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TANGO-CIRCULAR

Training A New Generation Of farmers and agricultural entrepreneurs to implement the concept of Circular economy in agriculture

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PEST Analysis

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Short description	This document is integrated in T2.2 of WP2 of the TANGO-Circular Project. The aim of this Deliverable is to carry out a political, economic, social and technical analysis of agricultural waste management in the EU and in the project's partner countries. This document was prepared by UEvora with the collaboration of partners from each of the countries included in the project.

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1 Introduction

This report presents the results of the political, economic, social, and technical situation in the agricultural sector, utilizing the most recent scientific literature and providing a detailed overview on the status quo that will allow for targeted intervention through upskilling and reskilling opportunities. The report will, also, provide great dissemination and exploitation potential for a variety of stakeholders, including universities, VET providers, companies, farming organizations, etc.

The structure of this report will contain a section on the Framework of Agricultural Waste where a brief description will be made with some basic concepts and definitions of the main wastes and by-products produced in the sector. In the PEST Analysis section, the main goal is to carry out a general analysis of the Political, Economic, Social and Technical (PEST) situation of agricultural waste management in Europe and in each partner country of the TANGO Project.

2 Framework of Agricultural Wastes

2.1. Concepts

In the following paragraphs the basic concepts that are key points along the project are defined.

According to the European Commission the Concept of waste is defined in article 1 of Directives 75/442/EEC and in article 3 of Directive 2008/98/EC as follows:

Waste means any substance or object that its holder disposes of or is required to dispose of in accordance with the provisions of current national legislation.

The concept Disposal of waste means: a) the collection, sorting, transport and treatment of waste as well as its storage and tipping above or underground and b) the transformation operations necessary for its re-use, recovery or recycling.

By-product means (Directive 2008/98/EC) a substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste referred to in point 1 of Article 3, but as being a by-product only if the following conditions are met: a)further use of the substance or object is certain; (b) the substance or object can be used directly without any further processing other than normal industrial practice; (c) the substance or object is produced as an integral part of a

production process; and (d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.

In relationship to these two Key points concept the concepts of Residues, Co-products can be defined as follows:

Residue means: a small amount of something that remains after the main part has gone or been taken or used. The term does not define the quality of the leftovers. In this special case it does not define if a residue is waste or a by-product.

Co-product means: Any of two or more products coming from the same unit process or product system (EN ISO 14040:2006). A product produced together with another product.

Agricultural Waste and By-Product in Bioeconomy: Unavoidable agri-food waste arising from an efficient system is a suitable feedstock resource for the bioeconomy, as such waste cannot be prevented – it is a by-product. Avoidable wastes, on the other hand, represent mismanagement and inefficient use and are not a sustainable feedstock source for a bioeconomy (Toop et al. 2017), although if they will be discarded for agricultural use, they can be recycled as by-products in bioeconomy.

2.2. Main agro-industrial and forestry wastes

Following the previous definition of key concepts in bioeconomy, potential by-products that can be used as feedstock in Bioeconomy are classified according to their origin into lingo-cellulosic by-products from the field, farm animals, industrial plants and bio-based animal by-products (Table 1) and the remaining non-biobased (e.g. plastics) or blends of non-biobased and biobased (e.g. biodegradable plastics) by-products resulting from the application of agricultural technologies, which generally come from industrial products that support agriculture (Table 2). Forestry and the associated industry by-products are not specifically detailed in tables 1 and 2, but according to their nature they are considered forest lignocellulose plant by-products, similar to orchards woody crops. Main forest by-products are lumber waste, sawdust, leaves, barks, cones seeds, resins and pulp and paper industry by-products (Ferreira-Santos et al, 2020).

Agricultural Origin	**Field Lignocellulose plant By-products**	
	By-products	Crops/ Livestock
Herbaceous Crops	Straw, stalk, husk, Cob, pod, beet tailings, seed	Corn, wheat, barley, oat, rice, sunflower, rape, cotton, sugarbeet, soybean, alfalfa, flax
Vegetable Crops	Straw, vines stem, leaves, peel, skin, seed coat, rind, husk, hull Pulp, curd, bulb, tuber, root, gourd, seed, root	Onion, garlic, artichoke, cauliflower, broccoli carrot, tomato, potato, beet, sweet potato, pumpkin, pea, fava bean, bean, watermelon, melon, fennel, cabbage, saffron
Orchard Crops (stone and seed fruits, dry fruits)	Wood, pruning wood, leaves, peel, skin, seed coat, rind, shell thinned fruit and flower, hull, husk, pulp, seed, stone, kernel	Apple, peach, pear, apricot, plum, lemon, orange, mandarin, grapefruit, lime, grape, olive, pomegranate, almond, hazelnut, walnut, pistachio kiwi, mango, papaya, banana, avocado, plum, apricot, fig
	Industrial Plant By-products	
Olive Industry	Stones, flesh, seed, olive pomace, waste water	Olive, table olive
Fruit and Vegetable industry	Peel, pulp, leaves, bracts, stems, seeds, pomaces, kernel, flavedo, albedo, wood box, cartoon box	Tomato, potato, onion, pepper, green bean, artichoke, leek, apple, pear, peach, orange, lemon, pomelo, cherry, table grapes, pomegranate, plum, apricot, fig, cacao, coffee
Plant oil industry	Seed, shells, press cake, meal, mill waste	Sunflower, Soybean, Rape, linseed (flax)
Grain Industry	broken rice, bran, germ, mill waste, gluten meals, husk	Rice, corn, wheat, barley, oat, rice
Brewery and winery industry	Brewer's spent grain (BSG), Residual yeast, grape pomace, yeast lees, tartrate, grape seeds, grape stalks, apple pomace	Barley, wine grape, cider apples
	Farm animal By-products	
Livestock	Manure, animal bedding	Bovine, swine, poultry, goas, sheep, equine, rabbit
	Industrial Animal By-products	
Slaughterhouse waste	Skin, bones, horn and hooves, blood, fat, offal	Bovine, swine, poultry, goas, sheep, horse, rabbit
Poultry Industry	eggshells, feathers	Chicken, turkey, dug, goose
Swine Industry	blood, bones, hides, skin, hair, lard, feet (pig's trotters), internal organs, and chitterlings (pig's small intestine),fat	Swine
Sheep Industry	wool, wool wax, skin, horns, hoof, bones, intestines, fat	Sheep, goats
Bovine Industry	blood, bones, tendons, meat trimmings, fat or tallow, hides, hooves, horns, internal organs, viscera, feet, hairs	Beef, dairy
Honeybee Industry	Beeswax, pollen, propolis, bee bread, royal jelly	Bees

Table 1 - Potential Agricultural bio-based by-products: field biomass, farm animal and industrial plant-animal by-products

Agricultural Origin	**Plastics (none bio-based, compostable, soil biodegradable)**	
	By-products	Crops/ Livestock
Vegetable Crops Ornamental Crops Fodder	Greenhouse films, mulching films, silage film, blanching films, transplant trays, plastic nets, tapes, irrigation tapes, pesticide and fertilizers containers, seeds and fertilizers sacks, blanching caps, hydroponic sacks, trellising threads and nets, pots, pheromones traps,	Tomato, pepper, eggplant, bean, watermelon, melon, pea, onion, garlic, artichoke, cauliflower, broccoli, carrot, potato, beet, sweet potato, pumpkin, fava bean, fennel, cabbage, cotton, asparagus, sweet corn
Orchard Crops (stone and seed fruits, dry fruits)	Irrigation tubs, irrigation complements, pheromones traps, grafting bands, rubber bands, fruit-grape protection bags, fruit picking box, mulching films	Apple, peach, pear, apricot, plum, lemon, orange, mandarin, grapefruit, lime, grape, olive, pomegranate, almond, hazelnut, walnut, pistachio kiwi, mango, papaya, banana, avocado, plum, apricot, fig
	Other by-products	
Al crops	fuels, oils, lubricants, batteries, tires, construction materials, PPE	Cereals, Orchard and Vegetable crops, animal farms

Table 2 - Non Bio based, inorganic, blends of bio based and none bio-based Agricultural By-products: Plastics

3 PEST Analysis

3.1 Political Situation

3.1.1. European Union

EU waste policy aims to contribute to the circular economy by extracting as much as possible, high-quality resources from waste. The European Green Deal aims to promote growth by transitioning to a modern, resource-efficient and competitive economy. As part of this transition, several EU waste laws are being reviewed.

The **Waste Framework Directive (WFD)** (Directive 2008/98/EC on waste as amended by Directive 2018/851) is the EU's legal framework for treating and manage waste in the EU and lays down some basic waste management principles. It requires that waste be managed:

- without endangering human health and harming the environment;
- without risk to water, air, soil, plants or animals;
- without causing a nuisance through noise or odours;
- and without adversely affecting the countryside or places of special interest.

It explains when waste ceases to be waste and becomes a secondary raw material, and how to distinguish between waste and by-products. The Directive also introduces the "polluter pays principle" and the "extended producer responsibility".

The basis of EU waste management is the five-step "waste hierarchy", established in the Waste Framework Directive. It establishes an order of preference for managing and disposing of waste, advocating that prevention of waste production should be the preferred option, and sending waste to landfill should be the last one (European Commission, 2022a).

Different categories of waste require specific management approaches. The EU has many laws to address different types of waste, as i.e., plastics, that represent a problem in the agricultural sector.

The EU has the goal to achieve climate neutrality by 2050, according with the commitments of the Paris Agreement. Reaching this objective will require a transformation of Europe's society and economy, which will need to be cost-effective, fair and socially balanced.

The European Green Deal is a package of policy initiatives, which aims to set the EU on the path to a green transition, with the ultimate goal of reaching its 2050 climate goal (European Commission, 2022b).

The new Circular Economy Action Plan (CEAP) is one of the main building blocks of the European Green Deal. The new action plan announces initiatives along the entire product's life cycle. It targets how products are designed, promotes circular economy processes, encourages sustainable consumption, and aims to ensure that waste is prevented and the resources used are kept in the EU economy for as long as possible. It introduces legislative and non-legislative measures targeting areas where action at the EU level brings real added value (European Commission, 2022c).

There is no general and specific legislation for agricultural waste, however there is a European Union strategy for some of the waste that has the greatest environmental impact, such as plastics in agriculture. In terms of organic agricultural waste, there is no specific strategy. However, it is possible to verify that according to EU policies, there is an incentive for these by-products to be reintegrated into the production process, from a circular economy perspective.

Agricultural Plastic Waste

The EU's plastics strategy, as part of the circular economy action plan, aims to protect the environment and human health by reducing marine litter, greenhouse gas emissions and our dependence on imported fossil fuels.

According to the European Commission (2022d), several EU member states have their own national regulations in place with regard to the valorization of agricultural plastics but, apart from packaging products, there is no common European regulation in this respect. However, several provisions in the following existing EU legislation address agri-plastics to some extent:

- **Waste Framework Directive**: While specific end of life management requirements for agricultural plastic waste are not further detailed in the WFD, Article 11 states that:

"Member States shall take measures to promote high quality recycling and, to this end, shall set up separate collections of waste where technically, environmentally and economically practicable and appropriate to meet the necessary quality standards for the relevant recycling sectors. Subject to Article 10, by 2015 separate collection shall be set up for at least the following: paper, metal, plastic and glass."

Furthermore, Article 10 of the WFD states that such separately collected waste should not be incinerated:

"Member States shall take measures to ensure that waste that has been separately collected for preparing for re-use and recycling pursuant to Article 11 and Article 22 is not incinerated, with the exception of waste resulting from subsequent treatment operations of the separately collected waste for which incineration delivers the best environmental outcome in accordance with Article 4."

The above-mentioned obligations, however, appear to have had limited impact as there are several Member States without separate collection for agri-plastics in place. Likewise, while the WFD Preamble provides that "Member States should support the use of recyclates, such as recovered paper, in line with the waste hierarchy and with the aim of a recycling society and should not support the landfilling or incineration of such recyclates whenever possible.", there is no specific provisions laid out regarding the landfilling of plastic waste (Hann, et al., 2021).

- **EU Plastics Strategy:** sets out measures to increase plastics recycling and reuse, including rules to harmonise the implementation of Extended producer responsibility (EPR) schemes across the EU.
- **Single-use Plastics Directive** (Directive 2019/904): Article 5 prohibits Member States from placing products made from oxo-degradable plastic on the market.
- **REACH Regulation** (Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals): sets requirements related to valorization operations, including mechanical processing, the use of recycled material, and the use of legacy additives such as cadmium and lead stabilisers.
- **Incineration Directive** (Directive 2000/76/EC): forbids uncontrolled burning of waste, including bio-waste.
- **Landfill Directive** (Directive 99/ 31/EC): forbids the uncontrolled burying of waste.

3.1.2. Portugal

In Portugal, the Organization responsible for coordination, ensuring and monitoring the implementation of a national strategy for waste is the National Authority for Wastes (ANR), whose powers are assumed by Portuguese Agency for Environment (APA).

The fundamental guidelines for waste policy are contained in the National Waste Management Plans, the Waste Prevention Programs and the Municipal, Inter-municipal and Multi-municipal Waste Plans.

The national-level management plans, prepared by the ANR, are part of the National Waste Management Plan (PNGR) and the Municipal Waste Management Plans. This planning is reflected in the General Waste Management Regulation (RGGR).

Regarding agricultural waste, there is no specific national management plan for it, that is, some agricultural waste falls under the Urban and Non-Urban Waste Management Plans, while others have their own legislation.

With regard to the management of agricultural by-products, the guidelines contained in the Community and national regulations must be complied with, namely those relating to animal by-products and derived products, the application and control of which are fundamentally the responsibility of the Ministry of Agriculture for certain products and in certain circumstances, jointly with the Ministry of the Environment. Livestock producers, when licensing their livestock activity, must take into account the regulations for the management of the by-products, showing the application of the rules associated with the storage, transport and valorization of these by-products. Livestock Effluents management is regulated by specific legislation (CAP, 2022).

Legislation for agricultural wastes and by-products

- **Wastes**

In Portugal, the diploma that established the RGGR was DL n.º 178/2006, 5 September. This decree-law was later updated by DL n.º 73/2011, 17 June, in order to meet EU directives.

In December 2020, this document was updated again through DL n.º 102-D/2020 of December 10th. This update was intended to promote and give special emphasis to circular approaches that prioritize reusable products and sustainable and non-toxic reuse systems over single-use products, primarily with a view to reducing the waste generated.

The RGGR covers several economic sectors, including the agricultural, establishing rules in terms of waste prevention, production and management, including waste transfers. Some residues generated on agricultural

holdings are excluded from the scope of application of this law, which, when they have certain subsequent uses, are designated as agricultural by-products.

Fecal matter, straw and other non-hazardous natural materials from agriculture, livestock or forestry are excluded from the RGGR, provided they are used in agricultural activities (i.e., direct application to the soil or after composting, animal litter, animal feed, etc.) or in the production of energy through processes or methods that do not harm the environment or put human health in risk (i.e., production of fuels from biomass by physical processes - pellets).

As an examples, we indicate as non-hazardous natural materials from the agricultural sector: agricultural crop residues; waste from activities relating to the preparation or conservation of agricultural products, such as fruit and vegetable scraps; substrates from the production of agricultural crops, such as mushrooms; plant material of silvicultural origin resulting from cleaning and forest exploitation. Also excluded from the RGGR are animal by-products (such as animal carcasses, skin, wool, hair, feathers, bristles, horns and hooves, food of animal origin unfit for human consumption, products of animal origin for the manufacture of food, residues of milk, semen residues, among others) except for those destined for incineration, use to produce biogas or composting, or disposal in landfills. Finally, in the agricultural sphere, substances that are intended to be used as raw materials for animal feed and which are not, nor do they contain, animal by-products are also referred to as exceptions to the RGGR.

The collection, transport, storage, sorting, treatment, valorization and disposal of waste covered by the RGGR constitute operations regulated by this law.

For waste management to meet the national policy strategy, it is essential that waste is properly separated and classified at the source, so that its final destination can be as appropriate and as less harmful as possible to human health and for the environment. The waste classification process allows assigning the LER code that best characterizes a given waste, which allows it to be forwarded to the most appropriate destination. Based on this classification, in the case of specific waste, the farmer is responsible for selecting the entities, duly licensed, for its treatment.

