D3.2: Study on Circular Economy & Environmental Impact

Responsible Beneficiary: GREEK ASSOCIATION OF SUPPLY CHAIN MANAGEMENT (PB3)

with the contribution of:

PB2: SMALL ENTERPRISES' INSTITUTE OF THE HELLENIC CONFEDERATION OF PROFESSIONALS CRAFTSMEN AND MERCHANTS

PB4: REGIONAL CHAMBER OF COMMERCE AND INDUSTRY – BLAGOEVGRAD

PB5: RENEWABLE ENERGY SOURCES CLUSTER

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1 Introduction

Project "Enhancing the Competitiveness and Sustainable Growth in the Agrofood Sector through the promotion of Circular Economy" with Acronym AGROFICCIENCY is implemented under the 6th Call of Cooperation Programme "Interreg V-A Greece-Bulgaria" 2014-2020. The initiative aims to improve Cross-Border (CB) cooperation between Greece and Bulgaria, with the main goal of promoting entrepreneurship, in particular by making it easier to commercialize fresh ideas and stimulating the formation of new businesses, especially through business incubators. The cross-border area on the Greek side includes the P.E. of Thessaloniki, Serres, Drama, Kavala, Xanthi, Rodopi, and Evros. For the Bulgarian side, it includes Blagoevgrad, Smoljan, Khadzali and Haskovo.

This report is the Overall Study of the Deliverable 3.2 (D3.2) in Work Package 3 (WP3), which includes the research that need to be conducted in order to help support agri-food SMEs in the CB area. The overall study was prepared by the Greek Association of Supply Chain Management, combining the Greek study, which was conducted by the Aristotle University of Thessaloniki as an external expert of the Greek Association of Supply Chain Management and ETAM CONSULTING SERVICES SA, subcontractor of the Small Enterprises' Institute of the Hellenic Confederation of Professionals Craftsmen And Merchants (IME GSEVEE), and the Bulgarian Study, prepared by the Regional Chamber of Commerce and Industry Blagoevgrad and the RENEWABLE ENERGY SOURCES CLUSTER.

This study focuses on highlighting circular economy practices as well as their environmental benefits and aims to:

(i) capture the uses and environmental impacts of Circular Economy principles,

(ii) study of the Circular Economy practices that are and can be applied in SMEs and industries in the CB region with emphasis on the applications in the agri-food sector, and

(iii) suggest Circular Economy solutions in the CB region.

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The remaining of this report is structures as follows:

1. Introduction: this section provides all the information on the sector in Greece, Bulgaria and Europe, defines Circular Economy and relevant concept and highlights the current status-quo according to data from official statistics sources.
2. Environmental Impact: include information on the environmental impact of the agrifood sector and data and policies in the European Union.
3. Circular Economy Applications in the Agri-food Sector: a literature review on best practices of Circular Economy in the Agri-food sector in Greece and Bulgaria, focusing on the CB region, as well as a few from Europe.
4. The Status Quo of Circular Economy Practices and Environmental Impact in Greece: The survey design, the results of the Circular Economy Questionnaire as well as commentary on them is presented to assess the current situation in Greece and to provide a focused analysis of the trends, viewpoints and future opportunities.
5. The Status Quo of Circular Economy Practices and Environmental Impact in Bulgaria: the same analysis for the Bulgarian side.
6. Comparison of the current status quo between Greece and Bulgaria.
7. Conclusions
8. Annexes: the full survey in English and Greek is presented in this section and a more detailed analysis for the Greek side study.

1.1 The Agri-food Sector

The agri-food sector is a significant one for the European Union (EU), with a Gross Production Value over 300 million $ throuagh years (FAO, 2020). As shown in Figure 1, while in the rest of the world this index had been gradually devaluing through the years, in the EU it tended to have a stable value. In 2018, livestock products accumulated almost 50% of the Gross Production Value, while vegetables and fruits and cereals followed with 29% and 16% respectively (Figure 2).

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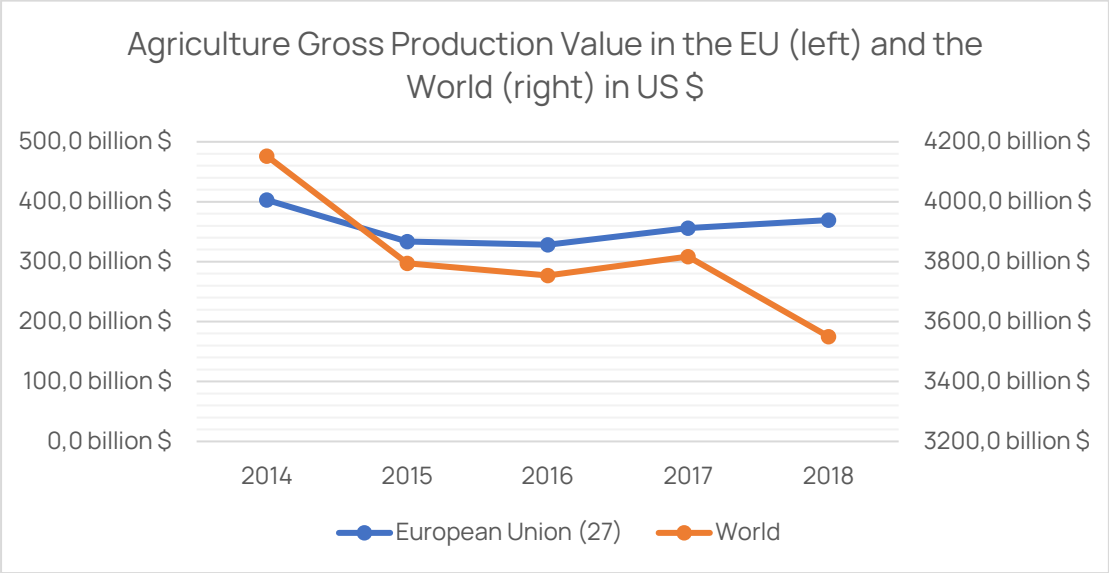

Figure 1. Agriculture Gross Production Value in the EU (left) and the World (right) in US $ (FAO, 2020)

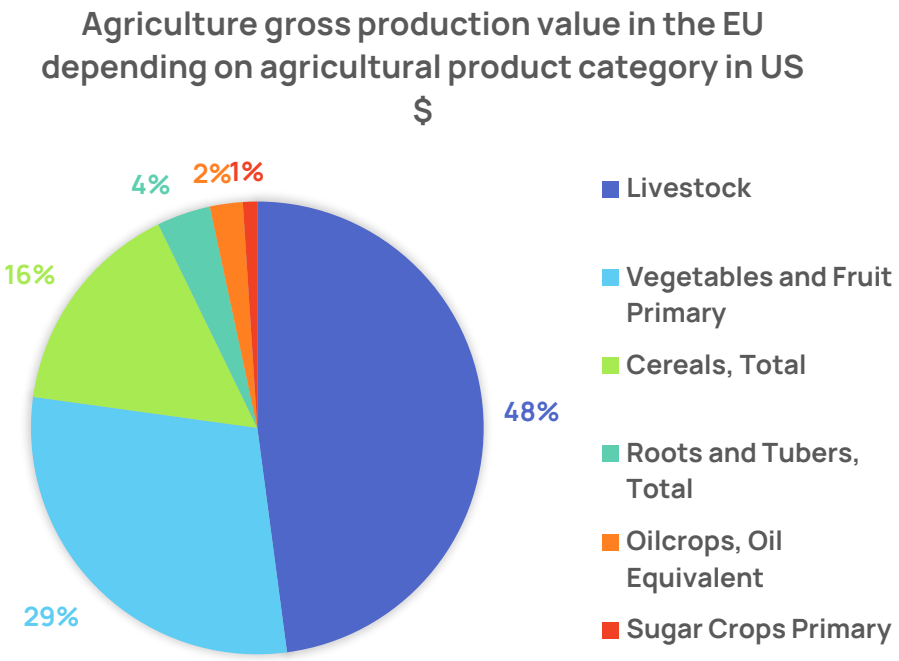

Figure 2. Agriculture Gross Production Value in the EU depending on Agricultural product category in US $ (FAO, 2020)

In the case of Greece specifically, the same data show a stable index until 2017, but a drop in 2018 (Figure 3). However, in Greece the main product category is

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Vegetables and fruits with 47%, while livestock follows with 34%, as shown in Figure 4.

