) with potential industrial applications, which can be grown on marginal lands unsuitable for traditional crops.

The FRONTSH1P project aim to:

- create new production and income opportunities for farmers, thanks also to the agreements signed with farmers' associations, especially for areas of the country characterized by the presence of marginal lands at risk of abandonment or where crops are being changed, thereby avoiding any competition with food crops.
- reduce the environmental impact on the soil and water by using innovative solutions such as biodegradable mulch film, phytosanitary products made

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with pelargonic acid to control infestations and biolubricants for agricultural machinery; and enhance the value of the landscape.

This sustainable approach to agriculture has not just led to bio-based biochemicals and bio-intermediaries for biorefineries but also food and animal feed products and renewable energy, thanks to the cascading use of biomass and protein flour derived from the extraction of seed oil.

Progress beyond state of the art and success criteria

In the project biobased industries will cooperate with farmers in the Lodzkie Region to establish innovative oil crops genotypes adapted to local pedoclimatic conditions and in full respect of regional biodiversity in identified marginal lands to obtain low impact biodegradable biolubricants and animal feed while revitalizing soil quality and maximizing economic opportunities for farmers. Based on the experience acquired in previous projects (i.e. First2Run) in Mediterranean Region, genotypes of selected crops and related technical/agronomic protocols for cultivation will be evaluated taking into account the following:

i) application of compost from biowaste and/or biochar for crops cultivation, to ensure further reduction of synthetic fertilisers' input and provide organic carbon to soils;

ii) strategies for pest control and phytosanitary defence of the species;

iii) rotation schemes with food crops to fully valorise land productivity, improve soil conditions and keep biodiversity.

iv) reduced content of erucic acid and glucosinolates to allow use of oil meal as feed.

Based on the defined agronomic protocol, cultivation of selected genotypes will be progressively implemented at open field by farmers in revitalized marginal lands. Harvested seeds will be then processed by engaged farmers in cooperation with farmers association by valorising existing crushing units available in the territory. This process will allow to obtain two main streams: vegetable oils and protein oil meals. Oil meals rich in proteins will be validated by farmers as animal feed in partial substitution of conventional diet typically based on soybean meal which is imported from outside Europe.

Vegetable oils from grown crops genotypes will be processed and tested to formulate innovative low impact biodegradable biolubricants that could be used for several application, such as:

i) hydraulic oils for industrial use and or agricultural machines;

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ii) dielectric fluids in power plant;

The valorisation of marginal lands in the Lodzkie Region will be scaled-up at TRL7 for oil crops towards the obtaining of biodegradable bio lubricants and animal feed.

4.5. Technical implementation plan.

4.5.1. Deliverable and Milestones

A clear plan of the actions was defined and attached in Appendix and, due to the presence of confidential information is restricted to the consortium. The scope is to implement all the actions needed for the realisation of the scope of the project.

The main results will be the following.

DELIVERABLES:

D4.3 Agricultural waste conversion into FFAs feasibility – LNEG M35

D4.4 Food industry waste conversion into compostable bags for OFMSW separate collection and its valorisation into compost/biomethane feasibility – NVMT M35

D4.5 Feasibility of marginal lands valorisation into the obtaining of biodegradable biolubricants and animal feed – NVMT M39

D4.6 LCA, S-LCA and LCC & main outcomes from CSS2 – LNEG M42

D4.7 Ecodesign case studies CSS2 – LNEG M24

MILESTONES:

MS3 All CSSs deployed – WP4: This Milestones represents the development and initial deployment of all the technical and social activities of each CSS. The means of verification is represented by the release of the deployment roadmap scheme and by the technology of each CSS deployed and under test, namely: • CSS2 – FFAs from agricultural waste and Compostable bioplastics from food waste - K-FLEX M12

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5. Conclusions

Eastern European countries 10 year ago were among the European countries with the lowest levels of waste separate collection, and Poland was one of them with ~ 5 kg/inhabitant of biowaste separate collection. Landfilling was the most used approach with the connected disadvantages (increased volume of waste dumped in the landfill and consequent higher management costs).

In the last 10 years the situation is rapidly changing following the legislative evolutions (EU regulations and the connected national transpositions).

This transitional phase requires the individual states to change established waste management systems, with many difficulties in local and regional waste management related to organization of separate collection, the involvement of citizens and the construction of separate collected management plants. However, in parallel, it offers the opportunity to implement and test innovative and systemic circular solutions that can significantly reduce waste management costs with the aim of creating new innovative circular and economically autonomous and locally connected supply chains.

The Łódź voivodeship represents a strategic area for Polish circular transition due to its characteristic. It is a controversial region characterized by 19% of the surface protected by environmental regulation, with a strongly agricultural vocation (70% of surface covered by agricultural land), but also with relevant areas at marginalization risk and areas with important territorial exploitation activities such as mines for hard coal, cretaceous sands iron ore and limestone. The region has also a growing industrial context, related to the valorisation of food produced in the region and raw materials extracted.

This makes it an ideal region for the implementation of a circular biorefinery system where wastes and by products and marginal land agricultural productions can be valorised in new innovative products such as monomers for the production of biomaterials and biodegradable and compostable bioplastics.