It should also be noted that the publication of Ordinance no. 79/2002 of 3 February clarifies that the products obtained as a result of the transformation by composting or anaerobic digestion of livestock effluents and other by-products of animal origin and products derived either alone or combined with livestock effluents do not have waste status.

- **By-products**

In relation to livestock by-products, their management is reflected in the licensing of livestock exploitation, through the new Regime for the Exercise of Livestock Activity (NREAP), framed by DL n.º 81/2013, of 14 June.

Equally relevant are: DL n.º 75/2015, of 11 May, which frames the Single Environmental Licensing Regime (LUA) and which approves the procedure for articulation with NREAP; and Ordinance No. 79/2022 of 3 February, on the management of livestock effluents.

On the other hand, the management of animal by-products complies with Regulation (EC) No. 1069/2009 of the European Parliament and of the Council of 21 October 2009, which defines health rules for derivatives not for human consumption, the application of which in Portugal has led to the publication in the national legal framework of various regulations, including the Ordinance on livestock effluent management and DL n.º 33/2017 of 23 March, on the system for collecting dead animals on farms (SIRCA).

Licensing of agricultural waste and by-product management activities

- **Wastes**

Activities associated with waste management, which are part of its treatment, are subject to licensing, under the terms of Article 59 of the RGGR, applying in particular to agricultural waste valorization operations (excluding domestic composting).

In the case of the agricultural sector, waste associated with the use of production factors (of a non-organic nature), delivered to the reception structures of the integrated waste management systems, is not treated or valued by the farmer, so in this case, it is the waste management companies that have to apply for the respective licensing.

When dealing with waste classified as part of the RGGR, the valorization and disposal operations, including the respective prior preparation, are subject to licensing with classification in the RGGR (Annex I and II).

The entities responsible for licensing waste management operations are the ANR, whose powers are assumed by the APA and the Regional Waste Authority (ARR) territorially competent, which is performed by the respective Regional Coordination and Development Commission (CCDR). The licensing request is made under the terms of DL n.º 75/2015, of 11 May, which approves the Single Environmental Licensing Regime (LUA).

- **By-products**

All livestock production units must proceed with their registration and licensing, in accordance with DL nº 81/2013, of 14 June (NREAP). When applicable, it is also necessary to proceed with the licensing of livestock effluent valorization activities, in accordance with Ordinance No. 79/2022 of 3 February, which regulates the management of livestock effluents and also determines the complementary rules concerning the transport, storage and valorization, agricultural and organic, of other animal by-products and derived products.

DGADR defines the different forms of admissible valorization and disposal for livestock effluents, as well as the respective entities involved in licensing these activities.

In summary, the licensing of livestock effluent managers, as well as the authorization to value/treat/dispose, depends on the characteristics of the livestock effluents and the activity to be carried out, so the operators involved need to inform the competent authorities about the procedures.

Pursuant to DL No. 81/2013 of 14 June (NREAP) and taking into account Annex I of Ordinance No. 79/2022 of 3 February, the licensing of complementary livestock effluent management activities is an integral part of the livestock exploitation authorization process.

In the case of livestock farms that produce by-products of animal origin not for human consumption, as well as the treatment units (disposal and/or valorization) of these by-products, in addition to the intervention of the Ministry of Agriculture for licensing and inherent authorizations, it is important to take into account the authorities of the Ministry of the Environment.

3.1.3. Spain

In Spain, the primary entity responsible for coordination, ensuring and monitoring the implementation of a national strategy for waste is the Ministry for the Ecological Transition and Demographic Challenge. Regarding the effective exercise of powers on waste, the Law respects the constitutional distribution between the State and the Autonomous Communities, at the same time that guarantees the skills that traditionally have been exercising local authorities in matters of urban solid waste (Ley 22/2011; BOE 181 del 29 Julio 2011). Law 7/2022, of April 4, on waste and contaminated soils, which transposes the European Directive 2008/98/CE, obliges the State and the Autonomous Communities to draw up management plans and allows local entities to develop waste management programs in the field of their competencies.

- **State Waste Prevention Program (PEPR)**

The fundamental guidelines for waste policy are contained in the State Waste Prevention Program 2014-2020 (PEPR) together with the Waste Management Framework State Plan (PEMAR). The PEPR 2014-2020 develops the waste prevention policy, in accordance with current European Regulations (Directive 2008/98/CE) to advance in compliance with the objective of reducing waste generated in 2020 by 10% with respect to the weight of waste generated in 2010. The State Program (PEPR) describes the current situation of prevention in Spain, carries out an analysis of existing prevention measures and assesses their effectiveness. This program is configured around four strategic lines aimed at influencing the key elements of waste prevention: reduction in the amount of waste, reuse and extension of the useful life of products, reduction of the content of harmful substances in materials and products, and reduction of adverse impacts

on human health and the environment, of the waste generated. The State Waste Prevention Program was sent to the Autonomous Communities in order they could develop the four mentioned strategies at regional level.

- **State Waste Management Framework Plan (PEMAR)**

In 2015 the State Waste Management Framework Plan (PEMAR) 2016-2022 was approved. The aforementioned Plan is the instrument to guide the waste policy in Spain in the coming years, which promotes the necessary measures to improve the deficiencies detected and promotes the actions that provide a better environmental result and that ensure that Spain complies with the legal objectives. With this new Plan, it complies with: the EU obligation to have waste management plans before 2015, fulfilment of one of the conditions of the waste sector for access to EU funds for this sector in the next period 2014-2020 and the adaptation to the contents that Spanish Law 22/2011, on waste and contaminated soils, establishes for the State Framework Plan. The Plan guides the waste management in Spain through the plans of the Autonomous Communities where specific actions will be specified based on their needs. The final objective of the Plan, as is that of the EU waste policy, is to turn Spain into an efficient society in the use of resources, which advances towards a circular economy. In short, it is about replacing a linear economy based on producing, consuming and throwing away, with a circular economy in which materials containing waste are reincorporated into the production process over and over again for the production of new products or raw materials.

Progress towards the circular economy is reflected in the PEMAR through the application, in all waste streams included, of the principle of hierarchy established in community regulations. The update of this plan will be done through the new Law 7/2022 of April 8.

- **Legislation applied to Agricultural Waste and By-products in PEMAR**

The State Waste Management Framework Plan 2016-2022 is the first Spanish State Plan that includes Agricultural Wastes and By-Products. The regulation on Agricultural Waste have been recently updated through Law 7/2022. The problems associated with agricultural residues derive mainly from the spatial dispersion of the producers of agricultural residues, the seasonality of the generation of agricultural residues and the heterogeneity of the residues produced on agricultural farms.

Laws 7/2022 on waste and contaminated soil.

Law 7/22 defines Agricultural and Forestry wastes as: residues generated by agricultural, livestock and forestry activities. Certain agricultural residues are excluded from this law (fecal matter, straw and other natural, agricultural or forestry materials), when used in agricultural and livestock farms, in forestry or in the

production of energy based on this biomass, under the terms provided in article 2, section 1e. On the other hand, in accordance with the provisions of article 2, section 2.b, the Waste Law is applicable to animal by-products not intended for human consumption and their by-products (SANDACH) when they are destined for incineration, landfills, or are treated in a biogas or composting plant. Likewise, the Waste Law is applicable to the SANDACH in aspects not regulated by Regulation (EC) No. 1069/2009 of the European Parliament and of the Council, of October 21, 2009, which establishes the sanitary standards applicable to animal by-products and derived products. Law is also applicable to the carcasses of animals that have died in a different way than slaughter and that are not disposed of in accordance with Regulation (EC) no. 1069/2009. Consequently, agricultural waste not exempted from the application of Law 22/2011, on Waste, and issues not regulated in other regulations, are regulated by Law 22/2011. It should be noted that according to the distribution of powers established in article 12, the management of agricultural waste is not a mandatory responsibility of the municipalities.

Given the diversity and complexity of agricultural waste, the Plan focuses mainly on the following waste:

- **Agricultural Plastics**

The Law 22/2011 does not contemplate agricultural plastics but they are considered in PEMAR and updated in Law 7/2022. These plastics are generally not biodegradable and are a bulky waste, and if they are not managed properly, they become a risk to the soil, water, flora, fauna and the habitability of the place due to the degradation of the territory they produce. The introduction in the market of products made with oxo-degradable plastic is forbidden. Mainly agricultural plastic wastes are treated together with plastic waste from other sectors. The main agricultural plastic waste treatment plants are currently located in Andalusia, Extremadura, Galicia and Murcia. In some autonomous communities, initiatives have been launched to facilitate and improve the collection and management of this waste (Decreto 73/2012). Thus, the Xunta de Galicia has a plastic collection system and has covered the costs of collection, transport and treatment. Cicloagro has been set up in Andalusia, as a system for the management of non-packaging agricultural plastic waste. According to the new Law 7/2022.

- **Agricultural no hazardous Containers**

For these types of no hazardous plastic containers there is not currently an established Integrate Waste Management System but the possibility to organize a new System is being discussed by the AEFA (Asociación Española de Fabricantes de Agronutrientes) and AEVAE (Asociación Española para la Valorización de Envases). The responsibility for the proper management of this packaging waste lies with the final owner, who must deliver it for proper management in accordance with article 12 of Law 11/1997, of April 24. For this reason, some farmers decide to adhere to the SIGFITO system. For plastic containers, to encourage

prevention and promote quality reuse and recycling, measures may be adopted to facilitate the establishment of deposit, return and refund systems.

- **Agricultural hazardous Containers**

This type of packaging is subject to the extended responsibility of the producer (Royal Decree 1416/2001, of December 14, on packaging of phytosanitary products). Most of the manufacturers of these products comply with their obligations through the SIGFITO and Integrated Management System. Thus, farmers take the phytosanitary packaging waste to the existing collection points; these points are located mainly in agricultural cooperatives and distributors, another part of these containers is managed in collaboration with local authorities.

- **Remains of Phytosanitary**

In relation to this type of waste, the Royal Decree 1311/2012, of September 14, which establishes the framework for action to achieve a sustainable use of phytosanitary products, is applicable.

- **Plant Wastes (Law 7/2022; Catalan Decree 198/2015)**

The burning of vegetable residues generated in the agricultural or forestry environment is not allowed. The burning of this waste may only be allowed on an exceptional basis, and as long as they have the corresponding individual authorization. The decree 198/2015, of September 8, establishes the agricultural management of effluents produced in wineries and oil mills.

The State Plan (PEMAR) includes strategic lines and guidelines to advance in the management of agricultural wastes, among them the following can be mentioned:

Advance in the improvement of the management of plastic waste through measures such as: the use of compostable and biodegradable materials (following the European standards EN-13432, EN-14995, EN-17033), the extension of the useful life of products, improving their recyclability and replacing harmful additives. The separation of plastic waste according to its final destination (recycling or energy recovery) is of particular importance.

Improve the collection of agricultural waste, developing the availability and suitability of collection points, the implementation of separation at source of certain waste streams, and the organization of transport logistics for waste generated on farms. Carrying out pilot experiences for the implementation of “agricultural clean points”.

Delimit the scope of application of the waste regulations to certain agricultural waste, in particular in the case of livestock manure, waste subject to the SANDACH regulations and plant waste.

3.1.4. Italy

In Italy, the disposal of agricultural waste requires the producer company to follow specific procedures. If the waste is environmentally hazardous, the obligations are more stringent. Among the obligations deriving from the management of an agricultural company (the figure of the agricultural entrepreneur is regulated by art. 2135 of the Italian Civil Code) there is also that of the disposal of agricultural waste: an activity that can be a source of high costs but also of considerable opportunities related to reuse and processing.

The reference regulation is composed of Legislative Decree 152/06 and EU Directive 2008/98/EC, issued with a view to a circular economy (raw material - distribution - production process - waste collection - recycling - raw material) and implemented by Legislative Decree 205/2010. This regulation, aided by other specific provisions, introduced stringent administrative and documentary requirements, peremptory periodic deadlines for disposal, and a strict penalty system for non-compliance.

Under Italian law (Art. 183), waste is any substance, object that the holder discards, intends to discard, or is obliged to discard. Pursuant to Article 184-bis of the same decree, on the other hand, it is not waste but by-product any substance or object originating from a production process not primarily intended for their production and having the following characteristics: it is certain that they will be used, directly and without any further specific treatment, in the same or a subsequent production process by the producer or a third party; their use does not give rise to polluting emissions and has no environmental impacts other than those authorised for the production plant intended to use them. By-products are excluded from the application of waste legislation. Furthermore, a waste ceases to be a waste when it has undergone a recovery operation and, at the same time, can be used for specific purposes, has a market and complies with the technical requirements for the specific purposes as well as the legislation applicable to the products. Substances such as sewage, animal carcasses, faecal matter (manure, slurry), plant materials and stones are not subject to waste requirements because they are governed by specific provisions.

- **Agricultural Wastes**

Agricultural waste is special and may also be hazardous. Given that letter C of para. 3 of Art. 184 considers them to be special waste, agricultural waste is divided into three categories: 1- hazardous waste (lead batteries, exhausted motor oils and their filters, containers of agro-drugs or fertilisers, expired veterinary substances, needles and syringes are hazardous waste); 2- non-hazardous waste (packaging (plastic, glass, cardboard, wood or mixed), seed sacks, nets for rows, nylon covers for greenhouses, anti-hail sheeting and plastic pipes are considered non-hazardous waste); 3- potentially infected waste (empty containers of live-agent vaccines and objects that have had biological contact with animals (e.g. fertilisation cannulae) are defined as potentially infected.

The fundamental distinction between hazardous and non-hazardous waste (including potentially infected waste) is important because the legislation provides for different storage, transport and disposal procedures as well as different documentation requirements.

Agricultural waste producers must register with the relevant regional section of the Register of Environmental Managers (held, in most regions, by the local Chamber of Commerce), paying the relevant annual fee. Excluded from the obligation to register with the National Register of Environmental Managers are agricultural entrepreneurs who transport their waste within the provincial or regional territory where the company is based in order to deliver it to the organised collection circuit.

Entities and companies that initially produce special hazardous waste from agricultural and agro-industrial activities or from professional fishing and aquaculture activities with more than 10 employees, excluding, regardless of the number of employees, the entities and companies referred to in art. 2135 of the Civil Code that deliver their waste within organised collection circuits, pursuant to Article 183, paragraph 1, letter pp) of Legislative Decree 152/2006, are required to adhere to SISTRI, i.e. the Ministry of the Environment's Waste Traceability Control System, for the computerisation of the traceability of special waste at a national level.

- **Agricultural Plastics**

With specific reference to agricultural plastic waste, the question of polyethylene waste management required in Italy the creation of a compulsory Consortium (PolieCo) - the Italian Consortium for disposal of PE-based waste - with the primary objective of promoting collection, re-use, recycling and re-utilization of polyethylene. This Consortium is based on the concept that “Waste management is carried out in accordance with the principles of precaution, prevention, sustainability, proportionality, responsibility and cooperation of all parties involved in the production, distribution, use and consumption of goods from which originate the waste and the ‘polluter pays’ principle”.

Many Italian Municipalities are currently realizing agreements with Agricultural Associations in order to promote concerted and planned actions aiming to recovery, recycling and suitable disposal and using, at same time, simplified and economic procedures for farms, especially small ones that represent the majority.

3.1.5. Greece

The legislative framework for the management of agricultural waste in Greece, includes several pieces of legislation based on EU law. In terms of the Global Climate Crisis, one of the Directives and Decisions Greek government has adopted, is the National Waste Management Plan (including: municipal waste, industrial waste, agricultural waste, other hazardous waste, excavation, construction and demolition waste, other waste streams that fall into alternative management & hazardous waste of healthcare units).

The NWMP is the country's strategic and political waste management plan, where its redaction is an obligation of the EU member states. The Ministry of Environment and Energy is in charge for its preparation, which is approved by the Council of Ministers in order to constitute a political commitment of all Ministries for its implementation.

The NWMP is implemented for a period of ten years 2020-2030 and it is evaluated every five (5) years (if revision is needed), in accordance with the provisions of Law 4685/2020 (A' 92). This National plan aims to reduce waste production, minimize the use of natural resources with the ultimate goal of transitioning to a circular and sustainable economy.