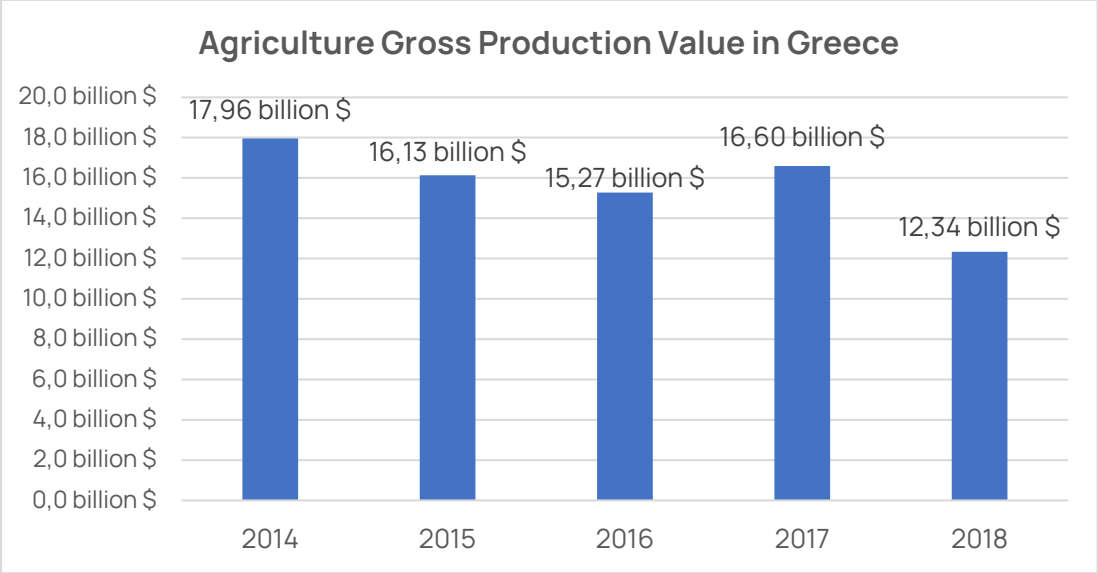

Figure 3. Agriculture Gross Production Value in Greece (FAO, 2020)

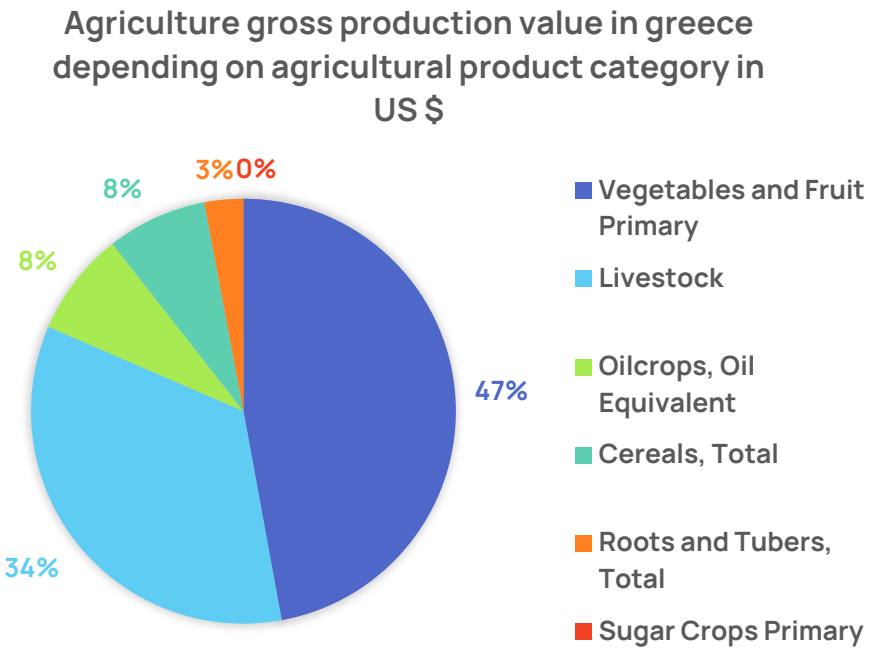

Figure 4. Agriculture Gross Production Value in the EU depending on Agricultural product category in US $ (FAO, 2020)

The gross value added from agriculture in relation to the GDP has stayed at 1,3% when comparing 2005 to 2020 in the EU, while in Greece, who performed second best in 2020 and third in 2005, the it is over 3% according to (Eurostat, 2021),

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proving the sector is a significant one for the Greek economy. In the same study it is mentioned that the food and beverage processing industry represent 11,4 of the value added and 15,1% of the employment within manufacturing in the EU. In the case of Greece, those shares are much higher and thus manufacturing activity is even more concentrated in agri-food products, further underlining the importance of the sector for the Greek Economy.

1.1.1 The agri-food Supply Chain

In the following table, some definitions on agri-logistics are provided to better understand the meaning of the supply chain in the agri-food sector.

Table 1. Agri-logistics definitions

Authors (year)	Definition
(Daoping et al., 2012)	The logistics of food crops is a special type of logistics of agricultural products. The production, circulation and sales of food crops matters to state strategic reserve.
(Frederico, 2011)	Logistics plays a central role in modern agricultural production. The predominance of the logic of commodity trading, expressed by the standardization and international regulation of production, has been promoting the deepening of the territorial division of labor, leading to regional agricultural specialization. The enlargement of the agricultural productive spatial circuits has integrated the flows on a global scale, calling for ever further–reaching logistics in the linking up of the stages spatially separate from production.

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(Gan et al., 2011)	It is defined agricultural product logistics is the economic activity from agricultural product producer to the consumers in order to satisfy customers' demands, including the links such as agricultural product production, purchasing, transportation, storage, loading and unloading, handling, package, processing, distribution and information processing.
(Li et al., 2012)	Agricultural products logistics refers to moving material objects and related information from producer to consumer physically for meeting customer's needs and achieve the value of agricultural products.
(Li et al., 2013)	Taking agricultural products as the core, the agricultural products logistics refers to the organic combination of the entity flowing from producer to receiver and the involving technology, organization, management and other basic functions. It consists of a series of links, such as agricultural production, purchase, transport, storage, loading and unloading, handling, packaging, distribution, circulation processing, information activities, and etc. and realizing agricultural product appreciation and organization objectives in the process.
(Shufeng et al., 2010)	Modern agriculture logistics should have 12 functional elements of procurement: supply, storage, transportation, loading and unloading sorting, packaging, distribution, distribution processing, marketing, recycling, and information control; the task of modern agriculture logistics management should not only put foot on solving to lower the logistics cost, and lessen and avoid the logistics operating

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	risks, but also research how to promote all of function elements to comprehensively play the integrated effects to create plentiful "3rd party profit" of logistics enterprises, and become the source of power of the village lowering agricultural production cost raising agricultural economic benefit promoting the peasants to raise the income and push forward modern agricultural economic development.
(Tan, 2012)	Logistics in agriculture are activities associated within the process itself, to improve the quality of agricultural products. The logistical process is improving and ensuring the quality of agricultural products, reducing logistics costs, an optimal allocation of resources, promote the welfare and protection of the environment, strives for the development of agricultural product logistics in the direction of green logistics.
(Xu, 2011)	Based on the understanding of modern logistics, modern agricultural logistics can be defined as: an integrated industrial activities of integrated operation and management relying on advanced computer networks and information technology, integrating the use of modern transport and storage facilities, through a large number of business information instructions, engaged in agricultural transportation, storage, processing, handling, packaging and distribution processing, distribution and information processing. The aim is to optimize the distribution channels of agricultural products, reduce operating costs of agriculture-

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	related enterprises in full range, and provide faster and better service to consumers of agricultural products.
(Yao et al., 2009)	Agriculture products logistics dynamic alliance provided a suitable mode for agriculture products logistics.

1.1.2 The new CAP

The common policy of the EU countries on agricultural products focuses on quality and not on quantity. It helps and encourages producers not only to produce, but also to protect the environment and the animals they use during production. The main points of the EU's common agricultural policy (CAP) for 2018 (European Union, 2018) are:

1. support farmers and increase agricultural productivity to ensure a steady supply of inexpensive and quality food;
2. protect European Union farmers' ability to make a livelihood;
3. aid in the combating climate change and the conservation of natural capital;
4. preserve rural areas and landscapes across the EU;
5. keep the rural economy strong through fostering jobs in agriculture, agri-food, and related businesses.