The Łódź voivodeship also has a well spatially distributed ramification of medium-sized cities and municipalities, which may represent a challenge in terms of waste collection and management.

Over the last four years, many communes implemented or extended separate collection of waste and in particular of biowaste and kitchen waste with a forecast increase **higher than 500%** in the Lodzkie region (shifting from 55.800 tons collected in 2017 to the 287.515 tons forecasted in 2031.

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The construction of modern composting plants connected to the use of compostable applications for organic waste collection could provide an opportunity to valorize organic urban waste for energy (methane) and quality compost production that could be reused in agriculture as an organic soil improver in a fully circular approach.

A clear implementation plan for the targeting of CSS2 objectives is presented as well as the comparison of current state of the art.

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5.1.1. Timeline

Task	Partner.	Months																																										
		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
T4.1	LNEG								M+D																																			
T4.2	OPUS								D																																			
T4.3	LNEG																														D													
T4.4	NVMT																														D													
T4.5	NVMT																																		D									
T4.6	NTUA																																					D						
T4.7	LNEG																		D																									

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Appendix

Appendix 1 Area of wasteland in hectares in communes

TERYT Number	Area of wasteland in [ha]	TERYT Number	Area of wasteland in [ha]	TERYT Number	Area of wasteland in [ha]	TERYT Number	Area of wasteland in [ha]	TERYT Number	Area of wasteland in [ha]
1001042	4774.46	1010072	58.52	1002011	35.72	1012142	23.97	1007032	14.41
1009052	1767.43	1013032	58.20	1016072	35.68	1002022	23.93	1012011	14.20
1001072	1149.56	1008072	57.06	1009062	35.65	1016082	23.55	1015052	13.69
1009082	247.92	1001052	56.87	1010062	35.41	1021022	23.39	1005092	13.65
1061011	234.44	1014082	56.33	1005102	34.48	1017062	23.37	1016022	13.63
1004072	232.70	1010082	56.14	1011012	33.39	1011052	22.99	1019011	13.54
1009013	210.94	1001032	56.08	1002043	32.99	1012032	22.68	1016062	12.71
1003042	194.19	1020062	55.31	1004082	32.91	1017093	22.21	1019023	12.48
1011043	187.16	1001062	52.13	1010042	32.50	1010032	21.95	1015092	11.79
1004052	142.70	1009032	49.93	1007012	32.27	1006073	21.63	1010022	11.52
1012092	140.66	1014011	49.33	1016011	31.98	1005011	21.56	1014032	11.38
1007072	137.33	1012053	48.66	1016092	31.94	1021011	21.38	1063011	11.17
1020092	121.77	1020083	48.38	1014052	31.90	1007062	20.86	1005062	10.95
1014093	110.73	1016042	47.76	1010012	31.88	1017022	20.54	1004011	9.62
1005042	109.44	1011033	47.71	1002082	31.37	1018052	20.35	1007043	9.58
1005022	108.94	1017032	45.85	1013042	31.21	1006103	20.21	1020011	7.95
1009043	103.99	1004042	45.85	1012132	30.48	1016102	20.07	1002072	7.39
1010052	102.18	1013023	45.25	1015082	29.83	1015062	19.42	1006022	7.13
1011022	91.66	1010102	44.82	1015032	29.66	1018062	19.32	1002092	6.32
1010093	87.54	1019032	44.36	1016112	28.75	1007052	19.06	1021042	6.25
1005072	86.59	1012072	44.28	1017072	28.47	1021032	18.92	1005082	5.90
1003023	83.98	1006032	43.52	1018043	28.39	1017052	18.86	1018012	5.73
1020072	83.89	1002062	43.28	1015042	28.30	1014113	17.88	1016032	5.56
1003032	82.98	1011062	43.18	1014062	28.15	1012042	17.74	1014072	5.48
1005052	81.76	1017042	42.26	1004022	27.52	1018032	17.42	1062011	5.27
1019042	76.40	1014023	40.45	1015013	27.43	1020052	17.25	1020021	4.98
1016052	75.09	1015022	40.34	1014102	27.09	1008011	16.75	1008052	4.18
1001083	69.99	1013062	38.98	1012062	26.63	1003052	16.74	1005032	3.64
1002052	68.28	1014042	38.85	1020043	26.42	1004032	15.72	1002032	3.39
1012113	67.64	1008032	38.12	1008021	26.16	1021052	15.67	1017012	2.55
1007082	66.68	1012122	37.03	1006113	25.07	1004063	15.42	1001011	2.37
1001022	65.59	1008042	36.70	1018073	25.04	1020031	15.12	1013052	2.25
1012102	62.80	1010113	36.65	1002113	24.81	1007023	15.08	1013011	2.18
1012082	62.13	1008063	36.22	1015072	24.20	1009022	15.05	1018022	1.09
1012022	60.22	1017082	35.87	1009072	24.16	1017102	14.72		
		1002102	35.81	1003012	24.00	1006082	14.69		

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Source: own work based on data from GUS 2021.

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