Current state of agricultural waste management

All types of agro-livestock waste considered in the context of NWMP and their current management status are presented below:

- **Crop residues**

The massive production of agricultural waste remains unexploited due to the lack of a specific and effective legislative framework, causing significant environmental pollution.

- **Livestock waste and by-products**

For livestock waste, there are no quantitative targets set by Greek legislation. Their valorization methods are carried out in accordance with the European regulation for animal by-products (Regulation 1069/2009/EC, L 300).

- **Plant protection packages**

In this category are included all packages of Plant Protection Products (PPPs) such as fertilizers, agrochemicals and veterinary medicinal substances. The department of Plant Protection of the Ministry of Rural Development & Food in accordance with the Law No. 4063/2012 (Government Gazette issue A΄8) " Placing pesticides on the market, their rational use and related provisions", issued Guidelines for the plant protection packaging management. According to code of good agricultural practices, all the agricultural plastics should be collected, managed properly and not left in the field, or among the crops or burned.

- **Agricultural plastics**

To address this problem and for the responsible management of agricultural plastic waste, in 2020 the Greek government launched a national program called "New Agriculture for the New Generation". This program aims to support farmers, so that they can secure their business competitiveness by adopting good management practices contributing to safeguarding the environment.

3.1.6. France

In France, regulations provide for a number of precautions to be taken to ensure good waste management, protecting the environment and human health. In the framework of the Law on Energy Transition and Green Growth in 2015 a national waste management plan was established to provide an overall vision of the waste management system and national policy. The measures, objectives and legislative, regulatory and/or fiscal guidelines were proposed by a roadmap (FREC) detailing 50 measures for a circular economy published in 2018. This document has made it possible to respond not only to the Law but also to the new provisions integrated in the Waste Framework Directive 2008/98/EC. In addition, the anti-waste law for a circular economy, voted in February 2020, proposes new actions to accelerate the transition to a circular economy.

Waste for recycling comes either from companies or from households. At the national level, the law on energy transition for green growth sets the objectives of recovering 55% of non-hazardous non-inert waste in the form of materials in 2020 and 65% in 2025, and of reducing the quantities of non-hazardous non-inert waste admitted to landfill by 30% in 2020 compared to 2010, and by 50% in 2025.

In France, the prioritisation of waste management operations has been accompanied by national targets based on the data indicated in the "Grenelle" environmental law. Since 2012, the so-called "Grenelle II" law has made it mandatory to sort bio-waste at source. In 2015, the law on the energy transition for greener growth (LTECV) has a global objective on waste recycling of 65% in 2025. In 2020, the AGEC law (Fight against waste and circular economy) transposes the objectives of the European Directives into French law.

3.2 Economic Situation

3.2.1 European Union

According to a definition provided by the European Commission, the bioeconomy encompasses the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy independently of the processing technologies. It thus includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, bio-technological and energy industries (BIOEast, s.d).

In 2012 a bioeconomy strategy was established at EU level with the aim of improving investments in research and innovation reinforcing policy interaction and stakeholder engagement and enhancing the market and competitiveness in the bioeconomy sectors, however, due to the diversity of the different Member States the individual strategies adopted by them are far from identical but at the same time all of them set the goal to reach coherence in bioeconomy related policies (BIOEast, s.d).

The analysis of the 2017 Eurostat data shows that the turnover of the total bioeconomy, including food and beverages and the primary sectors of agriculture and forestry, results in just over 2.4 trillion euros in the EU-28, meaning an increase by 25% since 2008. Roughly half of the turnover is accounted for by the food and beverage sector, roughly 30% is contributed by the bio-based industries, such as bio-based chemicals and plastics, pharmaceuticals, paper and paper products, forest-based industries, textiles, biofuels and bioenergy. The remaining 20% is generated by the primary sectors – agriculture and forestry and represents 0.46 trillion euros (BIC, 2020).

The 2017 data also reveal that the European bioeconomy employed 18.5 million people in total which shows a minor decrease from the 18.6 million people in 2016 – mainly through efficiency increases in production. The primary biomass production, mainly agriculture plus the forestry and fishery sectors generate a lot of employment (55%) but low turnover (20%) (Figure 1) (BIC, 2020).

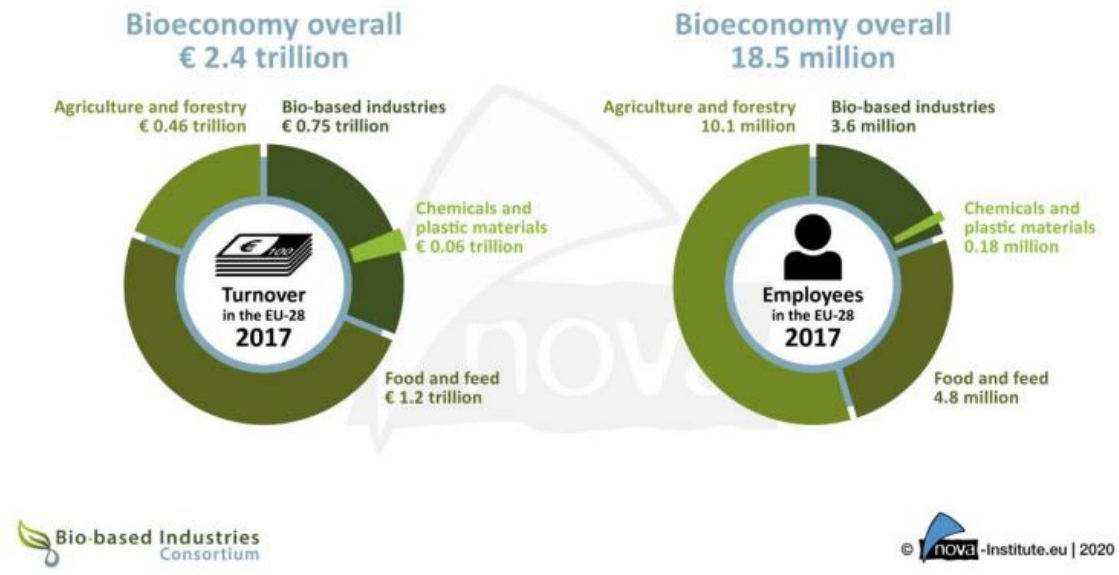

Figure 1 - Bioeconomy overall in Europe 2017 (Source: BIC, 2020)

In 2020, the total waste generated in the EU by all economic activities and households amounted to 2,151 million tons, 4 808 kg per capita. The share of different economic activities and of households in total waste generated is presented in Figure 2. In the EU, construction contributed 37.1 % of the total, followed by mining and quarrying (23.4 %), manufacturing (10.9 %), waste and water services (10.7 %) and households (9.5 %);

the remaining 8.4 % was waste generated from other economic activities, mainly services (4.5 %) and energy (2.3 %). Agriculture, forestry and fishing represent only 1% of the waste generation (EUROSTAT, 2022a).

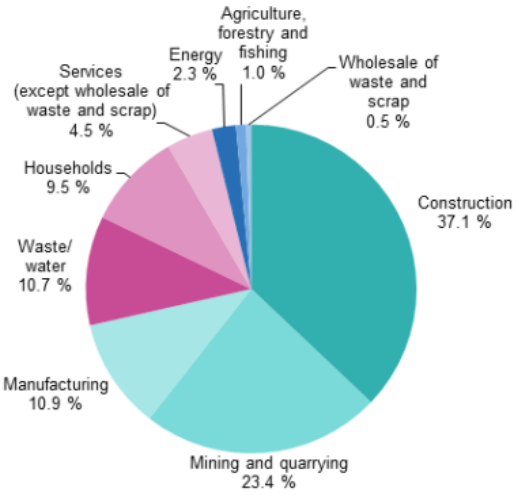

Figure 2 - Waste generation by economic activities and households, EU, 2020 (% share of total waste) (Source: Eurostat, 2022a)

Agricultural wastes production

The activities of agriculture, forestry and fishing generate a wide range of waste products, particularly animal and vegetal wastes. These include slurry and manure, as well as various green wastes including biodegradable waste.

Agriculture, forestry and fishing in the EU-27 generated 21,5 million ton of waste in 2020, which represented 1% of all the waste produced by economic activities and households in the EU (table 3). The vast majority of this waste (17.7 million ton) was animal and vegetal waste.

	Total waste	Animal and mixed food waste	Vegetal wastes	Animal faeces, urine and manure
European Union	21490000	1040000	4210000	12430000
Austria	168233	2597	23473	68581
Belgium	417301	12540	128592	1028
Bulgaria	892764	1373	234709	579690
Croatia	565300	12	1386	554615
Cyprus	21156	9940	1245	-
Czechia	398041	14655	48743	49989
Denmark	389498	6188	50779	231101
Estonia	195258	799	28835	123298
Finland	-	-	-	-
France	1291230	450087	334	300000

Germany	1004332	73107	277978	276639
Greece	758070	4581	150087	531497
Hungary	295152	9509	2536	260342
Ireland	-	-	-	-
Italy	348501	2108	45424	274
Latvia	133282	8836	36811	0
Lithuania	301722	391	249043	10034
Luxembourg	11445	-	6527	-
Malta	11851	1585	197	9469
Netherlands	4896548	213	1221013	3190981
Poland	281119	3895	42690	51536
Portugal	94347	1734	8277	31306
Romania	720130	-	699920	-
Slovakia	562354	4588	88585	422440
Slovenia	55730	123	-	-
Spain	6330651	193114	819554	4766113
Sweden	1045928	28486	42709	924180

Table 3 - Agricultural Waste Production, EU, 2020 (ton) (Adapted from: Eurostat, 2020)

The main component of animal and vegetal waste produced by this sector of the economy was animal faeces, urine and manure (Figure 3). Farms produced 12.4 million ton of this type of waste. Two-thirds of the EU's animal faeces, urine and manure waste was produced in Spain (38%) and the Netherlands (26% of the EU total).

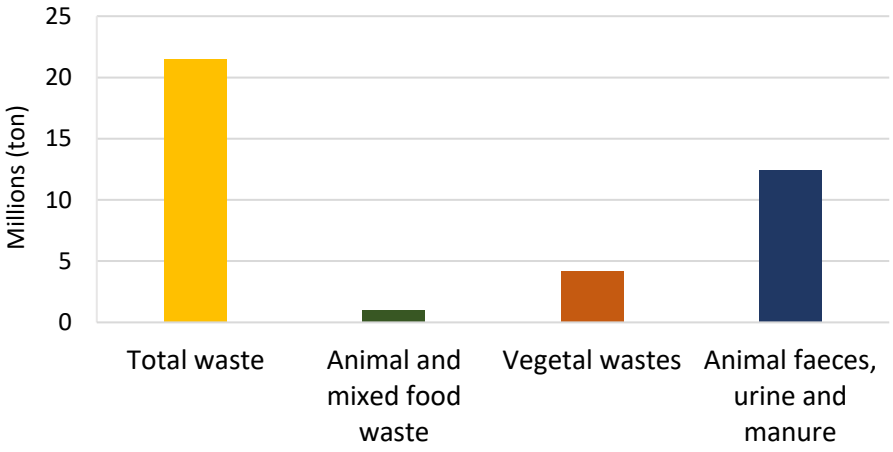

Figure 3 - Agricultural Waste Production, EU, 2020 (ton) (Adapted from: Eurostat, 2020)

Agricultural Plastic Wastes

The Organization for Economic Co-operation and Development (OECD) has defined EPR as "an environmental policy approach in which producer's responsibility for a product is extended to the post-consumer stage of a

product's life cycle". In essence, it enables producers to ensure the appropriate collection and recycling or disposal of their products at their end-of-life and internalizes environmental and other externality costs into the price of the product. The way EPR is implemented will depend on the products characteristics and therefore could be differentiated accordingly to be most effective. Most EPR schemes currently target packaging, especially at the consumer or municipal level (FAO, 2021).

Extended producer responsibility schemes may be run by individual companies, or collectively through a Producer Responsibility Organization (PRO). The individual companies or PRO can directly provide the collection and recycling service or contract a third party. In addition, they also cover, as a minimum, the costs of collecting specified products separately and ensuring that they are adequately recycled or treated, and the collation and reporting of data used to track the scheme's effectiveness. They may also be voluntary or mandated under legislation (FAO, 2021).

Several schemes currently operate within specific countries or across regions. These include schemes funded by producers or importers of products containing plastics (i.e., EPR schemes) or schemes that are funded solely by farmers and private sector waste collectors/recyclers. The latter are purely commercial operations and are only viable where the scheme operator is able to make a profit. In essence, the net cost of recycling (cost of collection and treatment of the used product less the value of the recycle) is less than all other legal disposal options (CPA, sd).

Collection and recycling efficiency varies, depending on the scheme and types of products collected. Data from APE Europe (Europe's non-packaging plastics products' association for agriculture) suggest that collection rates, calculated as the share of the quantities of plastic waste collected (and may include contaminants such as dirt or plant residues) and the amounts put on the market in selected countries, are between 50% and 84% (Figure 4), with reported recycling rates of the amounts collected varying between 80% and 100%. However, what is not known is the extent of contamination nor the quantities rejected by the recycling facility. Moreover, approximately 16% of agricultural plastics appear to remain uncollected for recycling.

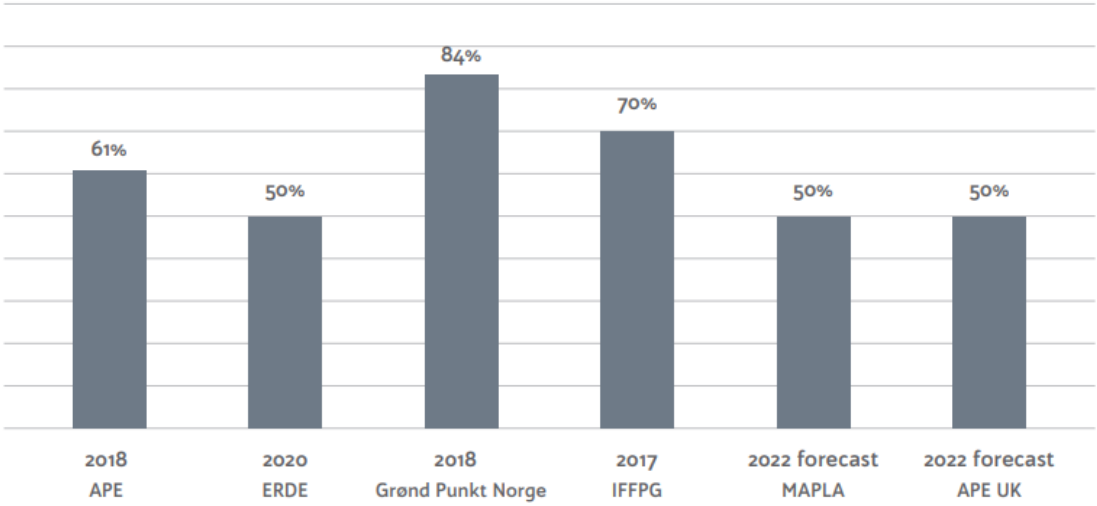

Figure 4 - Collection rates of agricultural plastics in selected European countries (Source: FAO, 2021)

There are also challenges and additional factors to consider. The lack of a formalized EPR scheme and reliance on a voluntary farmer and waste collector/ re-processor-led initiative has the potential to be vulnerable to macro- and micro-economic change. These include changes to waste legislation or a drop in revenue from recycle sales, which can turn such initiatives uneconomic. Without producer funding, these schemes can struggle to achieve a 'critical mass' of material and leverage economies of scale. This includes, for example, the development of cleaning and drying infrastructure for some agricultural plastics prior to re-processing (FAO, 2021).

3.2.2 Portugal

In Portugal, the bioeconomy represents a turnover of 41,000 million euros (11,700 million added value) and employs around 685,000 people, according to data from the Joint Research Center (JRC) of European Commission for 2017 (GPP, 2021a).

The Agriculture and Livestock sector (including associated manufacturing industries) holds a prominent position, representing 60% of the turnover generated (25,000 million euros) and 75% of employment (515,000 jobs), with primary production being responsible for ¼ of value added and for 59% of total employment (GPP, 2021a).

The Agriculture and Livestock sector has a very relevant potential in the production of biological resources, with emphasis on vegetable production, which represents 61% of the total national agricultural production (approximately 4,700 million euros in 2019) and recorded, in terms of volume, an average annual growth

rate of 2.6% over the last 9 years. In the same period, animal production decreased, representing 39% of total agricultural production in 2019, compared to 41.3% in 2010 (GPP, 2021a).