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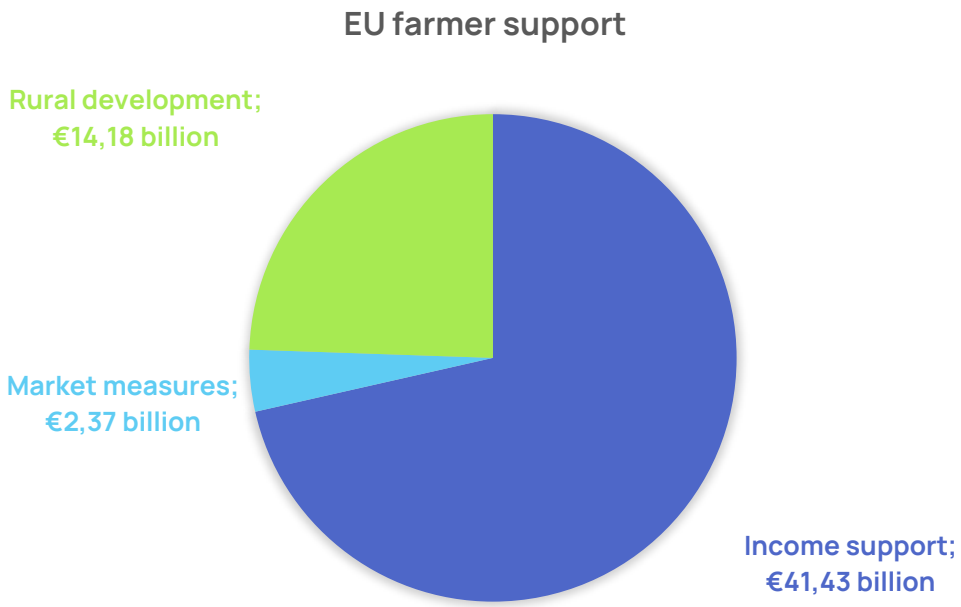

Figure 5. CAP financing in 2019 (data from https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en#title)

1.2 Circular Economy

1.2.1 Circular Economy Definitions

According to the traditional model of economics, valuable materials used for food production, infrastructure and housing, consumer goods or energy supply are discarded when the corresponding products are consumed or no longer useful (EKT, 2019). This model is also known as linear economy, which means that the higher the production of goods, the greater the consumption of environmental resources and the burden on the environment with waste, completely ignoring the viability of the whole process (Bonciu, 2014). Through the circular economy, the aim is to create cycles through which raw materials, components and products lose as little of their value as possible.

There are many definitions of circular economy (CE). An encompassing definition of CE could be: "Circular Economy is an economic system that targets zero waste and pollution throughout materials lifecycles, from environment extraction to industrial transformation, and to final consumers, applying to all involved

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ecosystems. Upon its lifetime end, materials return to either an industrial process or, in case of a treated organic left over, safely back to the environment as in a natural regenerating cycle. CE operates creating value at the macro, meso and micro levels and exploits to the fullest the sustainability concept. Used energy sources are clean and renewable. Government agencies and responsible consumers play an active role ensuring correct system long-term operation." The final goal of reaching CE is reducing to a minimum the environmental pressure on the economic growth.

In the Regulation (EU) 2020/852 (EUROPEAN PARLIAMENT, 2020, p. 852) of the European Parliament and the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088, Circular Economy means an economic system whereby the value of products, materials and other resources in the economy is maintained for as long as possible, enhancing their efficient use in production and consumption, thereby reducing the environmental impact of their use, minimizing waste and the release of hazardous substances at all stages of their life cycle, including through the application of the waste hierarchy.

At the same time, every year in the European Union every citizen uses almost 15 tons of materials, while on average, more than 4.5 tons of waste are produced per person, of which more than 50% ends up in landfills. Due to the increase of the population, the produced waste is increasing but also the demand for rare raw materials with the result that the resources of the planet are being depleted faster than they are replenished. This growing shortage of resources (minerals, fossil fuels, feed, food, clean water, fertile soils) degrades the environment. Consequently, the linear economy model, which relies entirely on resource extraction, is no longer sustainable (EKT, 2019).

Thus, the transition to a new, more sustainable model of economy called the circular economy is necessary. The circular economy aims to maintain the value of products, materials and resources for as long as possible, returning them back to

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the product cycle when their use is complete, while minimizing the production of waste (Eurostat, n.d.).

Circular Economy design in the development of each new product or service starts from the beginning of a product life cycle based on (i) durability, (ii) reuse, (iii) repair, (iv) reconstruction and (v) recycling, ie the conversion of waste into raw materials (EKT, 2019). Smart product design and smart production processes can help save resources, efficient waste management and create new business opportunities (Eurostat, n.d.).

The circular economy aims to transform the current economy into self-sustaining with the idea of reducing waste and the ecological and environmental imprint of industries before the ecological damage happens rather than addressing the consequences of the damages. This is done by designing new economic models and production and industrial solutions, which optimize the existing resources, rather than reaching out for more new resources.

The idea of CE is not new. It was developed back in the 1970s. However, the actual revisit and expansion of the idea are recent. The climate and environmental challenges prompted companies and individuals to reconsider their production and ways of consumption with the circular economy being framed as one of the main solutions to these challenges. The main reason for politicians and companies tilted to the CE economic model is that it is hoped that by doing so, the economic growth will continue without adding burden on finite earth natural resources. It also delinks the use of resources from the economic growth, especially with the earth's growing population. Finally, CE reduces dependence on imported natural materials, lowers CO_2 emissions, production of waste, and above all creates added value by using new ways of production and consumption. In a production sense, the circular economy could provide reliable supply of raw materials, reduce the price volatility, spills and waste. It also extends the life cycle of products, serves new segments of customers, and generates long term stakeholder value.

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The circular economy aims to build a sustainable society that is based on recyclable and renewable resources with much less waste. This type of economy does not look at the natural resources as unlimited and focuses on reuse of the existing resources. This economic development model evolves around the idea of producing goods and services accounting for the environmental and social costs. Circular economic development supports circular economy to create new societies in line with new waste management and sustainability ideas in mind. It is about making the economies and the societies to become more sustainable and self-reliant.

The economic growth model in the last 150 years has been linear. That model bases economic growth on the ideas of extracting resources, making products and services and then disposing them into landfills or in incinerators, creating a lot of waste and pollution, which needs to be addressed separately. The circular model, on the other hand, is inspired by the existing living systems, considering that our economic and production systems should work like organisms, processing nutrients that can be send back into the cycle and therefore it closes the production loop.

The linear economy is clearly a one-way process with a beginning and an end. The process starts with extraction from raw materials, sale, consumption, or usage, followed by discarding them.

The term has been analyzed in multiple occasions, with more than 114 definitions by 2017 (Kirchherr et al., 2017), while the European Union promotes it on its "Roadmap to a Resource Efficient Europe" in order to achieve resource efficiency (COMMISSION STAFF, 2014). The material flows are the main concern CE policies address. In the case of biological nutrients, after they are discarded they can be reintroduced into the natural cycle, while the rest are designed to be circulated by being reused and recycled (Haas et al., 2015).

The Circular Economy is a development strategy for many countries, as it helps save energy and make more rational use of natural resources, reduces air, soil and

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water pollution and helps tackle climate change (EKT, 2019). However, in order to achieve the transition of the economy from linear to circular, companies must play a dominant role. They must take advantage of any opportunity to extend the life of their products, while creating more competitive products. When cyclicality outside the business extends to the entire supply chain it can lead to cost reduction, waste and environmental burden (EKT, 2019).

The transition to a circular economy is not just about making adjustments to reduce the negative effects of a linear economy. Instead, it represents a systemic change that creates long-term resilience, creates business and economic opportunities, and provides environmental and social benefits (Ellen MacArthur Foundation, 2012). According to a recent study, applying the principles of the circular economy to the EU economy has the potential to increase GDP by 0.5 % by 2030, creating around 700,000 new jobs.

1.2.1.1 Linear Economy

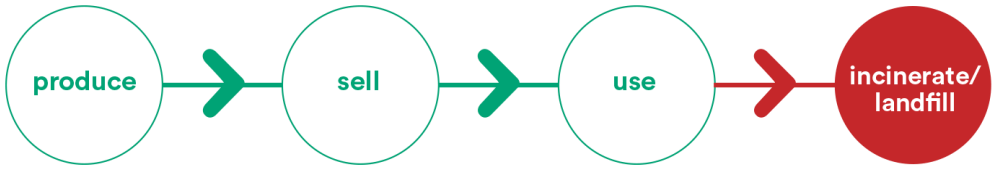

Figure 6. Chart of linear growth business model

1.2.1.2 Reuse Economy - transition from a linear to circular economy

At the shifting stage from a linear to a circular economy goes beyond recycling and reusing the discarded materials. The circular economy's environmental impact of products and their components are reevaluated from the initial concept stage through the end-use and the wastes are regenerative in a new form.