Agricultural production trends, despite some fluctuations, tend to increase steadily over time (Figure 5).

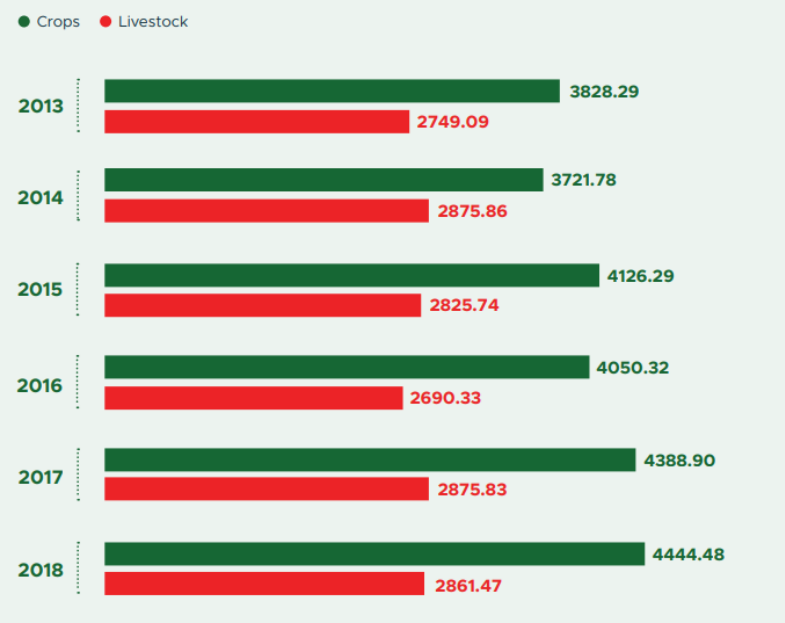

Figure 5 - Agricultural production trends (M€, Eurostat)

The different sectors of the Portuguese economy generated 11.3 million ton of waste in 2020 (Table 4). The sectors linked to "waste management and valorization", generated in 2020 around 4.2 million ton of waste (37.3% of total waste). The "manufacturing industry" is the second largest group generating waste, with a total of 2.9 million ton (26.1% of the total calculated). Agricultural, forestry and fishing sectors contributed to 0.9% of total waste generated, approximately 94,000 ton.

Economic Sector	Total (ton)	Total (%)
Agricultural, forestry and fishing	94347	0,8
Trade and services	1450546	12,8
Construction	1780360	15,7
Waste management and valorization	4222369	37,3
Extractive industry	24741	0,2
Manufacturing industry	2950436	26,1
Energy	212674	1,9
Water distribution and sanitation	587539	5,2
Total	**11323012**	**100**

Table 4 - Agricultural Waste Production, Portugal, 2020 (ton) (Source: INE, 2021b)

The relatively low percentage of total waste produced by agriculture, forestry and fishing activities is, at least in part, related to the fact that animal manure and slurry and plant biomass are not quantified in this type of statistics, since they are reused in agriculture as fertilizers or organic soil amendments (INE, 2021a).

Within the scope of Agriculture, animal production, hunting, forestry and fishing activities, a range of non-hazardous waste of different typologies is presented (Table 5). Emphasis on feces, urine and animal manure that generated 31,000 ton (33.6% of the total non-hazardous waste generated), followed by construction and demolition waste with 15,000 ton (16.2 %); plastic waste with a total of 11,000 ton (12% of the total waste generated); and vegetal biomass with 8,000 ton (8.9%).

Non-hazardous Wastes	Production (ton)
Chemical waste	126
Industrial effluent sludge	14
Waste from the provision of health and biological care	2
Ferrous metal waste	3890
Non-ferrous metal waste	171
Mixture of ferrous and non-ferrous metal waste	5610
Glass waste	41
Paper and cardboard waste	1177
Rubber waste	290
Plastic waste	11097
Wood waste	7606
Equipment out of use	86
Waste batteries and accumulators	3
Residues of animal origin from food preparations and products	1734
Waste of plant origin	8277
Animal feces, urine and manure	31306
Household and similar waste	3745
Mixed and undifferentiated	1832
Common sludge	304
Mineral waste from construction and demolition	15128
Other mineral residues	76
Combustion residues	148
Soils	473
Total	**93135**

Table 5 - Non-hazardous Waste Production, Portugal, 2020 (ton) (Source: INE, 2021b)

Regarding agricultural plastics waste management, in Portugal there is an entity responsible for the management of packaging waste from plant protection products, biocides and seeds for professional use called VALORFITO. This scheme is managed by SIGERU – Integrated System for the Management of Packaging and Waste in Agriculture, a non-profit entity, which aims to collect and forward to an appropriate destination the waste for which it is licensed.

The average recycling rate of the VALORFITO scheme stood was approximately 34.8% in 2021. This is slightly higher than the average European recycling rate which is around 30%. The waste managed by VALORFITO, from professional agriculture, stands out clearly, placing the agricultural sector in a leading position, demonstrating the responsible and sustainable approach (Macedo, 2022).

In the last decade this contributed to avoid the emissions of 4,792 ton of CO2 eq. into the atmosphere, reflecting the 3704 ton of waste collected since 2012, which corresponds to 12263 barrels or 1668 ton of oil. Over the last decade, it appears that the collection of packaging waste is closely linked to the increase in the value of avoided emissions, in a proportion of 1.3 tons CO2 eq. per each ton of waste collected (Macedo, 2022).

3.2.3 Spain

According to data from the Joint Research Center, in Spain in 2017 the bioeconomy sector generated a turnover of 219,366 million euros (9% of the total for the EU-28), 65,132 million euros of added value (10% of the total of the EU-28) and 1.42 million jobs (8% of the total of the EU-28).

At the regional level, various Autonomous Communities have or are working on some type of bioeconomy planning through specific initiatives (such as the Catalan Circular Bioeconomy Strategy), while others address it within the framework of the circular economy or through other types of regulations.

Quantifying the value of the circular bioeconomy requires a definition operation that includes all the sectors that produce materials, natural raw materials and those who use them to transform them into bio-products, biomaterials and bioenergy.

The figures for the quantification of the circular bioeconomy in Catalonia for the year 2018 for the different sectors are shown in Figure 6.

For the quantification, IDESCAT data have been used in agreement with the classification CCAE-2009 applying the weights in the input-output framework of Catalonia 2014.

	VAB		Producció		Llocs de treball	
	Mio EUR	vs. PIB	Mio EUR	vs. Total	ut	vs. Total
Agricultura, ramaderia, silvicultura i pesca	2.062	0,9%	4.967	1,1%	62.469	1,7%
- Agricultura, ramaderia i caça	1.843	0,8%	4.569	1,0%	56.564	1,5%
- Silvicultura i explotació forestal	80	0,0%	110	0,0%	2.486	0,1%
- Pesca i aqüicultura	138	0,1%	289	0,1%	3.419	0,1%
Indústries alimentació, begudes i tabac	5.836	2,4%	28.352	6,4%	96.161	2,6%
Indústries tèxtils (fibres naturals) i cuir	245	0,1%	778	0,2%	2.962	0,1%
Indústria de la fusta i del suro	428	0,2%	1.216	0,3%	8.803	0,2%
Indústries paper	1.320	0,5%	5.183	1,2%	13.307	0,4%
Bioquímica i biofarmacèutica	453	0,2%	1.851	0,4%	1.070	0,0%
Biomassa per a energia	242	0,1%	394	0,1%	39	0,0%
Residus biodegradables	346	0,1%	736	0,2%	7.163	0,2%
BIOECONOMIA	**10.932**	**4,5%**	**43.476**	**9,8%**	**191.973**	**5,2%**
Total	221.141		441.410		3.725.000	
Impostos nets sobre productes	20.546					
PIB	241.687					

Figure 6 - The Catalan circular bioeconomy in figures for 2018 (in millions of euros and jobs) (Source: Own preparation based on IDESCAT data.)

The set of activities that belong to the Catalan circular bioeconomy, in 2018, recorded the following figures (Figure 7):

- a turnover of 43,476 million euros, equivalent to 9.8% of the total value of domestic production;
- in relation to added value, the weight of the circular bioeconomy it is 4.5% of GDP (PIB);
- in terms of employment, it generates 192 thousand jobs, that is to say, 5.2% of the total

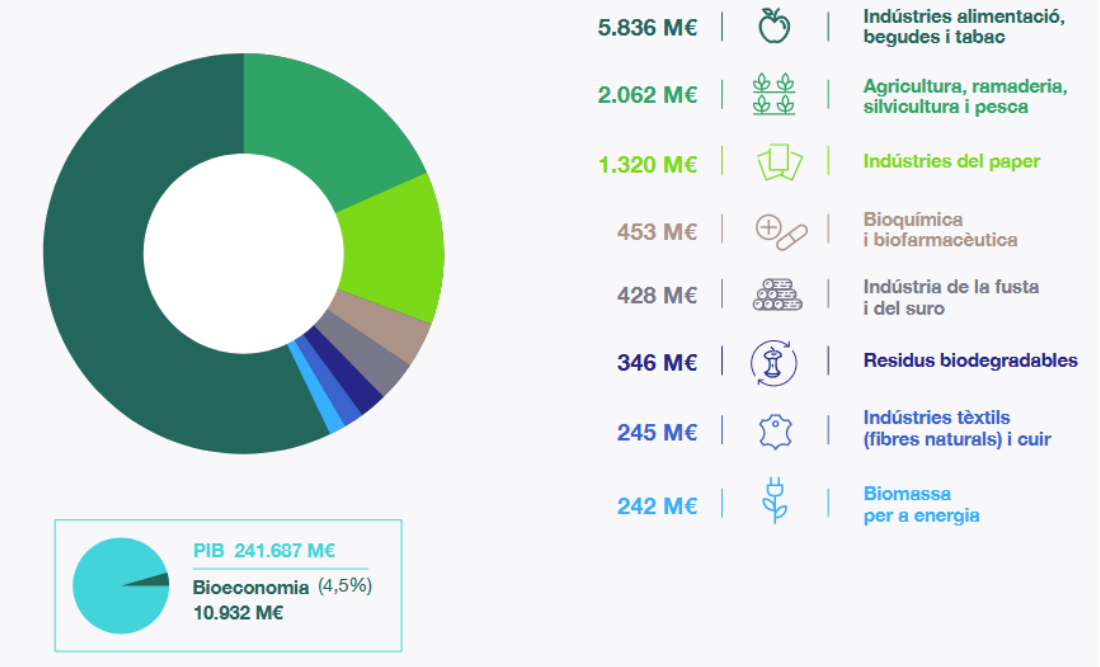

Figure 7 - The bioeconomy in Catalonia (VAB 2018, Mio EUR) (Source: Own preparation (CTFC) based on IDESCAT data)

The weight of each of the economic sectors in production, job employment and the GVA (VAB) of the Catalan circular bioeconomy (2018) is detailed in Figure 8.

The overall picture is diverse, with a plurality of sectors, actors and interests. From the data in Figure 7, it follows that the dominant sector is the food industry, which in the case of Catalonia represents 2.4% of GDP (PIB), while the rest of combined sectors represent 2% of GDP (PIB).

The development of the circular bioeconomy needs the approach foundation and the valorisation of biodegradable resources and waste on a larger scale, which requires public intervention and private in terms of regulation, management and infrastructure.

These elements make it even more important to adopt a perspective territorial and systemic, since the circular bioeconomy is not more a sum of activities, but a way of conceiving balance between humans and the environment.

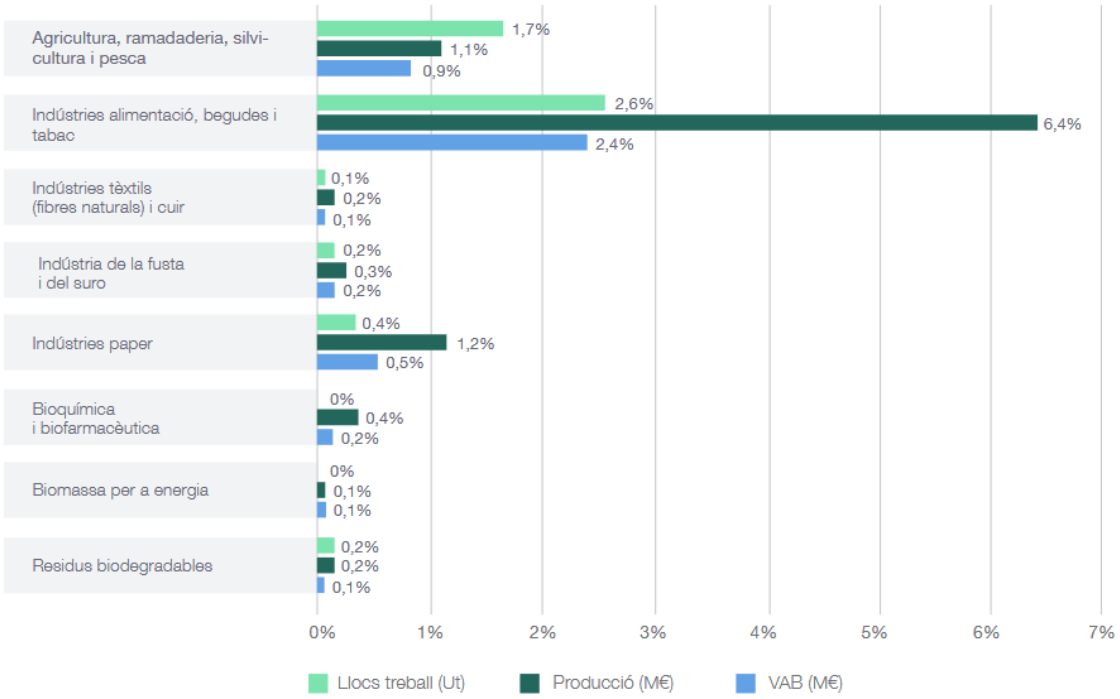

Figure 8 - Weight of the economic sectors related to the circular bioeconomy that contribute to the Catalan economy (2018). (Source: Own preparation (CTFC) based on IDESCAT data)

The biomass potential data for Catalonia is characterized by high dispersion, the difficulty in quantifying the different flows of resources and waste, and by the different quantification methods it contains. As biomass, it is understood to be the set of all organic matter of plant, animal or microbial origin, which includes the materials that come from the transformation natural or artificial.

According to data from the Waste Agency of Catalonia, the potential of biomass includes the following resources: algae, biomass forestry, bioresidues (FORM), dried fruit flakes, eggshells, bio-waste compost, vegetable waste compost, compost from manure, WWTP sludge compost, agro-industrial sludge compost trials, biowaste digestate, organic waste digestate, sludge of WWTP, agro-industrial sludge, waste bin sludge, manure, wood of forest exploitation, grass, dredging sludge, waste food, coffee brown, oliasses, straw, food losses, pine silage/sansa, tree pruning, slurry, slaughterhouse waste, scraps harvest, natural wood sawdust, industrial by-products tria, cork and vinasses.

Figure 9 shows the list of biomass resources, sector productive, location, competent bodies and quantity. As it can be observed, numerous data are missing, which is obvious the need to better characterize the current amount like the biomass potential of Catalonia.

Biomssa / Recurs	Sector productiu	On es produeix	Organismes competents	Quantitat (t/any) 2019	Potencial
Algues	Sistemes Naturals, Aqüicultura	Llacs, Mar, Pantans, Platges, Rius	EELL / AOA / OHE / DARP / ICAEN	n.d.	n.d.
Biomassa (Forestal)	Aprofitaments Forestals, Indústria de la fusta i de la Biomassa	Boscos, serradores, indústria de biomassa	DARP / OTFO / OPF / FO / EELL / ICAEN / ARO	600.000 t	n.d.
Bioresidus (FORM)	Residus Municipals	Domicilis, comerços, allotjament (hotels, campings, etc.), restauració (restaurants, bars, etc.) , escoles, etc.	ARO / EELL	400.000 t	1.200.000 t
Clofolles de fruita seca	Indústria de la fruita seca	Empreses de desclofollat de fruita seca	DARP / ARO	2.000 t	n.d.
Closques d'ou	Indústria Avícola	Incubadores d'ous, granges ponedores d'ous	DARP / ARO	525 t	n.d.
Compost de biorresidus	Gestió de residus	Plantes de Compostatge. A Catalunya es tracta de plantes majoritàriament públiques	ARO / DARP / EELL	35.000 t	180.000 t
Compost de residus vegetals	Gestió de residus	Plantes de Compostatge (públiques i privades), empreses de jardineria	ARO / DARP / EELL	n.d.	n.d.
Compost de fems	Gestió de residus	Plantes de Compostatge privades, Granges	ARO / DARP	n.d.	n.d.
Compost de fangs d'edar	Gestió de residus	Plantes de Compostatge (públiques i privades)	ARO / AOA	266.180 t	n.d.
Compost de fangs agroindustrials	Gestió de residus	Plantes de Compostatge privades	ARO / DARP	n.d.	n.d.
Digest(at) de bioresidus	Gestió de residus	Plantes de digestió i codigestió de bioresidus (centralitzades o descentralitzades)	ARO	1.600 t	n.d.
Digest(at) de residus orgànics	Gestió de residus	Plantes de digestió i codigestió d'altres residus orgànics (centralitzades o descetralitzades)	ARO / AOA / DARP	230.000 t	n.d.
Fangs d'edar	Gestió de residus	Depuradores d'aigües residuals urbanes	AOA / ARO	500.000 t	n.d.
Fangs agroindustrials	Sector Agroindustrial	Depuradores d'indústries agroalimentàries	ARO / DARP	210.000 t	n.d.
Fangs de paperera	Indústria Paperera	Depuradores de la indústria paperera	ARO / DARP	n.d.	n.d.
Fems	Ramaderia	Granges d'animals (bovins, ovins, cabrum, porcins, aviram, equins, conills, altres)	ARO / DARP	9.954.096 t	n.d.
Fusta d'aprofitament forestal	Aprofitament Forestal	Treballs forestals	ARO / OPF / OREAF / OTFO / DARP / FO	n.d.	n.d.
Gespa	Jardineria	Manteniment de jardins (publics i privats), camps d'esports, camps de golf, etc.	ARO / EELL	n.d.	n.d.
Llots de dragatge	Manteniment d'infraestructures hidràuliques	En tasques de dragatge de riu6, canals, ports, embassaments, pantans, etc.	AOA / ARO / EELL / OHE	n.d.	n.d.
Malbaratament alimentari	Sector agroalimentari, sector de la distribució, sector restauració	Al llarg de la cadena de producció i consum d'aliments	ARO / DARP	260.000 t	n.d.
Marro de cafè	Sector agroalimentari	Indústria de torrefacció de cafè	ARO / DARP	8.000 t	n.d.
Oliasses	Sector agroalimentari	Indústria Oleícola	ARO / DARP	11.000 t	n.d.
Palla	Sector Agrícola	Conreus cerealístics	DARP	n.d.	n.d.
Pèrdues alimentàries	Sector agroalimentari	Indústria Fruticola i Hortícola	DARP / ARO	n.d.	n.d.
Pinyolada / Sansa	Sector agroalimentari	Indústria Oleícola	ARO / DARP	n.d.	n.d.
Poda d'arbres	Residu Municipal	Parcs i Jardins	ARO / EELL	1.900 t	n.d.
Purins	Ramaderia	Granges d'animals	ARO / DARP	$9{,}4{*}10^6$ t[20]	n.d.
Residus d'escorxador	Sector agroalimentari	Escorxadors	ARO / DARP	19.000 t	n.d.
Restes de collita	Sector Agrícola	Cereals, Horticultura	DARP	n.d.	n.d.
Serradures (de fusta natural)	Sector Forestal	Serradores	DARP / OPF / OREAF / OTFO / FO / ARO	31.000 t	n.d.
Subproductes de la indústria	Sector agroalimentari	Indústria alimentària	DARP / ARO	n.d.	n.d.
Suro	Sector Forestal	Indústria del suro	DARP / OPF / OREAF / OTFO / FO / ARO	n.d.	n.d.
Vinasses	Sector agroalimentari	Indústria vitivinícola	DARP / ARO	47.000 t	n.d.

Figure 9 - List of biomass resources, production sector, location, competent bodies and quantity produced in 2019 in Catalonia. (Source: Waste Agency of Catalonia)

3.2.4 Italy

The Italian bioeconomy includes all the main sectors of primary production, i.e. agriculture, forestry, fisheries and aquaculture, those of the transformation of biological resources, such as the paper industry, wood processing, biorefineries, biotechnology industries and some industries associated with the sea. Together, it currently achieves around 250,000 million euros/year in turnover and 1.6 million jobs.

Tables 6 and 7 show estimates of biomass units produced and amounts of plastic waste produced in Italy.

Type of biomass	Origin	Volume prod./year	Unit	Season	Location	Data source
Straw	Forage crops	14.270.944	(t/year) (dry matter)	October – March	ITALY	Pierro et al., 2021
Pruning	Pruning waste	2.264.224	(t/year) (dry matter)	All year	ITALY	Pierro et al., 2021
Shells	Scraps of dried fruit shells	117.950	(t/year) (dry matter)	August – November	ITALY	Pierro et al., 2021
Pomace	Pomace: waste from oil mills and pomace factories	424.332	(t/year) (dry matter)	October – December	ITALY	Pierro et al., 2021
"Pastazzo" (Citrus Paste)	Citrus Paste	302.467	(t/year) (dry matter)	November – June	ITALY	Pierro et al., 2021
"Vinaccia" (Vine Scraps)	Wine Waste	824.489	(t/year) (dry matter)	June – October	ITALY	Pierro et al., 2021
Vegetal Oil	Vegetal Oil	322.269	(t/year)	All year	ITALY	Pierro et al., 2021

Table 6 - Biomass in Italy (Pierro et al.,2021)

Type of plastic	Origin	Volume prod./year (tons years^{-1})	Season	Location	Data source
Plastic films Mulch films Irrigation pipes	Different crops	54.569.23	All year	Italy	Cillis et al., 2022
Greenhouse and walking tunnel films (in use)	Different crops	54.675.00	All year	Italy	Briassoulis et al., 2013
Greenhouse and walking tunnel films (waste)	Different crops	18.225.00	All year	Italy	Briassoulis et al., 2013
Small tunnel films (in use)	Different crops	29.350.00	All year	Italy	Briassoulis et al., 2013
Small tunnel films (waste)	Different crops	29.350.00	All year	Italy	Briassoulis et al., 2013
Direct covers NW fabrics (in use)	Different crops	25.000.00	All year	Italy	Briassoulis et al., 2013
Direct covers NW fabrics (waste)	Different crops	3571,00	All year	Italy	Briassoulis et al., 2013
Mulching films (in use)	Different crops	46.495.00	All year	Italy	Briassoulis et al., 2013
Mulching films (waste)	Different crops	46.495.00	All year	Italy	Briassoulis et al., 2013
Sum of specific agricultural plastic use and waste generation per country (t/year) (in use)	Different crops	155.520.00	All year	Italy	Briassoulis et al., 2013
Sum of specific agricultural plastic use and waste generation per country (t/year) (waste)	Different crops	97.641.00	All year	Italy	Briassoulis et al., 2013

Table 7 - Agricultural Plastic Waste in Italy (Cillis et al., 2022, Briassoulis et al., 2013)

Concerning the analysis of the economic situation and the dynamics of collection, transport and disposal of one of the most worrying agricultural wastes in Italy (plastics), it can be noticed that it's very difficult to know the right amount of agricultural used plastic materials and the situation worsens in establishing the production of agricultural plastic waste due to high amount disposed in illegal ways (burned, buried, traded to other Countries, etc.).

Calculating the economic value of agricultural plastic waste, to be considered a "source" to recovery, is a very challenging task. Agricultural plastic wastes can be recycled through mechanical or chemical recycling, or used to produce energy, but the main point is that they come recovered in order to have economic and environmental benefits. In Italy, for example, during the 2019 year, the PolieCo Consortium has produced 375,000 tons of recycled material (not all from the agricultural sector), saving up both about 200,000 equivalent tons of oil (the first material) and 225,000 kWh of energy and avoiding the letting in the air of about 637,500 tons of CO2, too. All that in front of a cost of recover among the lowest of Europe, 15.60 €/tons.

Besides, in order to limit the export of the plastic waste toward other countries, the PolieCo Consortium has tried to sustain the companies in the waste disposal cost, helping them with an economical contribution. It was proportioned (suitable for) to the industrial/farming activity. The economical contribution binds the associated members (industry or farm) to don't export the plastic waste illegitimately out of UE (the loss of the contribution is the penalty).

Finally, the continuous increase of the price of crude oil is another cause that probably has an influence on the collection rate of the agricultural plastic waste.

The collaboration between PolieCo and the Italian Waste National Observatory has permitted to the Consortium to offer to the associate firms the possibility to achieve the certification of the regenerated products. This certification offers the guarantee to buy a "different" product, performed with technical adjustment, with respect to an anonymous and ambiguous product, like some Asian products. PolieCo has already listed in the Repertoire of the Recycling several firms, for which the consortium will sustain, as for the other, the economic burden.

3.2.5 Greece

The Bioeconomy sector today in Greece registers a turnover of about 27,000 million euros and about 500,000 employers. About 80% of their activities are directly or indirectly related to the agricultural sector. Agriculture is a significant sector in the Greek economy and it contributes 4.1% to the Greek Gross Domestic Product (GDP) accounting for 70% of agricultural products and 30% of animal product (Papadopoulou, et al., 2018).

As regards agricultural waste, in the year 2018 the total production was 12.469.086 tons, accounting for 40.3% of the total waste production in Greece. More specifically, the exact produced quantities in the reference year (2018), of each of the agricultural wastes, as well as the estimation of the future production, are shown in the table below.

Agricultural waste	Production in the reference year 2018 (tons)	Production 2020 (tons)	Estimated production 2025 (tons)	Estimated production 2030 (tons)
Crop residues	2.297.336	2.200.526	2.418.190	2.528.985
Withdrawn fruits & vegetables	129.138	123.696	135.931	142.159
Livestock waste	10.033.312	9.610.508	10.561.127	11.045.010
Waste plant protection products	800	800	879	919
Agricultural plastic waste	8.500	8.500	9.341	9.769
Total production (tons)	12.469.086	11.944.030	13.125.468	13.726.842

Table 8 - Evolution of agricultural waste production until 2030, Greece, (Source: National Waste Management Plan, including hazardous waste, 2020-2030)

Important data can be obtained from a study about technical and achievable potential of advanced biofuels, renewable gases and recycled carbon fuels for the Greek transport sector until 2050, in which is presented the waste potential in Greece for a reference year and is also estimated the waste potential until 2050.

The feedstocks analysed and examined in this study are: the biomass fraction of mixed municipal solid waste (MSW), the biomass fraction of industrial waste, straw, animal manure and sewage sludge, fruit tree pruning, grape narcs and wine lees, used cooking oil (UCO), crude glycerine, perennial crops, CO2 feedstocks from industrial sources and plastics.

In the table below is presented the feedstock potential in Greece (million tonnes of dry matter content) for the years 2020, 2030, 2040, 2050.

			2020	2030	2040	2050
Biomass fraction of mixed municipal waste		Theoretical	2.02	1.96	1.90	1.82
		Technical	1.98	1.88	1.77	1.63
Biomass fraction of industrial waste	**Olive Mills**	Theoretical	0.43	0.43	0.43	0.43
		Technical	0.26	0.26	0.26	0.26
	Cotton Mills	Theoretical	0.13	0.13	0.13	0.13
		Technical	0.08	0.08	0.08	0.08
	Rice Mills	Theoretical	0.03	0.03	0.03	0.03
		Technical	0.02	0.02	0.02	0.02
	Tobacco	Theoretical	0.02	0.02	0.02	0.02
		Technical	0.01	0.01	0.01	0.01
	Sewage Sludge	Theoretical	0.12	0.14	0.15	0.16
		Technical	0.12	0.14	0.15	0.16
Agricultural Residues	**Straw**	Theoretical	1.06	0.93	0.81	0.71
		Technical	0.21	0.19	0.16	0.14
	Animal Manure (wet tons)	Theoretical	11.20	10.60	10.00	9.50
		Technical	7.28	6.89	6.50	6.18
	Grape Pomace	Theoretical	0.93	0.93	0.93	0.93
		Technical	0.56	0.56	0.56	0.56
	Olive Tree Prunings	Theoretical	1.10	1.10	1.10	1.10
		Technical	0.55	0.55	0.55	0.55
	Fruit Tree Prunings	Theoretical	0.62	0.62	0.62	0.62
		Technical	0.31	0.31	0.31	0.31
	Used Cooking Oil	Theoretical	0.03	0.03	0.03	0.03
		Technical	0.03	0.03	0.03	0.03
	Crude Glycerine	Theoretical	0.02	0.02	0.02	0.02
		Technical	0.02	0.02	0.02	0.02
	Perennial Crops	Theoretical	1.17			
CO_2 Feedstocks	**Production of Steel & Iron**	Theoretical	0.12	0.12	0.12	0.12
		Technical	0.12	0.12	0.12	0.12
	Petroleum Refining	Theoretical	5.60	5.04	4.48	3.92
		Technical	5.60	5.04	4.48	3.92
Non-Recyclable Wastes	**Plastics**	Theoretical	0.70	0.63	0.56	0.49
		Technical	0.63	0.50	0.39	0.29

Table 9 - Feedstock potential in Greece in million tonnes of dry matter 2020-2050, (Source: Paris et al., 2021, Feedstock analysis, technical and achievable potential of advanced biofuels, renewable gases and recycled carbon fuels for the Greek transport sector

Considering the biomass, it remains largely unexploited not only in Greece but worldwide. On average, around 14% of the total biomass is exploited globally (mostly in the field of energy) although 1 ton of biomass is equivalent to about 0.4 tonnes of fossil oil. Biomass residues are also not exploited. It is estimated that

waste generation in Greece is approximately 58 million tons/year, including agricultural and industrial waste (53%) and livestock manure (47%). However, only 3% of total biomass is exploited in Greece, mainly as a fuel, while the most widespread practice at least for the management of organic wastes is burning and landfilling. Based on the anaerobic treatment scenario, 21.9 TWh of electricity can be generated from the biomass in Greece, accounting for a 39% of gross electricity consumption in the country. The exploitation of agricultural and forest residues could compensate for the consumption of 3-4 million tons of petroleum per year, while the exploitation of energy crops could save 30-40% of the amount of fossil oil consumed annually in the country (Papadopoulou, et al., 2018).

3.2.6 France

The objectives pursued by the national policy, as defined by the energy transition law for green growth of August 2015, are to avoid producing waste through prevention and reuse, to increase material recovery, as well as the energy recovery of unavoidable waste that cannot be recovered in material form, by achieving 55% recycling of waste by 2020.

In 2015, the turnover in the bio-economy sector for France was 333,000 million euros (14.7% of the EU turnover). Food, beverages and tobacco represent more than half of France's bio-economy sector (measured in terms of turnover), and the agriculture presents just over 20% of the total bio-economy sector. Other important sectors are the biobased chemicals, pharmaceuticals, and the plastics and rubber sector (7.5%) (NEA, 2019).

In 2016, the INSEE-ESANE database lists 8,243 companies in the waste, collection, treatment and disposal, "recovery" and "depollution" sectors, with 6,232 having a recycling activity, 1,274 a collecting activity and 737 a treatment activity. According to the SDES (Statistical Data and Studies Service), 111,650 jobs were linked to waste management or recycling activities in 2017. According to the national recycling report, in 2017, the collection and preparation of materials for recycling represented 28,000 jobs in France, with a turnover of 9 billion euros.

3.3 Social Situation

3.3.1 European Union

In accordance with EUROSTAT (2020), agriculture remains a big employer within the EU; the equivalent of an estimated 8.8 million people worked full-time in agriculture in 2019. People working in agriculture (and

hunting) accounted for an estimated 4.5% of total employment in the EU in 2017. Particularly in Romania agriculture is a big employer, accounting for a little less than one in every four persons (22.8%).

Farmers are typically male and relatively old (Figure 10). Seven in every ten (71.2%) farmers in the EU in 2016 were male and a majority (57.8%) of all farmers were 55 years of age or more. Only about one in every ten (10.7%) was a young farmer under the age of 40 years. This top-heavy age structure underlines the policy interest in farm succession and the need to encourage a new generation of farmers.