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The circular economy closes the loop of the linear pattern of "take-make-consume-throw away" by keeping the highest utility and value of the products, parts and materials as long as possible. In CE, waste is reduced to a minimum because everything that is produced is being transferred and reused somewhere else.

1.2.1.3 Benefits of the Circular Economy

1. It reduces waste since it promotes the recycling of the finished goods.
2. It reduces the risk of potential price volatility of the raw materials.
3. It achieves efficiency since the resources are recycled to get new products.
4. It promotes continuous usage of products and spurs new business opportunities by promoting reusage rather than purchasing a new item.
5. It benefits and preserves the environment.
6. It creates new businesses, and new employment opportunities.

In practice, cradle-to-cradle is a radical rethinking of the process of designing and packaging. It includes the whole life cycle of a product, not just the period when the product is used.

1.2.2 Similar Terms

1.2.2.1 Green Supply Chain

The idea of a "green" supply chain was first formulated by the Manufacturing Research Center of the University of Michigan in 1996, which focused on the required attention to be paid to the environmental footprint of a supply chain processes. Essentially, the goal was to minimize the negative impact on the environment from the processes along the chain, while maximizing the efficiency of the resources used. At that time, this theory was mainly used in the construction industry, but then Sarkis Joseph (1998) noted that the "green" supply chain includes the company's internal logistics (material management), external (product standardization and packaging) and reverse logistics (product returns). Moreover, Nagel (2000)added that the "green" chain covers all processes from production to the use-exploitation of materials. Finally, Hall (2000)considered in

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his work that such a chain as an ecological business plan throughout the production process, from the purchase of raw materials to production and consumption and finally the recycling of waste products, with a view to the sustainable development of society and business.

1.2.2.2 Sustainability

The viability of an agro-supply chain is of paramount importance when designing and operating networks in which the pillars of economy, environment and society must be balanced. Stakeholders are encouraged to adopt a certain level of commitment to sustainable practices, based on "Corporate Social Responsibility" activities, mainly due to regulatory pressures from Governments, in the case of Greece the EU, NGOs, activists and competition.

Most activities that take place along a chain can be responsible for a significant share of the total energy and resource consumption and the environmental impact on the agri-food sector, such as increased traffic problems on the road network, emissions, emissions, health and safety of workers and citizens. Such activities are the harvesting of various types of machinery that use fuel, the multiple handling and transport, the storage of products for a long time and finally the production of goods with less environmentally friendly techniques. The nature of agricultural products is such (irregular packaging, bulk loads), that it needs the development of special infrastructure during their transport-distribution to be environmentally friendly. After all, the transport process is responsible for most of the environmental damage, so discussions about vehicle selection, optimal route and routes are constantly being raised and must be taken into account in the long run.

1.2.2.3 Waste Management

After the disposal of waste there is an evident need to manage it by a process that can be named “waste management”. This process includes all the activities such as collection, temporary storage, transportation, transfer, loading and unloading processing, utilization and reuse, without compromising the human health or the environment. The purpose of waste management can be summed up to:

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- collection, deposition, treatment and disposal of waste with the least environmental effects,
- reduction of their production, and
- recovery, restorage and reuse of materials.

All these goals are comparable to the aims of CE, as one of them is to minimize the outputs of the value chain. As a result, we could potentially characterize waste management as a part or a tool for CE.

1.2.2.4 Other terms

According to (Ellen MacArthur Foundation, 2012), CE is a concept with a blurry past as to its roots, but is however base on these "schools of thought":

- Regenerative design: systems and their processes can be designed in a regenerative matter by renewing themselves and/or regenerating the resources they consume.
- Performance Economy: a business model developed by stahel, which aims at the reintegration of waste into the production process and the closure of linear flows (Stahel, 2010).
- Cradle to cradle: taking nature itself as a model, (McDonough and Braungart, 2002) believe that products can be designed in order to provide nourishment (either as biological or technical nutrients) after their useful life. This term will be more thoroughly explored in the next subchapter.
- Industrial Ecology: This method focuses on the links between operators within the 'industrial ecosystem,' with the goal of generating closed-loop processes that use waste as an input. Industrial ecology takes a systemic approach, developing production processes taking into account both the local ecological limits and their global influence from the beginning, and seeking to design them to perform as closely as possible to living systems.
- Biomimicry: as the name suggests, this approach tries to imitate nature's designs and processes, relying on the three principles: (i) Nature as model, (ii) Nature as measure and (iii) Nature as mentor.

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1.2.3 Cradle-to-Grave Design

The cradle-to-grave design (take-make-waste), which is part of the linear economy is how most products we currently use are made.

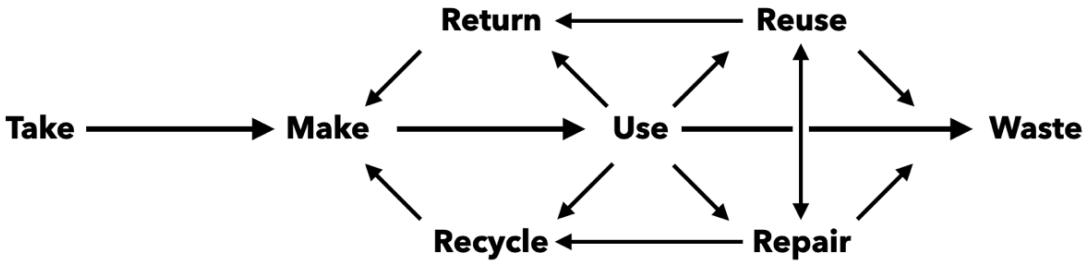

Figure 7. Cradle to Grave Design Model

That system operates under the notion that there is an unlimited supply of Earth's resources to make products and unlimited availability of space in landfills for the products to be buried. The current system relies on finite resources and does not consider the fact that one day they will run out.

1.2.3.1 Definition of Cradle-to-Cradle

The Cradle-to-cradle (C2C), which is a part of the Circular Economy, is a way of designing products or processes that work more like ecological systems. This design method is intended to replace a make-take-waste approach, which starts with new raw materials taken from the earth and ends in the garbage. In practice, cradle-to-cradle is a radical rethinking of the process of designing and packaging. It includes the whole life cycle of a product, not just the period when the product is used.

C2C approach is modeled after nature's long-evolved, minimally-waste, energy-preserving processes. Just like a plant is born from soil created by other dead plants, grows using local resources, produces flowers or seeds, and then dies, in turn creates food and soil for other organisms, human beings can make products

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that are part of an ongoing closed circular system. Because of that, C2C is sometimes referred to as being biomimetic. For example, say someone wants a desk. The conventional cradle-to-grave model would include extracting petroleum products and metals from the earth and spending tremendous energy to transport and manufacture them into a desk that is used for a few years, which later breaks or is discarded, and ends up in the landfill. In the C2C model, the desk is made from materials that are already being used. The materials could be from another desk or another type of product.

Cradle-to-cradle as a concept is credited to Swiss architect Walter Stahel. The C2C idea was first developed in 1976 in a research report for the European Commission written by Stahel and Genevieve Reday. At that time, Stahel worked on developing new way to manufacture products at Geneva's Product Life Institute. It had four objectives: "product-life extension, long-life goods, reconditioning activities, and waste prevention," according to the Ellen Macarthur Foundation. Today, "cradle-to-cradle" is a registered trademark of McDonough Braungart Design Chemistry consultants. In 2002, William McDonough and Michael Braungart published a book called "Cradle to Cradle: Remaking the Way We Make Things," which made C2C more popular. The book is both a manifesto that details how C2C could work and proof of how it does work through real products.

1.2.3.2 Principles of C2C Design

The cradle-to-cradle design principles have evolved over time, but the foundational ideas remain the same: "The safe and potentially infinite circulation of materials and nutrients in cycles. All constituents are chemically harmless and recyclable," according to EPEA, Michael Braungart's company. Cradle-to-cradle usually applies to product design, but it can also be used when thinking about or designing other systems such the CE business models, too. Materials and products can also be more sustainable using the cradle-to-cradle model. Eliminating the concept of waste disposal is crucial to C2C. Braungart and McDonough wrote that we should not look at the waste as a problem to get rid of, it should be thought of

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differently, the way nature works which "waste equals food." This is a fundamental concept for C2C, and products and materials can be designed to be used perpetually. So, instead of waste, the used materials are nutrients that can fed into a circular system. Those nutrients can be one of two types: biological or technical. Importantly, products from biological cycles have to stay within the biological cycle, and technical materials have to stay within the technological cycle.