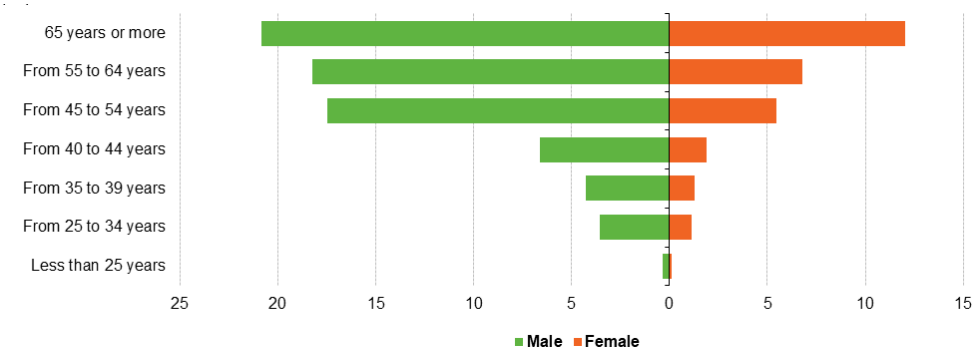

Figure 10 - Farm managers by age, class and sex, EU-27, 2016 (Source: Eurostat)

Aside from their vital role of providing inputs for food processing, the EU's farmers are increasingly being asked to adapt their farming practices in relation to a range of subjects, such as animal welfare, protection of natural habitats and landscapes, sustainability and other environmental aspects. To do so, farmers and their workforces will likely need to reskill, among other things, to use emerging digital technologies, become data analysts and rural innovators (EUROSTAT, 2022b).

Awareness and Training

The lack of awareness and training of farmers regarding the environmental and health implications of incorrect disposal of agricultural waste is one of the main problems in waste management.

Awareness-raising tools, including projects, campaigns, brochures and training courses can be easily carried out by entities involved in the agricultural sector, with the aim of making farmers aware of the importance of the correct waste management.

Training farmers to implement a waste management policy is an essential requirement for successful agricultural waste management improvements. However, training is not a goal in itself, rather, it is a mean to achieve a goal, such as changing behaviour to improve management practices. Training is successful if it leads to observable improvements in performance.

For this reason, training should be used alongside other tools, such as media (e.g., posters, signs, television programmes), incentives (i.e., prizes and individual recognition) and information sharing sites (e.g., best practices, monitoring, reflective supervision and corrective action on agricultural residues).

Very few farmers in the EU have full agricultural training. Most farmers in the EU only have practical experience; this was the case for seven in every ten (68.3%) farmers in 2016. Less than one in ten (8.9%) farmers had full agricultural training, and the rest (22.7%) had basic agricultural training (EUROSTAT, 2022b). In 2016, of the 10.3 million farmers in the EU, 916,000 (or 8.9%) had received full agricultural training. In other words, the overwhelming majority of farmers had not received training in a higher education establishment. There were however considerable differences between EU Member States. For example, a majority (52.8%) of farmers in Luxembourg had completed full agricultural training, while this share was also higher than one third in Czechia (38.7%) and France (34.9%). By contrast, fully trained farmers accounted for no more than 2.5% in southern and eastern EU Member States (which were characterised by high shares of older farm managers): Portugal, Croatia, Spain, Malta, Greece, Cyprus and Romania (where the lowest share, 0.4%, was recorded) (EUROSTAT, 2022b).

The share of trained farmers progressively falls as a function of age, with very few farmers aged 65 years or over having completed full agricultural training (2.5%). This may represent that agricultural training can, among other consequences, have an influence on the environmental impact of agriculture, as a greater proportion of younger farmers are more susceptible to issues related to the circular economy, sustainability and waste management (EUROSTAT, 2022b).

3.3.2 Portugal

In 2020, the population employed in the agriculture, livestock, hunting, forestry and fishing sector was 255,800 people, which represented 5.3% of total jobs in Portugal. About 68% of the population employed in the primary sector are men (GPP, 2021).

According with GPP (2021), since the beginning of the 21st century, the sector lost around 368,800 jobs, reflecting not only the abandonment of the activity but also its technological modernization.

Awareness and Training

The educational level of the population employed in the agriculture, livestock, hunting, forestry and fishing sectors has always been low in Portugal. According to INE (2020), 48% of the population employed in this sector completed only the 1st cycle of studies and 8% did not have any level of education. With the 2nd and 3rd cycles of schooling completed, 31% of the population is employed in the sector. The number of people

with higher education represents only 3.7% of the total number of employees in the sector. The number of people with secondary and post-secondary education represents 9% of employment in the sector (Figure 11).

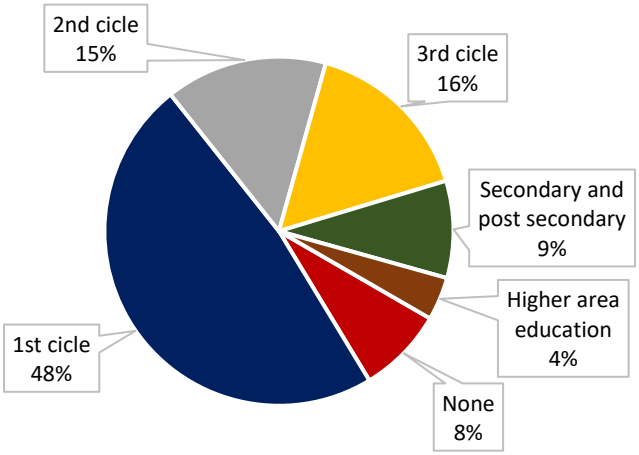

Figure 11 - Educational level of the population employed in the agriculture, livestock, hunting, forestry and fisheries sector, %, 2020 (Adapted from: INE, 2020)

However, there is a trend towards an increase in the level of education and training in the sector. This trend is also reflected in waste management and represents the evolution of the sector in recent years. According with Macedo (2022), there was an increase from 243 ton of packaging waste collected in 2012 to the current 512 ton in 2021, reflecting the results of training, professionalization and implementation of good environmental practices in the sector.

3.3.3 Spain

In the agricultural sector, according to data from the 2020 Agrarian Census (INE-Spain; 2020a), the owner's workforce represents 46%, that of the owner's family members 22%, and hired labor 33%. And as for the dedication to the exploitation according to the units of work-total year (UWTY), only 18.5% have a dedication to 100%, and with a dedication between 50 and 100%, 34.4%, and less than 50% the 65.6%, which indicates that full dedication to the sector is low and that many workers share their dedication with other activities in other sectors.

Awareness and Training

The educational level of the employed population in the agriculture, livestock, hunting, forestry and fishing sectors in Spain according to the data for the year 2001 from the latest active population survey available (INE-Spain; 2022), the 52.9% of the employed population in this sector completed only the 1st cycle of studies

and 2.9% had no educational level. With the 2nd and 3rd cycle of schooling completed, 38.3% of the population is employed in the sector. The number of people with higher education represents 5.8% of the total number of employees in the sector (Figure 12).

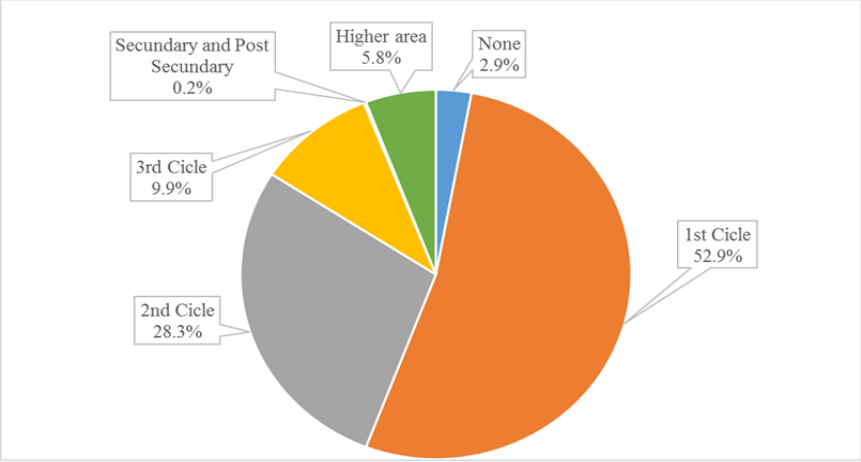

Figure 12 - Educational level of the population employed in the agriculture, livestock, hunting, forestry and fisheries sector, %, 2001 (Adapted from: INE-Spain, 2022)

In the second quarter of 2022, the employed population in the agriculture, livestock, hunting, forestry and fishing sectors was 729,000 people, which represents 3.5% of total employment in Spain; and where 77.7% of the employed population in the sector are men (INE-Spain, 2022). In the first quarter of 2008, the active population in the aforementioned sector was 870,100 (INE-Spain, 2022), which means a loss of active population of 141,100 people, which reflects not only the abandonment of the activity but also its modernization technological.

According to the 2020 Agrarian Census (INE-Spain; 2020) farmers are usually men and relatively older (Figure 13). Nearly seven in ten (68%) farmers in 2020 were male, and the majority (62.2%) of all farmers were 55 years of age or older. Only one in five (18.2%) were farmers under 44 years of age. This age structure with an aging population highlights the policy interest in farm succession and the need to encourage a new generation of farmers.

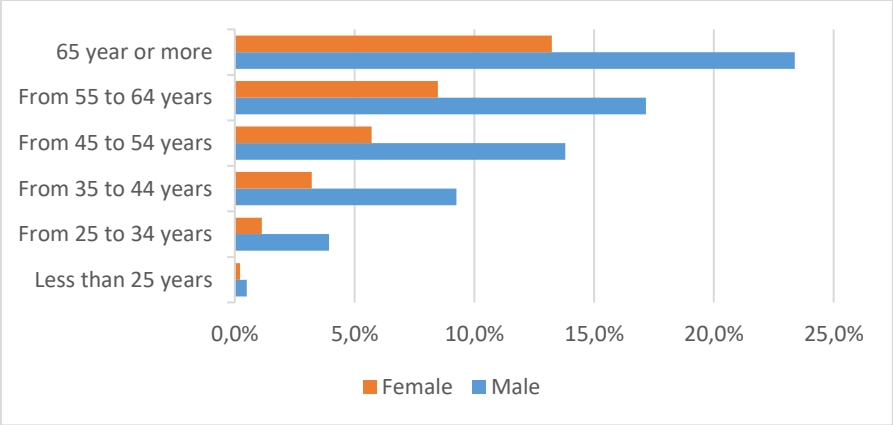

Figure 13 - Farm managers by age and sex, 2020 (Adapted from INE-Spain; 2020)

However, there is a trend towards an increase in the level of education and training in the sector. This trend is reflected in the management of agricultural packaging collection, which went from 3,834 tons of packaging waste collected in 2017 to 4,899 tons in 2021 (Sigfito; 2020), which reflects the results of training, professionalization, and implementation of good environmental practices in the sector.

3.3.4 Italy

In 2020, according with CREA (2022), the population employed in the agriculture, livestock, hunting, forestry and fishing sector was approximately 1 million people, which represented 4.3% of total jobs in Italy. About 70.5% of the population employed in the primary sector are men and 32.5% of the agricultural labour force was below 40 years old; 60.6% of those working in agriculture were 40-64 years old; and 6.9% were older than 64 (EUROSTAT, 2017).

Awareness and Training

The educational level of the population employed in the sectors of agriculture, livestock, hunting, forestry and fishing in Italy, according to data for the year 2016 (EUROSTAT, 2017), is distributed as follows: 61% of the population employed in this sector completed only the 1st cycle of studies; 34.7 completed the 2nd and 3rd cycles of schooling; and the number of people with higher education represents 4.2% of the total number of employees in the sector.

Besides educational attainment levels, more detailed information on the agricultural training of farm managers is also very important. In Italy, 3.1% of farm managers had only practical experience, 90.8% had basic agricultural training and 6.1% had followed full agricultural training (EUROSTAT, 2017).

3.3.5 Greece

The social situation related to the Agricultural waste sector, is important and has significant effects, considering that the 10.7% of the total population of Greece is being occupied in the Agricultural sector (Apostolopoulou, 2019).

In terms of agricultural employment, the absolute number of people has decreased significantly over time. The ratio employees in agricultural sector to the total number of employees decreased from 24% in 1989 to 15.2% in 2000 and 10.6% in 2017 but still remains significantly higher than the average of 4.4 % in 2017 in the European Union. Thus, in 2017 in Greece, 453,440 thousand people worked in agriculture (Paschalidis et al., 2021).

Awareness and Training

According to ELSTAT in 2016, 34.5% of the general population and 4.5% of the agricultural sector graduated from higher education. Some years before (in 2009), 1.49% of Greek farmers hadn't gone to school at all, 2.92% didn't completed the primary education, 56.6% completed the primary education, and 15.43% took a certificate of compulsory secondary education. Furthermore, only 19.74% graduated from high school and 3.83% hold degrees from Technological institutions and universities. However, it is important to be mentioned, that there is an improvement in the educational level in relation to a previous survey by ELSTAT and this is due to the retirement of a large part of the rural population that bequeaths the agricultural business to the children who have obtained a better level of education (Tsigkoias, 2020).

3.3.6 France

In France, over the past few years, while the size of farms has increased, the share of agricultural operators in employment has dropped dramatically, from 7.1% in 1982 to 1.5% in 2019. In the year 2020, the population employed in the agricultural sector was 759,000 people (Chardon et al., 2020).

In 2019, 3/4 of farmers are men, a proportion that has been growing for forty years, and more than half are aged 50 or over. The proportion of young farmers under the age of 40 remains stable (20%) in 2020. At the same time, the proportion of women running farms stabilizes at 27% in 2020 (Chardon et al., 2020).

Awareness and Training

The educational level of the population employed in the sectors of agriculture, livestock, hunting, forestry and fishing in France, according to data for the year 2016 (EUROSTAT, 2017), is distributed as follows: 24.1% of the population employed in this sector completed only the 1st cycle of studies; 58.8 completed the 2nd

and 3rd cycles of schooling; and the number of people with higher education represents 17.1% of the total number of employees in the sector.

Besides educational attainment levels, more detailed information on the agricultural training of farm managers is also very important. In Italy, 38.4% of farm managers had only practical experience, 32.2% had basic agricultural training and 29.3% had followed full agricultural training (EUROSTAT, 2017).

3.4 Technical Situation

Agricultural Waste Management Operations

According to the new EU guidelines, waste management operations are based on the concept of waste hierarchy (Figure 14). This concept, as mentioned above, aims to reduce waste production and disposal, as well as improve its monitoring throughout the production cycle. It also aims to reduce the volume of waste at source and manage its production, seeking to achieve a balance between the need to produce waste and its environmental impact.

Figure 14 - Waste Hierarchy Pyramid (Source: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en)

According to this concept, Prevention and Reduction appear at the top of an inverted pyramid. These are the most important steps and to which priority should be given, followed by Reuse. In case it is not possible to

reuse it, Recycling or another form of Valorization should be the option. Disposal should be viewed as the last management option. This principle aims to minimize the disposal of waste in a sanitary landfill or in the surrounding environment.

The main waste management operations involving different techniques are (CAP, 2022):

a) Prevention / Reduction

The prevention and/or reduction of waste production is the most important strategy of the management options, insofar as by avoiding the production of certain wastes one is contributing to the reduction of its environmental impacts. In this sense, waste must be minimized or avoided in the very places where it is generated, through practices that tend to reduce the quantities produced as a whole and/or potentially polluting substances.

b) Reuse

Reuse consists of reintroducing, without significant alterations, substances, objects or products into production or consumption circuits in order to avoid the production of waste. In other words, this process concerns the use of some of the waste components for identical or similar purposes to those of their original use, without the need to change their physical and chemical characteristics.

c) Recycling

In waste management, recycling is a necessary component. If properly designed, it can generate significant economic and social benefits, namely savings in the consumption of resources or landfill space, reduced pollution, increased efficiency of other processes such as composting or combustion. It also gives citizens an active role in improving the quality of the environment.

The recycling process involves the chemical or physical transformation of waste or its components. The recycling of some waste components, in order to obtain secondary raw materials, allows saving the use of virgin raw materials.

d) Valorization

The valorization process can be done by different forms: material valorization, agricultural valorization, organic valorization and energy valorization.