1.2.3.3 Cradle-to-Cradle Certification

One of the main objections to the cradle-to-cradle idea in the early stages of its implementation was that it was not easily accessible to companies or organizations since it was controlled by McDonough Braungart Design Chemistry consultants. Only after the non-profit Cradle-to-Cradle Products Innovation Institute was formed in 2012, C2C became more accessible. Credle-to-Credle Institute runs a certification program that has specific parameters listed on its website.

The Cradle-to-Cradle Certification consists of five categories: material health, material utilization, renewable energy and carbon management, water stewardship, and social fairness.

To qualify for certification, companies must ensure, through a third party, that they meet the current criteria of the cradle-to-cradle standard, which takes into account scores in each of the above categories.

The fourth version of this standard went into effect on July 1, 2021. It includes stricter criteria that take into consideration actions needed to address climate change, expanded requirements for water and soil health, and has new additions to the chemicals on the organization's Restricted Substances List. In other words, the standard evolves over time with new information and goals.

There are thousands of cradle-to-cradle certified products. They include everything from packaging, including food and beverages, to apparel for adults, kids and textiles used on outdoor furniture; from carpeting and interior wall

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materials for offices to types of paint, furniture, cleaning supplies, personal care products including perfume, glass coatings, glues, and more.

1.2.3.4 Cradle-to-Cradle Certification Criteria

According to the Cradle-to-Cradle Products Innovation Institute, the criteria for the Cradle-to-Cradle Certification are:

"Material Health: Material Health: ensuring materials are safe for humans and the environment.

Product Circularity: Product Circularity: enabling a circular economy through regenerative products and process design.

Clen Air & Climate Protection: Clean Air & Climate Protection: protecting clean air, promoting renewable energy, and reducing harmful emissions.

Water & Soil Stewardship: Water & Soil Stewardship: safeguarding clean water and healthy soils. Social Fairness: Social Fairness: respecting human rights and contributing to a fair and equitable society."

1.3 CE in the EU

The EU aims to ensure coherence between industrial, environmental, climate and energy policies to create an optimal business environment for sustainable growth, job creation and innovation. To support this, the EU has set an ambitious agenda to turn the EU economy into a cyclical one, where the value of products and materials is maintained for as long as possible, yielding significant economic benefits. The EU also supports European industry in the transition to a climate-neutral economy and improves the energy efficiency of products through ecodesign legislation (European Commission, 2021). The areas of action of the EU to achieve sustainability are distinguished (European Commission, 2021). The transition to a circular economy is not only equivalent to adjustments aimed at reducing the negative effects of the linear economy. Instead, it represents a systemic change

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that creates long-term resilience, creates business and economic opportunities, and provides environmental and social benefits (Wautelet, 2018).

With regard to Circular Economy, the EU undertakes a series of actions to support the transition to a more CE. These cover the cycle of production and consumption, DA and the purchase of secondary raw materials. In a CE, the value of products and materials is maintained for as long as possible and the use of waste and resources is minimized. This can contribute to innovation, growth and job creation (European Commission, 2021). On March 11th, 2020, the Commission adopted a new action plan for CE under the new industrial strategy for a cleaner and more competitive Europe. The plan is based on the success of the previous action plan adopted in 2015 and the conclusions of its implementation (European Commission, 2021). At the same time, the European industry is moving to a climate-neutral economy, signaling a change in the energy, manufacturing, transport and construction sectors.

1.3.1 CE in the EU in numbers

Ecodesign and energy labeling legislation is another effective tool for improving the energy efficiency of products. Helps eliminate the lowest performing products on the market, making a significant contribution to the EU's energy efficiency target for 2020. The energy savings associated with eco-design and energy labeling are estimated at 800 TWh per year by 2020.

Finally, the strategy for a sustainable built environment is an integrated approach to an ecologically neutral, smart and resilient built environment for all EU citizens. It will include (European Commission, 2021):

- Principles of Circular Economy and life cycle approaches.
- Climate, energy and resource efficiency.
- Construction and demolition waste management.
- Accessibility, digitization and skills.

For the transition to the circular economy and to address structural problems that will arise, as the redesign of production processes is required, financial instruments

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from the European Structural Funds and investment funds have been earmarked, such as Horizon 2020, the European Fund for Strategic Investments (EFSI) and the program LIFE. A total of €10 billion will be made available to support investment in the agriculture and livestock sectors for the European Commission's new programming period (2021-2027).

In order to assess the evolution of CE in the EU, Eurostat has developed an interactive tool that visualizes material flow diagrams in a Sankey diagram. In order to better understand the diagram, (Eurostat, 2022a) gives the following tips:

- The bands' width is proportional to the amount of material flow;
- Materials are collected from the environment in order to create products and assets or as a source of energy and in the end are being discharged as residuals into the environment.
- The closed loop refers to residuals that are not discharged into the environment but are instead utilized in the context of CE, such as in the production of secondary raw materials or for other purposes, preventing additional natural resource extraction.

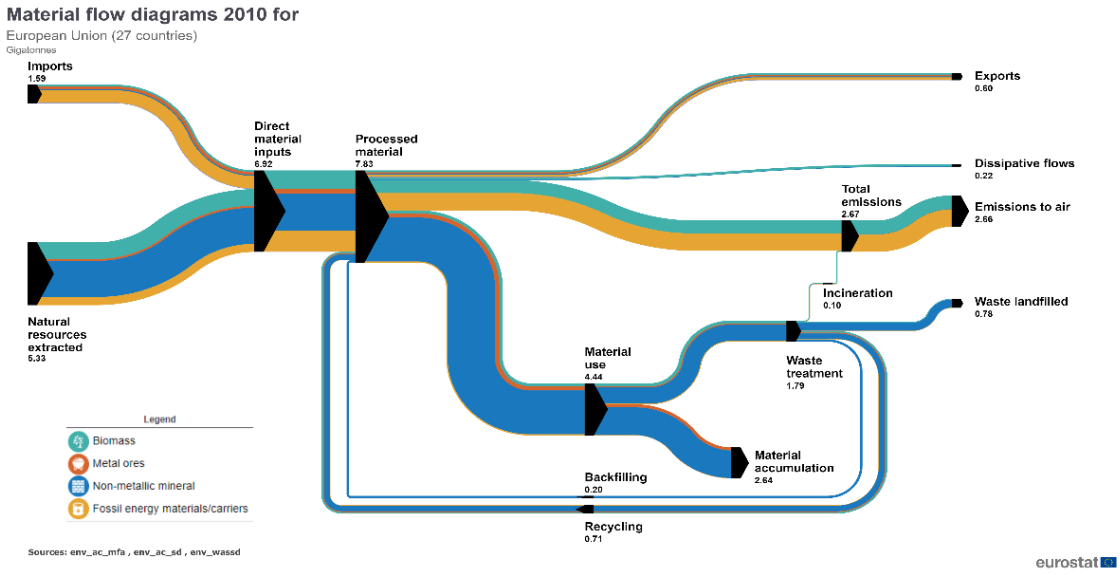

Figure 8. Material Flow Diagrams (2020) for the EU (Eurostat, 2022a)

As seen in Figure 8 and Figure 9, there is a decrease regarding the waste being landfilled and the material inputs in the EU when comparing 2020 to 2010,while

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recycling and backfilling have increased, showing that the economy in overall is becoming more circular. In the case of Greece, the same shift can be observed (Figure 10 and Figure 11); however, the direct material inputs reduction appears to be more significant.

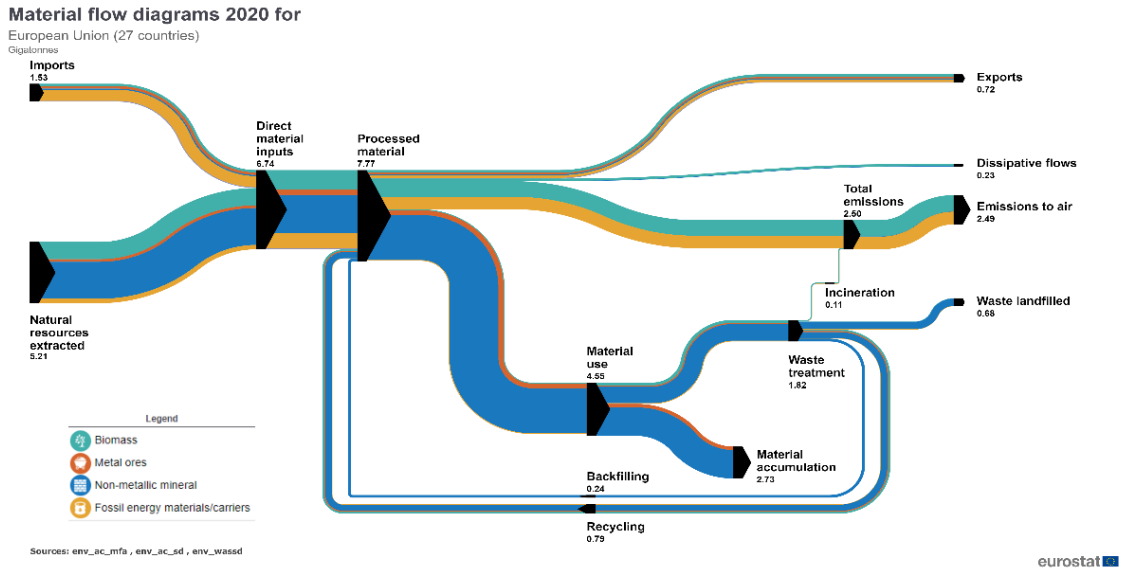

Figure 9. Material Flow Diagrams (2010) for the EU (Eurostat, 2022a)

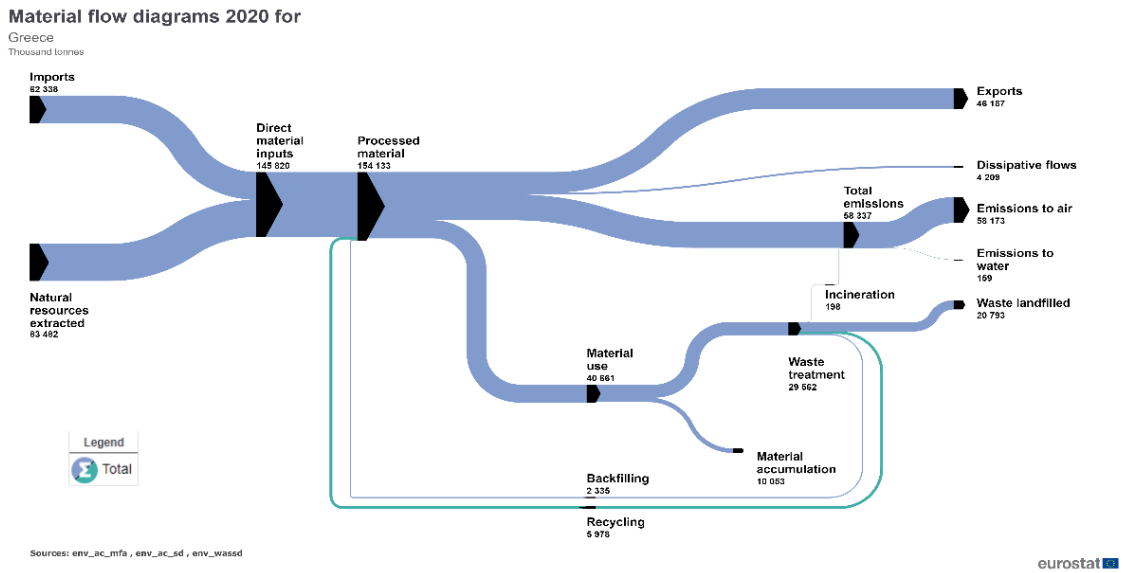

Figure 10. Material Flow Diagrams (2020) for Greece (Eurostat, 2022a)

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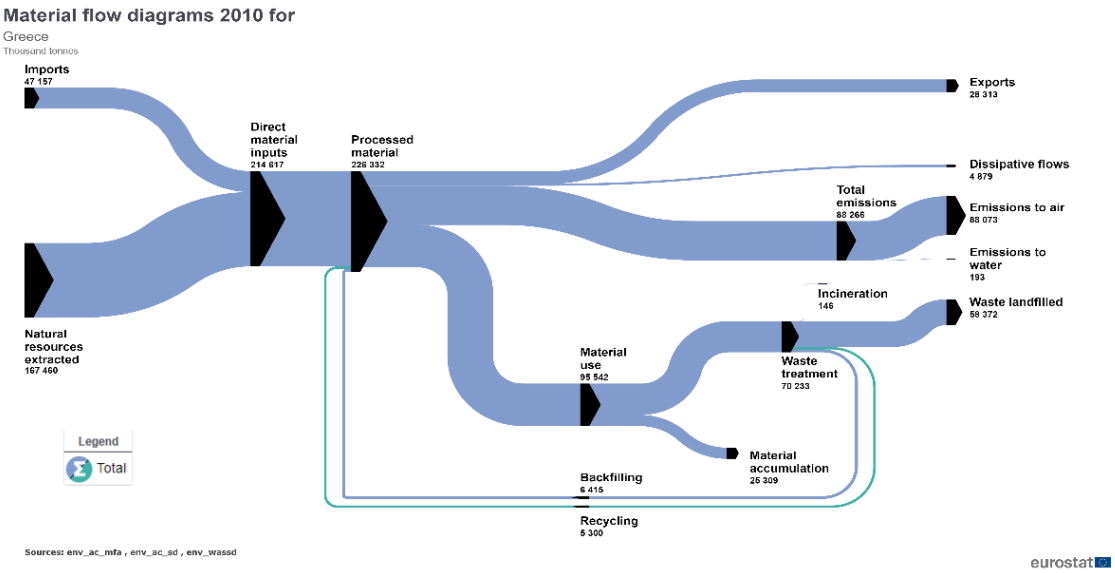

Figure 11. Material Flow Diagrams (2010) for Greece (Eurostat, 2022a)

Another metric used by Eurostat is the circular material use rate (CMR), which is defined as the ratio of the circular use of material to the overall material use (Eurostat, 2022b). In 2020, the EU average was at 12.8, with Netherlands, Belgium, France, Italy and Estonia performing the best with 30.9, 23, 22.2, 21.6 and 17.3 respectively. Greece was 19th with a CMU at 5.4.

1.3.2 The Circular Economy Package

The concept of the circular economy gained importance relatively recently on EU level, mainly because of high commodity prices in a situation of prolonged economic crisis. In 2011, the European Commission launched the 'Flagship initiative on resource efficiency' and a 'Roadmap to a Resource Efficient Europe'. In July 2014, the Commission adopted 'Towards a circular economy: a zero-waste programme for Europe', which lists six waste management directives that created the EU's first 'Circular Economy Package' (CEP). The main goals of the CEP were to boost recycling and prevent the loss of valuable materials, to create jobs and spur economic growth, to offer new business models, eco-design and industrial symbiosis that can contribute to the transition to a 'zero waste' economy, and to reduce greenhouse emissions and other environmental impacts. It also proposed

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setting a non-binding target to increase material productivity by 30% between 2014 and 2030, along with introducing and tightening existing waste-related targets. In December 2014 the EU Commission withdrew the CEP stating that it would instead introduce a new, more ambitious package by the end of 2015, which would cover the full economic cycle, rather than focusing on waste reduction and recycling. In December 2015 the Commission adopted the revised CEP, entitled 'Closing the Loop – An EU action plan for the circular economy', with the overall objectives of contributing 'to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy' to be delivered by 54 'actions' to be carried out by 2020. This section will describe the main elements of the revised CEP using the policy intervention classification and discuss progress with their implementation and their effectiveness in achieving their objectives.

The main regulatory requirements resulting from the CEP are binding goals on landfilling and recycling, which went into effect in July 2018. The targets include requirements for 65% of municipal waste to be recycled by 2035, and 70% of packaging waste by 2030, with intermediate targets for both, and a maximum of 10% of municipal waste to be sent to the landfill by 2035 (with waste suitable for recycling or other recovery prohibited from landfill by 2030). Like with the pre-existing waste-related targets, member-states are mostly free to select the specific policy instruments appropriate to achieve these targets. However, they must adhere to a range of other new requirements, including the obligation to establish separate collection for paper, metal, plastic and glass waste, and the establishment of EPR schemes for all packaging by the end of 2024. In 2017, 30% of total municipal waste in the EU28 was recycled. This is a substantial increase from 11% in 1995 (Eurostat, 2019a), but is a way below the 2020 target of 50% set by the 2008 Waste Framework Directive. 67% of all packaging waste was recycled in 2017 (varying from 40% in Malta to 82% in Belgium), with most member states meeting the target of 55% to be achieved by 2008-2015, and 17 already achieving the new 2025 target of 65% (and 6 even achieving the 2030 target) (Eurostat, 2019c). Around 23% of municipal waste in the EU27 was sent to landfill in 2017– nearly half

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the value experienced ten years prior, with substantial variation between member states, ranging from less than 1% in the top five, and above 70% in the lowest five (Eurostat, 2019a). As such, although broad trends are promising, meeting the targets set in 2018 – particularly for total recycling and landfilling - will require substantial further policy effort in many member states. The CEP also aimed to increase emphasis on circular economy aspects in requirements set under the Ecodesign Directive, including standards on material efficiency. Various eco-design regulations adopted in October 2019, including for washing machines, dishwashers, and refrigerators, include circular economy-related requirements, and, following a request by the Commission, standards on material efficiency aspects, including durability, repairability and recyclability. Other EU-wide regulatory ambitions proposed by the CEP, including minimum requirements for water reuse in agricultural irrigation and standards for secondary raw materials and material-efficient recycling for electronic waste and related products, are at various stages of development. Setting the appropriate fiscal framework using economic instruments is promoted as a core objective to encourage the development of resource efficiency and circularity in the EU.