- **Agricultural Valorization**

Agricultural valorization is associated with the application of residues directly to the soil, such as fertilizers and/or correctives, contributing to the increase of the soil's organic matter content, with all the advantages that come from it in terms, for example, of soil fertility and increasing its water-holding capacity.

- **Organic Valorization**

In organic valorization, the transformation of the organic fraction present in the waste occurs, giving rise to a compound that can be used in agriculture, with various applications.

- **Energy Valorization**

Energy valorization consists of recovering energy from waste, through incineration, co-incineration, anaerobic fermentation to obtain biogas, or combustion processes. The latter consistes of energy production through the combustion of gases produced by those materials.

- **Alternative ways of Valorization**

Over the years, other waste valorization techniques have emerged, based on biotechnological or biological processes. The polyphenolic contents of some of the agro-food residues and their antioxidant activity reveal the potential of some materials for application in the pharmaceutical and cosmetic industries.

e) ***Disposal***

Landfill disposal was the main form of disposal that was used in the past, but now it no longer makes sense to consider it as an option. Landfill, which faces increasing legislative barriers, namely through the Landfill Directive (Directive 2018/850 of the European Parliament and of the Council) and the demanding standards that it establishes in the very near future and that point towards a large-scale reduction of landfill of all waste suitable for recycling or other energy or materials valorization.

In landfill, through biological processes, the biodegradable fraction of waste is decomposed, neutralized and stabilized, giving rise to an essentially inert material. However, as decomposition proceeds, leachates are formed and greenhouse gases are released into the atmosphere, which is why landfilling of waste should be seen as the last option in the hierarchy of waste management operations and it should only be carried out when there is no possibility of applying the alternatives described above.

3.4.1 European Union

In Europe bioeconomy can be divided into a traditional part (agro-food, feed, paper and pulp sectors) and an emerging part (chemical, material and pharmaceutical sectors). Although there are some approaches and data on the traditional part, however, depending on the regions and countries there is a lack of information on the available amounts for potential by-products to be integrated in bioeconomy. Furthermore, there is a lack of information and data for its emerging innovative industries, such as chemistry and material sectors that process biomass into bio-based intermediate and end products (Kardung et al. 2019). An enormous quantity of organic waste is produced annually within the EU. By far, agriculture is the biggest contributor in organic rejects, followed by yard and forestry waste, sewage sludge waste water treatment plant, food processing waste and organic fraction of municipal solid waste (Bidlingmaier et al 2004). The unused biomass

at farm must be disposed as a special waste according to the European Waste Code (EWC) with additional fee charges for farmers (DeConato, 2020). In most European countries, plant biomass is self-composted in the fields and, depending on the type of straw or matter, it can be sold as feed for livestock production. In the bioeconomy framework, unused plant biomass on the farm should be avoided and introduced to boost the circular economy. Of special interest are the plant by-products from fruit and vegetables, which are an important source of potential products and chemicals coming from the whole food supply chain (orchards, agrofood industry, central markets, domestic waste). From them it is possible to extract bioactive compounds, enzymes and exopolysaccharides production, bioplastics synthesis, and biofuels manufacture (Esparza el al. 2020). In several European countries in general terms, it could be said that fruit and vegetable wastes represent the largest group in the composition of domestic food waste produced in Europe, followed by cereal products.

Animal manure biomass production and treatment has become an issue of concern in many EU farms in order to adequate their productions to the requirements of available arable lands, where usually this biomass is applied. Flotats et al. (2009) performed a comparative study of different scale manure producing farms with varied valorisation experiences (anaerobic digestion; anaerobic digestion with subsequent thermal concentration; nitrification–denitrification and composting). They concluded that the management and treatment technologies to be adopted for manure processing must result from a nutrient management planning (NMP), which must be designed taken into account local conditionals and considering cultivable soils as the end-users of manure. Individual, collective or combined scale management must also be chosen as a result of the NMP rather than being considered as an objective by itself. Managing aspects are usually more critical than technological aspects. Economic factors, which affect the decision about management and facilities scale, are influenced by the density and the intensity of farming in a given area. Areas with high intensity of manure production take benefit from a centralized NMP, since it allows optimizing logistics. Main factors explaining successful experiences are the involvement of farmers, contractors, technology suppliers and authorities, prices of energy and mineral fertilizers and the existence of a management planning as a global framework for actuations, either at individual or collective level (Flotats et al. 2009).

Waste composition information is of great importance since the choice of the most appropriate management technology will depend fundamentally on the nature and characteristics of the different compounds present in these residues. The biomass feedstock type and its composition determine the choice of pre-treatment process that further impacts on bio-refinery design (Sanford et a. 2016). Ones the resources (by-products) are present and their composition known, Mika et al. (2018) give some insights on how to obtain initials platform chemicals (ethanol, 3-hydroxypropionic acid, isoprene, succinic and levulinic acids, furfural, and 5-

hydroxymethylfurfural) from carbohydrate content of lignocellulosic biomass through catalytic transformations. Platform chemicals are intermediates that are the building block for the manufacturing of commercially valuable chemicals/ products. The concept of the biomass based bio-refinery is in the early stages of development in many parts of the world due to the lack of conversion technology and thus the market value of these potential products is low compared to other established processes. Goswami et al. (2022) summarizes various alternative feed stocks' availability and their chemical potential for bio-refinery. Based on the direct agricultural feedstock utilization, bio-refinery can be organized into the four generations. The common feed stocks focused in the first-generation biofuel production are crops rich in sugar, crops rich in starch, cellulosic biomasses and edible oils. The problem is that these feed stocks compete with human staple food for resources. Second-generation bio-refinery aims at producing many value-added chemicals (sugar alcohols, organic acids, oleo-chemicals, and solvents) along with biofuels from various bio-wastes.

In first-generation bio-refinery, biofuels such as biodiesel, bioethanol, bio-butanol, bio-hydrogen, bio-methane, syngas are solely produced from bio-resources. In second-generation bio-refinery, commercially valuable chemicals that are produced from the bio-wastes are organic acids, microbial lipids, glycerol and its derivatives, furfural and its derivatives, isoprene and sugar alcohols. These intermediate chemicals are used in pharmaceutical, cosmetics, industrial, nutritional supplements, and agrochemical industries. Third and fourth generation bio-refinery based on microalgae and microbial yields a lot of commercially important bio-products such as antioxidants and lipids, which are efficient feedstock for industries as well. In addition, several thermochemical techniques are able to convert biomass into various products via pyrolysis, torrefaction, hydrothermal treatment, gasification, combustion, fermentation, anaerobic digestion and anoxygenesis. With the continuously increasing demand for bio-based products, it is necessary to scale up the bio-refineries from lab-scale to industrial scale. Efficient management of resources, optimization of process conditions and continuous technological innovations are the major factors that need to be considered for the scale-up of lignocellulosic bio-refinery (Sanford et a. 2016). Therefore, it is essential to identify the right parameters for scale-up from laboratory scale to commercial scale.

The generation, management and valorisation of agricultural by-products and food waste depend on the different structures of the food supply chain, thus its optimal solution, can differ from region to region or from country to country. From this point of view, the optimal approach consists in an adequate balance between conventional management methods and emerging valorisation technologies, if possible both working in coordination in order to allow an integral management that minimizes the impact on agriculture and food security, wastage of natural resources and environmental damage. Once the full capacity of the possible valorisation technologies has been exploited the remaining materials will be likely best managed

through the conventional or traditional end-of-pipe technologies. In this regard, the biological methods (i.e. composting and anaerobic digestion) must be prioritized, if possible, over landfilling and incineration, though pyrolysis and gasification are thermal methods that also allow valorising the wastes.

3.4.2 Portugal

The main types of biomasses generated in Portugal that can be valorized are animal manure and slurry (originated in the production of dairy cattle, pigs and poultry); olive by-products (pomace, cuttings and pits); wine by-products (pomace, lees, stalks and grape seeds); and forest biomass.

The main valorization techniques used for animal manure and slurry are direct application to the soil, fertirrigation and energy production (the latter in smaller quantities) (Moreira et al., 2022). Regarding olive by-products, there are several techniques for their valorization. The most used in Portugal are direct application to the soil, animal feed, composting and biotechnological and chemical transformation for use in the food, pharmaceutical and cosmetic industries. Wine by-products are valorized mainly through composting techniques and chemical and biotechnological transformation, used for food, pharmaceutical and cosmetics industries (Magalhães et al., 2017a; Magalhães et al., 2017b). Forest biomass is valorized mainly through composting techniques and physical transformation processes as pellets production (Malico et al., 2019).

3.4.3 Spain

Agricultural plastics constitute sensitive waste in Spain. The practices of their abandonment, burial or uncontrolled burning represent a considerable environmental problem, which leads to a progressive and cumulative deterioration of the areas where these practices occur. Plastics are generally not biodegradable, so the only option is to recycle them. For this reason, it is mandatory to collect and recycle them in accordance with Spanish and Autonomous Community Laws. In Spain, in 2012, it was estimated that the amount of agricultural plastic waste is about more than 172.000 t/year (PEMAR 2016-2022); from them 51.677 ton were recycled. Currently this amount should be higher, as in such communities where an important amount of plastics waste is produced, like in Andalucía, 83.400 t of agricultural plastic waste were produced in 2018. In this region organized plastic collection and valorisation systems are present (PIRE Andalucía). The CICLOAGRO System pays for the thick plastic roofing and collects it on the farm, offering the collecting points for the delivery of thin films and other plastics, which must be delivered under certain cleaning conditions (depending on the type of film) and separated by typologies. In Andalucía 75% of agricultural plastics are collected and 85% recycled. In the case of Galicia each municipality facilitates

collecting points for agricultural plastics and once the amounts deposited at the point make withdrawal necessary, the City Council will contact the authorized company (Tryma) for collection and recovery. In the case of plastic mulch, in North-East Spain biodegradable plastic is frequent to be used, and also slowly is being more and more introduced in the South of Spain.

Agrochemical containers and packaging are treated inside the Integrate managing system SIGFITO who is in charge of the collecting and organizing its valorisation. In the year 2020, 5000 t were collected and recycled. This amount means that the 63% of the agrochemical containers put in the market were recovered (Sigfito 2020). Unused containers of phytosanitary products are returned to the point of sale. If the containers are not empty, it is the farmer's responsibility to deliver them to an authorized hazardous waste point.

Animal manure is usually composted in specific private facilities or at farms and applied to the fields and more and more frequently Anaerobic Digestion facilities are introduced in certain regions with high amounts of manure by-product generation (Flotats et al. 2009). In these regions biogas and fertilizers solutions (e.g. ammonium sulphate) are obtained. Plant by-products (e.g. straw, milled pruning wood) are usually left on the field, composted together with animal manure, or sold for animal feeding or animal bedding. Vegetables and not marketable from orchards or industries are also composted. Orchard's wood of the renewed plantations or pruning wood is also used as biofuel in farms or industries. In cooperatives and specific farms, different solutions can be found for the recovery of agricultural by-products, in some cases they are the first initials of biofactories, although the development of biofactories to obtain valuable products is at a very early stage. Currently there are many studies in universities, research centers and private companies to develop technologies for the recovery of agricultural by-products with the aim of developing biofactories throughout the country.

3.4.4 Italy

The main categories of agricultural biomass, deriving from co-products, by-products, residuals and waste generated in the Italian primary sector, are (Manniello et al., 2021):

- residues/waste from crop production: straw, prunings;
- manure/slurry from animal breeding (cattle, pigs, sheep/goat, poultry, rabbit, etc.);
- co-products, by-products and waste from agro-food industries: pomace (from oil mills), marc (from wineries), whey (from cheese factories), bran (from cereal mills – pasta industries), shells, husks, oil, seeds, pulp, orange skin, tomato peel (from fruit juice industries);
- wood from arboriculture and forests (conifers and deciduous trees).

The final fate of these different biomasses may vary, depending on their characteristics and location of productions. In some regions, some of these materials are used to directly fertilize the agricultural soil; in other cases, they are used for energy production. Often, however, they are discarded, since considered as a waste difficult to be recycled, or not-recyclable at all.

The main categories of non-organic waste generated in the Italian primary sector are (Briassoulis et al., 2013):

- plastic materials - mostly, film for mulching, low/medium tunnels and greenhouse/walk-in tunnels, as well as irrigation pipes/tapes, crates, sacks, ropes, etc.
- agrochemical containers – mostly, plastic-based;
- other types of waste, e.g., oil, batteries and filters from agricultural mechanizations; veterinary waste; etc.

Agricultural plastic materials would be collected by the Italian Consortium Polieco, that however unfortunately collects only a limited part – mainly, in Northern Italy - of the whole quantity produced at national level. This material is collected and routed towards industrial plants for their mechanical recycling.

3.4.5 Greece

The main categories of agro-livestock waste Greece generates, are crop residues, animal waste and agro-industrial waste. According to the most recent studies, estimating the potential of produced agricultural and livestock wastes in Greece, the main OB to consider are the straw coming from multiple cultivations such as cereal grasses (wheat, oats, rye, barley, buckwheat etc.), energy plants (maize, sunflower etc.). Cotton residues (straw, sticks, wood) is also a significant source of wastes, as well as prunings coming predominantly from olive trees, as it is one of the most common cultivations in Greece, followed by grapes. Lastly, the feedstock potential of animal manure (wet & dry) constitutes a major source of OB waste that needs to be considered. There is a lack of information concerning the potential of produced Inorganic Biomass in Greece. Nonetheless, as the most important source of INOB waste we can consider the plastics used for agricultural and animal husbandry activities, as well as Plant Protection Products (PPPs) packaging (such as plastics used for plant protection and shading, ground cover, pipes irrigation, silage coating, tanks, trays and containers for seedlings, packaging, bags etc.).

The most common utilization methods used for crop residues are soil incorporation or mulching, anaerobic digestion for biogas production, composting and combustion of crop residues in special or mixed boilers (petroleum & biomass or crop scraps etc.) for greenhouse heating, etc. The common practice for the olive tree prunings and the vine prunings is either the incorporation into the land after shredding or burning in open fireplaces at the fields. There are some examples for using them for the production of pellet or particle

boards. For livestock waste especially for liquid and solid manure the most common practices are anaerobic digestion and composting. Agro-industries waste mainly olive pomace used as biofuels. Finally, the plastic material generated from agricultural and livestock activities is collected, if this plastic material concerns the packaging of plant protection products (PPPs), triple rinsing is performed and made available for recycling.

3.4.6 France

In France, different actors are involved in waste management: farmers, distributors and industrialists. They try to work hand in hand to create a circular economy around waste management. The recycling of inorganic waste is rather efficient since almost all plastic waste from agricultural activities is recycled. The quality of the sorting done by farmers allows the collection of different materials.

In France, different recovery techniques are used. For example, the plastic films used for the plundering of crops, the tarpaulins etc. are cut, washed and then crushed into flakes which are heated to become granules. These granules are then extruded: the material reaches the melting temperature and is blown to obtain a new film or new objects.

Some plastic drums can also be recycled if the rinsing and draining instructions are correctly carried out. The cans can be recycled into other plastic objects through non-hazardous waste channels. The company Adivalor allows the recycling of the waste after the sorting made by the farmers.

As for organic materials, they are often treated to serve as compost and fertilizer for the soil. Harder materials such as wood or olive pits for example can be used as fuel for boilers.

4 Main Conclusions

This report sought to analyze agricultural waste management from a political, economic, social and technical point of view.

Regarding the political situation, it was possible to verify that all countries follow the guidelines of the European Union, with each country presenting specific legislation for certain types of waste.

The economic and social situation of the agricultural sector varies from country to country. This variation is related to several factors, such as the agricultural area of each country, adopted cultivation systems, type of crops, etc. and will be reflected in the volumes and types of agricultural waste produced.

The techniques adopted for managing agricultural waste in each country vary according to the volume and type of waste generated. In general, the types of valorization processes adopted by the countries analyzed

in this document follow the principle of the Waste Management Hierarchy, prioritizing prevention/reduction and seeking to avoid elimination. Some agricultural valorization techniques (composting, direct application to the soil, fertigation, etc.) are the most adopted due to the greater simplicity of the process and the reduced associated costs. Other types of valorizations, such as energy, are also adopted with relevance in some of the countries. However, this type of valorization presents some constraints in certain countries insofar as impositions or gaps in the legislation make its implementation difficult.