The environmental taxes, a cornerstone instrument in efforts to set the appropriate fiscal framework through pricing the externalities associated with resource extraction and use, accounted for just 6.1% of total revenues from taxes and social contributions in the EU28 in 2017 (ranging from 4.4% in Luxembourg, to 10.2% in both Greece and Slovenia). The vast majority (77%) of these revenues were raised through taxes on energy products, with taxes on resource extraction and pollution (excluding GHG emissions but including waste management levies) together accounting for just 1% of total environmental tax revenue (Eurostat, 2019b).

The generally weak environmental fiscal position in the EU is further illustrated by the presence of environmentally harmful subsidies (EHS), with debate most often focused on fossil fuel subsidies in the context of the need for climate change

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mitigation. In the EU, such subsidies were estimated to be worth €55 billion in 2016 (European Commission, 2019c). Although not directly tackled as part of the CEP, both these elements are addressed in the 2011 Roadmap, which proposes that member states should 'shift taxation away from labor to environmental impacts', with 'a major shift' achieved by 2020, and 'prepare plans and timetables to phase out EHS', with a phase out achieved by 2020 (European Commission, 2011: 11).

Education, information, and awareness proposed by the CEP may be grouped into three broad categories. The first category seeks to improve the collection and availability of data, including the further development of the EU Raw Materials Information System (RMIS), the development of a common way and indicators to measure food waste, and the development of a monitoring framework for the circular economy. Progress has been made on all these fronts. The RMIS, launched in November 2017, and presents data and other information across 12 thematic blocks covering crucial raw materials, secondary raw materials, and environmental and social sustainability. A common methodology to food waste measuring was adopted by the Commission in May 2019, and the circular economy monitoring framework with a set of 15 indicators across the value chain was first published in January 2018 (European Commission, 2019b).

The second category of interventions are those that seek to promote best practice amongst businesses, particularly in waste management. This includes the inclusion of circular economy aspects into Best Available Technique Reference (BREF) documents, published as part of the Industrial Emissions Directive. The third category are those that provide information to the end consumer. This includes presentation of circular economy-related information on product energy labelling (information on availability of spare parts, ease of repair, and facilitating end-of-life treatment is now available on such labels for various products); a 'fitness check' for the EU's Ecolabel. The CEP proposed action to enhance the integration of circular economy requirements into its voluntary GPP criteria and support a greater uptake of these criteria across member states, and in the EU's own institutions. Circular

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economy requirements are now included for various product categories, with the 3rd edition of the 'Buying Green' handbook and the brochure 'Public Procurement for a Circular Economy' published to support uptake.

Various innovation support and collaboration platform interventions were proposed by the CEP. Principal among these is a focus on circular economy issues under 'Horizon 2020', the EU's research and innovation programme for 2014-2020. Between 2016 and 2018, over 250 research projects related to the circular economy were financed, including those directly contributing to the actions described above, with public funding of over €1.2 billion (European Commission, 2019d). An additional €950 million is available for projects in 2018-2020 (European Commission, 2019b). Moreover, CEP 'actions' include establishing a pan-EU network of technological infrastructures for SMEs to adopt advanced manufacturing, improving the exchange of information between manufacturers and recyclers of electric products. In February 2018, the online Information for Recyclers Platform – I4R – was launched, to facilitate such information sharing as required by the WEEE Directive.

1.3.3 Circular Economy in Greece

In Greece, the circular economy, as a potential factor of productive reconstruction and strengthening of entrepreneurship, is fully compatible with the structural characteristics of the national economy (enhanced small and medium-sized entrepreneurship-social economy), the quantities and qualitative characteristics of the waste generated and the need to protect natural resources from increased anthropogenic pressures, in particular from agricultural activity and tourism.

It is noted that in the primary sector there is great potential for modernisation, with a reduction in production costs as it is characterised by low resource and energy productivity indicators. The country is also characterised by limited material reuse rates according to the European Statistical Office (Eurostat) of less than 3%.

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Finally, Greece has the appropriate scientific potential and know-how to implement the adjustments required for the transition to the circular economy, while it is supported by the EU through the proposed strategic guidelines and the availability of financial instruments mentioned above.

1.4 Barriers to Circular Economy

There are many obstacles and barriers on various levels, which hamper the faster introduction of the circular economy more widely. They can be summarized in three categories – governmental, societal and management barriers.

1.4.1 Governmental issues

Ineffective or unsupportive policies; lack of measuring indicators; unclear vision; weak economic incentives; high upfront/startup costs and insufficient short-term benefits prevents investment. Technological issues: product complexity overwhelms separation of materials making recycling harder; lack of enough information when tracking material composition of products to enable recycling and remanufacturing. Lack of enough public information and awareness to support participation in reuse / recycle / remanufacturing; lack of necessary skills in the workforce.

1.4.2 Societal barriers

Lack of consumer awareness about refurbished or remanufactured products; perception that quality of refurbished or remanufactured product is lower.

1.4.3 Management barriers

Lack of interest in the leadership in circular economy at management level; higher priority given to other supply chain issues; various organizational structures within firms inhibit implementation of CE practices; lack of successful business models and training; transnational supply chains with a lot of complexity. Lack of good relationships in supply chain, thus being "stuck" with the current suppliers; inability

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to transition from linear technologies; remanufacturing requires experience and knowledge.

1.4.4 Barrier examples

Some resource-efficient investments for companies might be financially positive in the long run, but are not made because the upfront costs are prohibitively high, or the rate of return is not high enough to justify transition to CE. Lack of pre-existing relationships - some resource efficiency gains can be achieved by maximizing synergies and coordinating materials and supply chains between multiple actors – but habits and lack of relationships can inhibit identification of such opportunities. Barriers because of which resource efficiency actions would not be to the financial benefit of the actors concerned. Examples include manufacturers not having the incentive to design products amenable to recycling or remanufacturing, because they are not exposed to the costs of waste disposal. Even if resource-efficient behaviour may be to the larger benefit of society and the environment, by reducing pollution and resource depletion, if such negative impacts do not have a financial price, then resource-efficient behaviour may not be in the financial interest of a private actor. If the cost of labour is too high relative to the cost of materials, this can also mean that resource-efficient choices are not financially efficient to individual companies. Risk perception associated with long-term investments in new and innovative resource-efficient processes and technologies may not make sense in the short term, provided that the status quo of the current economic structures remains in place. Investments in CE would then require justification and faith in the forthcoming evolution of such a broader system, and would be inhibited by the risk perception if such wider changes are not coming about.

1. It reduces waste since it promotes the recycling of finished goods.
2. It reduces the risk of potential price volatility of the raw materials.
3. It achieves efficiency since the resources are recycled to get new products.
4. It promotes continuous usage of products and spurs new business opportunities by promoting reusage rather than purchasing a new item.

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5. It benefits and preserves the environment.
6. It creates new businesses, and new employment opportunities.

1.5 CE in Agri-food Supply Chains

The CE concept is applicable both for technical and biological supply chains. In the food system, 31% of the produced food is lost or wasted, where 11% is consumer waste and 20% is value chain waste (i.e. waste created throughout the supply chain and before the consumer stage), while at the same time 95% of fertilisers do not provide nutrients for the human body and 30-85% of European Agricultural land suffers from land degradation (Ellen MacArthur Foundation, 2015). Circular Economy could potentially benefit the agri-food system, in the European Union and the CB region as well as worldwide, as we will explore in the following chapter.

The CE is an economic system that aims both to minimize the waste produced by a production process and to reuse and reintegrate it into the same or another production process, thus extending its life cycle. In other words, it is about a circular production model in which, unlike a linear model in which the waste produced is discharged into the environment, the waste continues in the same or "modified" form (include the terms reuse, repair, renovation, refurbishment, reconstruction or recycling) their life cycle by increasing the efficiency of their use and reducing the waste and degradation of natural resources.