5 References

Apostolopoulou, V., (2019). Περιορισμένος ο αριθμός γυναικών και νέων στο αγροτικό εργατικό δυναμικό της Ευρώπης. Accessed in: 10/10/2022. https://www.ypaithros.gr/periorismenos-arithmos-gynaikon-neon-agrotes-europi/

Aravani, V. P., Sun, H., Yang, Z., Liu, G., Wang, W., Anagnostopoulos, G., ... & Papadakis, V. G. (2022). Agricultural and livestock sector's residues in Greece & China: Comparative qualitative and quantitative characterization for assessing their potential for biogas production. *Renewable and Sustainable Energy Reviews*, *154*, 111821.

[BIC] Bio-based Industries Consortium. (2020). Bioeconomy worth 2.4 trillion EUR to the European economy as bio-based industries mark sizeable jump in turnover and bio-based share of chemicals reaches record high of 15%. Available at: https://biconsortium.eu/news/turnover-employment-2017

Bidlingmaier W., Sidaine J.M., Papadimitriou E.K. (2004). Separate collection and biological waste treatment in the European Community. Reviews in Environmental Science & Bio/Technology 3:307–320 https://doi:10.1007/s11157-004-2334-1

BioEast. (s.d). Bioeconomy: Scope of bioeconomy in the EU. Available at: https://bioeast.eu/bioeconomy/

Briassoulis, D., Babou, E., Hiskakis, M., Scarascia, G., Picuno, P., Guarde, D., & Dejean, C. (2013). Review, mapping and analysis of the agricultural plastic waste generation and consolidation in Europe. *Waste Management & Research*, *31*(12), 1262-1278.

[CAP] Confederação dos Agricultores de Portugal. (2022). Economia Circular Aplicada à Agricultura. In *Agricultura Sustentável.* (pp. 292-493). Lisboa, Portugal. Available at: https://www.dgadr.gov.pt/mediateca?task=download.send&id=396&catid=47&m=0

Cillis, G., Statuto, D., Schettini, E., Vox, G., & Picuno, P. (2022). Implementing a GIS-Based Digital Atlas of Agricultural Plastics to Reduce Their Environmental Footprint: Part II, an Inductive Approach. *Applied Sciences*, *12*(15), 7545.

[CPA] Comité français des Pastiques en Agriculture. (s.d). European regulation – National Collecting Schemes (NCS). Available at: https://www.plastiques-agricoles.com/ape-europe-missions/agricultural-plastics-european-regulation/

Chardon O., Jauneau Y., Vidalenc J. (2020). Les agriculteurs : de moins en moins nombreux et de plus en plus d'hommes. Available at: https://www.insee.fr/fr/statistiques/4806717

Christou, M. (2010). Biomass Potential in Greece. CRES/ Centre for Renewable Energy Sources and Savings. Available at: https://www.iene.gr/energyb2b/articlefiles/biomaza/christou.pdf

[CREA] Research Centre for Agricultural Policies and Bioeconomy. (2022). Italian agriculture in figures 2021. Rome, Italy. Available at: https://www.crea.gov.it/documents/68457/0/ITACONTA+2021_ENG+2021_WEB.pdf/25cb44ef-b254-219a-4009-c0983fc2da90?t=1653304692913

De Corato U. (2020). Agricultural waste recycling in horticultural intensive farming systems by on-farm composting and compost-based tea application improves soil quality and plant health: A review under the perspective of a circular economy. Science of the Total Environment 738 139840

ELGO-Dimitra/ Hellenic Agricultural Organization Διμιτρα (2022). Press Release, 16.03.2022. Available at: https://www.elgo.gr/images/pdf/DELTIO-TYPOU-16-3-2022.pdf

EN ISO 14040:2006: Environmental management – Life cycle assessment – Principles and frameworks.

[ENEA] Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile. (2017). Rapporto Annuale Efficienza Energetica "Analisi e risultati delle policy di efficientamento energetico del nostro Paese, Executive Summary

European Commission. (2022a). Waste Framework Directive. *Publications Office of the European Union: Luxembourg*. Available at: https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

European Commission. (2022c). A European Green Deal: Striving to be the first climate-neutral continent. *Publications Office of the European Union: Luxembourg*. Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

European Commission. (2022b). Agriculture and the Green Deal. *Publications Office of the European Union: Luxembourg*. Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/agriculture-and-green-deal_en

European Commission. (2022d). Plastics strategy. *Publications Office of the European Union: Luxembourg*. Available at: https://environment.ec.europa.eu/strategy/plastics-strategy_en

European Council. (2022). European Green Deal. *Publications Office of the European Union: Luxembourg*. Available at: https://www.consilium.europa.eu/en/policies/green-deal/

EUROSTAT. (2017). Archive:Farmers in the EU – statistics. *Publications Office of the European Union: Luxembourg*. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Farmers_in_the_EU_-_statistics

EUROSTAT. (2020). Archive:From farm to fork - a statistical journey. *Publications Office of the European Union: Luxembourg*. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:From_farm_to_fork_-_a_statistical_journey#Distribution_stage

EUROSTAT. (2022a). Waste statistics. *Publications Office of the European Union: Luxembourg*. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics#Total_waste_generation

EUROSTAT. (2022b). Agriculture statistics at regional level. *Publications Office of the European Union: Luxembourg*. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agriculture_statistics_at_regional_level#Economic_accounts_for_agriculture

FAO. (2021). *Assessment of agricultural plastics and their sustainability – A call for action.* Rome. Available at: https://doi.org/10.4060/cb7856en

Ferreira-Santos P., Zanuso E., Genisheva Z., Rocha C.M.R., Teixeira J.A. (2020). Green and Sustainable Valorization of Bioactive Phenolic Compounds from Pinus By-Products. Molecules 25, 2931 https://doi:10.3390/molecules25122931

Goswami L., Kayalvizhi R., Dikshit P.K. et al. (2022). A critical review on prospects of bio-refinery products from second and third generation biomasses. Chemical Engineering Journal 448 137677 https://doi.org/10.1016/j.cej.2022.137677

[GPP] Gabinete de Planeamento, Políticas e Administração Geral. (2021). Emprego – Agricultura, Silvicultura e Pesca: 4º Trimestre 2020. Available at: https://www.gpp.pt/images/Estatisticas_e_analises/Estatisticas/AgricolasEstruturais_Producao/NotaEmprego4Trimestre2020.pdf

[GPP] Gabinete de Planeamento, Políticas e Administração Geral (2021a). BIOECONOMIA: Linhas estratégicas dos sectores de produção primária no contexto do desenvolvimento da estratégia nacional para a bioeconomia sustentável 2030. Lisboa, Portugal. Available at: https://www.gpp.pt/images/Destaques/Noticia/Bioeconomia/BioEconomia-RelatorioPrincipal-Visualizacao.pdf

Hann, S., Fletcher, E., Molteno, S., Sherrington, C., Elliott, L., Kong, M., ... & Martinez, V. (2021). Relevance of Conventional and Biodegradable Plastics in Agriculture. *Publications Office of the European Union: Luxembourg*.

[INE] Instituto Nacional de Estatística. (2020). Estatísticas de Educação, Formação e Aprendizagem 2020. Available at: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_base_dados

[INE] Instituto Nacional de Estatística. (2021a). Estatísticas do Ambiente 2020. Available at: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_publicacoes&PUBLICACOESpub_boui=280813687&PUBLICACOESmodo=2

[INE] Instituto Nacional de Estatística. (2021b). Estatísticas dos Resíduos 2020. Available at: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_base_dados

Kardung M., et al. (2019). Monitoring the Bioeconomy (Biomonitor Project). D1.1: Framework for measuring the size and development of the bioeconomy. European Union's Horizon 2020 research and innovation programme under grant agreement N° 773297. https://biomonitor.eu/

Macedo, C. (2022). Valorfito: 10 Anos, 5000 toneladas de CO2 e 12.263 barris de petróleo depois. Available at: https://www.ambientemagazine.com/valorfito-10-anos-5000-toneladas-de-co2-e-12-263-barris-de-petroleo-depois/?utm_source=mailpoet&utm_medium=email&utm_campaign=ambiente-magazine-diaria-date-d-date-mtext-date-y_1

Magalhães, B., Cruz, V. F., & Ascenço, C. (2017a). Relatório de caracterização da economia circular. Alentejo Circular: Promoção da Economia Circular nas explorações agrícolas e agroindústrias do Alentejo, 1-110.

Magalhães, B., Cruz, V. F., & Ascenço, C. (2017b). Relatório de boas práticas de utilização eficiente de recursos e valorização de resíduos e subprodutos. Alentejo Circular: Promoção da Economia Circular nas explorações agrícolas e agroindústrias do Alentejo, 1-80.

Malico, I., Pereira, R. N., Gonçalves, A. C., & Sousa, A. M. (2019). Current status and future perspectives for energy production from solid biomass in the European industry. Renewable and Sustainable Energy Reviews, 112, 960-977.

Manniello C., Statuto D., Di Pasquale A., Picuno P. (2021). Planning the Integrated Management of Organic Waste Flows and Agricultural Residues for a Circular Economy. Proceedings of the European Conference on Agricultural Engineering - AgEng2021, 4 – 8 July 2021, Evora (Portugal), Vol. 1, pp. 137-145.

Mika LT, Cséfalvay E, Németh A. (2018). Catalytic Conversion of Carbohydrates to Initial Platform Chemicals: Chemistry and Sustainability. Chemical reviews 118: 505-613 https://doi.org/10.1021/acs.chemrev.7b00395

Moreira, O., Cruz, V., Trindade, H. (2022). *Roteiro para a gestão dos fluxos gerados na atividade agropecuária.* INIAV, I.P. Available at: https://projects.iniav.pt/goefluentes/

[MTES] Ministere de la transition ecologique et solidaire (2018). Économie circulaire - Plan ressources pour la France. Mise en œuvre de la feuille de route économie circulaire. Available at: https://www.ecologie.gouv.fr/sites/default/files/FREC%20-%20Plan%20Ressources%20pour%20la%20France%202018.pdf

Mourjane I., Fosse J. (2021). La biomasse agricole: quelles ressources pour quel potentiel énergétique?. France-stratégie. Available

at: https://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/fs-dt_-_biomasse_agricole_-_quelles_ressources_pour_quel_potentiel_energetique_-_29-07-21.pdf

[NAGREF] National Agricultural Research Foundation. (2022). Circular economy & agri-food sector. NAGREF Journal, Issue 28

[NEA] Netherlands Enterprise Agency. (2019). The bio-economy in France: Structure, market opportunities and possibilities for collaboration. Available at: https://www.rvo.nl/sites/default/files/2020/01/Bio-economy-in-France.pdf

Papadopoulou, E., Vaitsas, K., Fallas, I., Tsipas, G., Chrissafis, K., Bikiaris, D., ... & Vorgias, K. E. (2018). Bio-economy in Greece: Current trends and the road ahead. *The EuroBiotech Journal, 2*(3), 137-145.

Paris, B., Papadakis, G., Janssen, R., Rutz, D. (2021). Feedstock analysis, technical and achievable potential of advanced biofuels, renewable gases and recycled carbon fuels for the Greek transport sector until 2050. Renewable and Sustainable Energy Reviews 144:111038. Athens, Greece. doi: 10.1016/j.rser.2021.111038.

Pavlidis, G., Karasali, H., Doula, M.K., Ploumistou, E., Malamis, D. and Moustakas, K., (2018). Hazardous agricultural waste in Greece: Current status and future perspectives. 6th International Conference on Sustainable Solid Waste Management, Naxos, Greece, 13-16 June, 2018.

Petropoulos, D. P., Sotiropoulos, S. S., Ch, P. D., & Papakonstantinou, L. D. (2021). The Evolution of Agricultural Employment in Greece. *Advances in Management and Applied Economics*, *11*(4), 1-6.

Picuno P. (2014). Innovative Material and Improved Technical Design for a Sustainable Exploitation of Agricultural Plastic Film, Polymer - Plastics Technology and Engineering, 53:10, 1000-1011.

Picuno P. (2018). Agriculture: Polymers in Crop Protection. Encyclopedia of Polymer Applications, Mishra, M. (Ed.)., Vol.1, pp 67-92. Set. Boca Raton: CRC Press.

Pierro, N., Giocoli, A., Motola, V., & Dipinto, S. (2021). Valutazione disponibilità biomasse agro-industriali a livello nazionale e loro pubblicazione sul portale Webgis atlante delle biomasse.

Sanford K., Chotani G., Danielson N., Zahn J.A. (2016). Scaling up of renewable chemicals. Current Opinion in Biotechnology 38:112-122 http://dx.doi.org/10.1016/j.copbio.2016.01.008

Sigfito. (2020). Memoria annual Sigfito Agroenvases.

Toop TA, Ward S, Oldfield T, Hulla, Marie M, Kirbya E, Theodoroua MK. (2017). AgroCycle – developing a circular economy in agriculture. Energy Procedia 123: 76-80 https://doi.org/10.1016/j.egypro.2017.07.269

Tsigkoias, T., (2022). Marketing services in agricultural Supplies companies. MSc Thessis. University of Macedonia.

Weghmann, V. (2017). Waste Management in Europe. Good Jobs in the Circular Economy?. Available at: https://www.epsu.org/sites/default/files/article/files/Waste%20Management%20in%20Europe.%20Good%20Jobs%20in%20the%20Circular%20Economy%20for%20web.pdf

LEGISLATION

- European Union

Directive 75/442/EEC of 15 July 1975 on waste

Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008

Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009

Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018

Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018

Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019

Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006

Regulation (EC) no 1069/2009 of the European Parliament and of the Council of 21 October 2009

- reece

Law No. 4063/2012 (Government Gazette issue A΄8) Greek Government 8 October 2012.

Law No. 4685/2020 (Government Gazette issue A' 92) Greek Government 7 May 2020.

- Italy

Decreto Legislativo 18 maggio 2001, n. 1. pubblicato in Gazzetta Ufficiale

Decreto Legislativo 3 aprile 2006, n. 152. Norme in materia ambientale, pubblicato in Gazzetta Ufficiale n. 88 del 14 aprile 2006

Decreto Legislativo 3 dicembre 2010, n. 205. Disposizioni di attuazione della direttiva 2008/98/CE del Parlamento europeo e del Consiglio del 19 novembre 2008 relativa ai rifiuti e che abroga alcune direttive, pubblicato in Gazzetta Ufficiale n. 288 del 10 dicembre 2010

- Portugal

Decreto-Lei 178/2006 de 05 de setembro. Diário da República n.º 171/2006, Série I de 2006-09-05, p. 6526 – 6545.

Decreto-Lei 73/2011 de 17 de junho. Diário da República n.º 116/2011, Série I de 2011-06-17, p. 3251 – 3300.

Decreto-Lei 81/2013 de 14 de junho. Diário da República n.º 113/2013, Série I de 2013-06-14, p.s 3304 – 3329.

Decreto-Lei 75/2015 de 11 de maio. Diário da República n.º 90/2015, Série I de 2015-05-11, p. 2416 – 2426.

Decreto-Lei 33/2017 de 23 de março. Diário da República n.º 59/2017, Série I de 2017-03-23, p. 1573 – 1578.

- Spain

Programa Estatal de Prevención de Residuos 2014-2020 (PEPR). Dirección General de Calidad y Medio Ambiente. Ministerio de Agricultura Alimentación y Media Ambiente

Plan Estatal Marco de Gestión de Residuos (PEMAR) 2016-2022. Dirección General de Calidad y Medio Ambiente. Ministerio de Agricultura Alimentación y Media Ambiente

Ley 22/2011, de 28 de julio, de residuos y suelos contaminados. BOE 181: 85650-85750

Plan integral de residuos de Andalucía hacia una economía circular en el horizonte 2030 (PIRE 2030). 2021. Junta de Andalucía

Ley 7/2022, de 8 de abril, de residuos y suelos contaminados para una economía circular. BOE 85: 48578-48733

Decret 198/2015, de 8 de setembre, de gestió agrícola dels efluents produïts en cellers i almàsseres. DOG 6954 :1-8

Decreto 73/2012, de 20 de marzo, por el que se aprueba el Reglamento de Residuos de Andalucía

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