As it has been shown, cyclical business models compared to linear ones, in addition to their environmental benefits, can be equally sustainable from an economic point of view, contributing at local or national level to reduce imports, improve the trade balance and boost employment. The CE is fully compatible with the objectives and policies of the EU for Greece and the other Member States and can be widely applied in the agri-food sector for the benefit of local economies and the national economy. The key objectives of the national strategy for the CE include sustainable resource management, strengthening circular entrepreneurship and circular consumption.

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Information and education of all those involved (businesses, institutions, producers, citizens) is required etc) on the rational use of resources, the sustainable consumption of food, the management of waste and secondary products, etc. There are public life and policy issues that need to be studied and addressed in order for the transition to the CE to be smooth and real.

1.5.1 The Greek Agri-Food Sector and Circular Economy

The agri-food sector, one of the pillars of the Greek economy, by its structure and content is characterised by a high potential for implementation of the circular economy, however, beyond legislative and other interventions, structural changes and redesign of value chains are needed

In particular, changes may be required in production processes (extraction of raw materials, product and material design), handling and consumption, as well as changes in the treatment of the waste generated to enable its reuse (secondary raw materials). Furthermore, changes in cooperation models may be required as the circular economy relies exclusively on the interconnection of processes and networking between stakeholders and businesses.

In Greece, the concept of circular economy in the agricultural sector refers mainly to the management of biomass, aiming at the production of products that serve different purposes, such as soil amendments, animal feed, export of organic and inorganic compounds, production of biofuels and energy, packaging materials, etc. and an estimated 7,500,000 tonnes of agricultural crop residues and 2,700,000 tonnes of forest residues are produced annually.

1.5.2 Applications of the circular economy in the agri-food sector

Food loss and waste is a global issue. Around 88 million tonnes of food are wasted annually in the EU at an estimated cost of €143 billion (KMPG, 2018). In Europe a significant amount of food is lost in consumer waste, raising concerns about both the economic damage and the waste of resources. Reducing food waste can have positive benefits for the environment and communities. Beyond that, adopting a

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circular economy approach to reduce, reuse and recycle food waste, provides the opportunity to generate new business models and economic benefits.

Some good practices that have been implemented globally are:

i. The Dutch company Kromkommer, which makes soups from unsold vegetables.
ii. Instock restaurant has a menu of food that is not sold.
iii. Systems (ValuWaste) that control food waste in kitchens.

1.5.2.1 Food waste at EU level

Over 50% of food waste generated in the EU occurs at household level - which is the main area of interest for food waste prevention programmes in Member States. Other sectors contributing to food waste in the EU are food production (19%), hotels and food services (12%), the cultivation (11%), wholesale and retail trade (5%). In Greece, the distribution of food waste production is considered to be similar, but there is no precise data to prove this (Eunomia Research & Consulting IKE, 2021).

To accelerate EU progress, the Commission proposes legally binding targets to reduce food waste by 2023, as required by the Farm to Fork strategy. Member States are also committed to achieving the global sustainable development goal SDG 12.3 (Index 12.3.1 - Global food loss and waste), and putting in place national strategies and measures to combat food waste. An increasing number of countries are implementing national strategies and action plans to combat food waste (e.g., Austria, Belgium, Croatia, Germany, Finland, Germany, Ireland, Ireland, Luxembourg, the Netherlands, Portugal, Slovenia, Spain, Sweden, the United Kingdom and the United Kingdom). Some countries have also introduced legislative frameworks focusing on food waste prevention (e.g., France, Italy) (Eunomia Research & Consulting IKE, 2021).

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1.5.2.2 Biowaste in Greece and Bulgaria

The EU aims to promote the prevention of waste and the re-use of products as much as possible. If this is impossible, then it prefers recycling (including composting), followed by using waste to generate energy. The most harmful option for the environment and people's health is simply disposing of waste, for example on landfill, although it is also one of the cheapest possibilities.

According to statistics from 2017, **46% of all municipal waste in the EU is recycled or composted.** However, waste management practices vary a lot between EU countries and with many countries still landfilling large amounts of municipal waste.

Germany and Austria are the EU's top recycling countries. Landfilling is almost non-existent in countries such as Belgium, the Netherlands, Denmark, Sweden, Germany, Austria and Finland, where incineration plays an important role alongside recycling.

The practice of landfilling remains popular in the eastern and southern parts of Europe. Ten countries landfill half or more of their municipal waste. In Malta, Cyprus and Greece this is more than 80%. In Croatia, Romania, Bulgaria and Slovakia it is more than 60%, while it is also half or more in Spain and Portugal.

In Greece, the quantities of biodegradable waste (BOD) that have been sent to landfills exceed by almost 2 million tonnes the maximum permitted quantity set by the legislation and the previous NAP. Specifically, in 2018, 2,771,773 tonnes of BAM ended up in landfills, against a maximum permitted quantity of 910,000 tonnes of BAM. Between 2015 and 2018, separate collection of bio-waste increased from 4.7% to 5.7% of the total amount of biodegradable waste generated in the country. According to the adopted NAP 2020-2030, separate collection of bio-waste will become mandatory from 31 December 2022 through the extension of the "brown bin" at national level.

Experts agree that the Bulgarian waste market is difficult, as tenders and procurement processes for waste disposal are burdensome. Poor payment of the municipal contracting authorities is also hampering the process. Secondly, plants and services for waste treatment fall under concession law, which makes the installation of public-private partnerships even more complicated.

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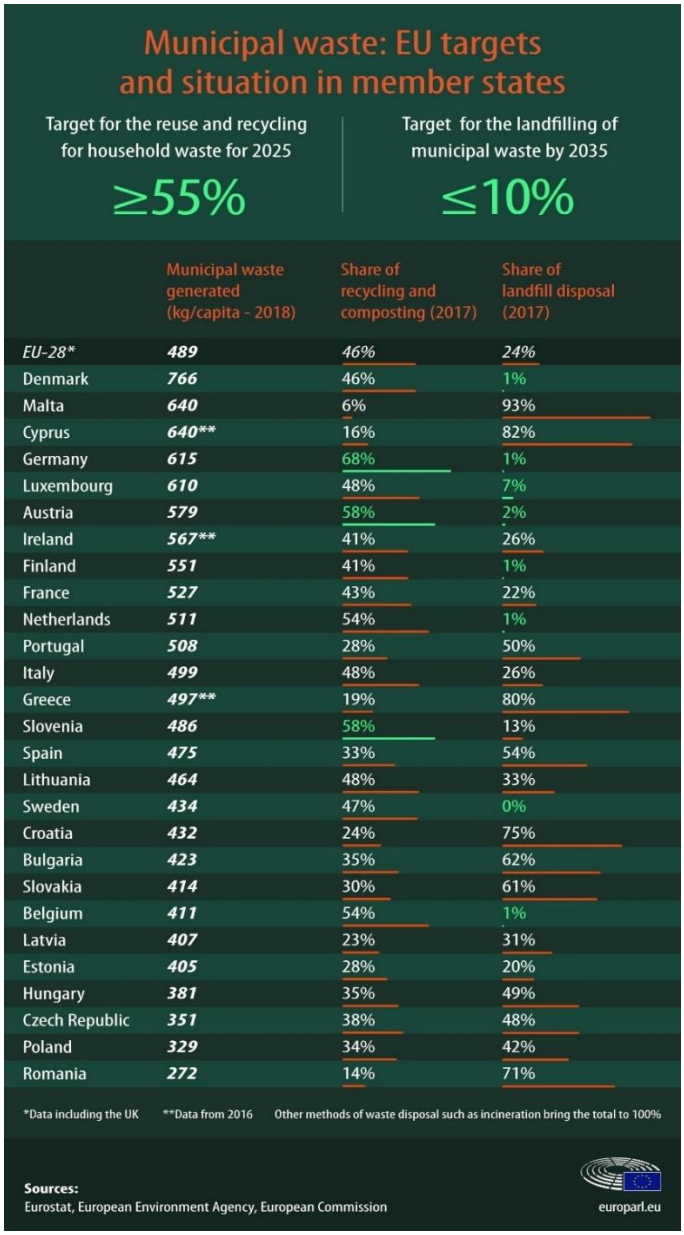

Figure 12. Municipal Waste in EU countries (2018)

There are no official statistics yet on the food loss for Bulgaria, but it is assumed that every Bulgarian throws away 100 kg of food per year. The sectors contributing to food waste the most are the Bulgarian households with 53% and the processing industry with 19%, the primary production with 10%, while catering establishments and shops are throwing away 12% and 5% of the total unused resource. According to a study by the European commission, 670 000 tonnes of food is produced annually in Bulgaria in excess, a third of more than necessary to feed the entire population.

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To support the UN Objective 12.3 for reduction of food waste by 50% by 2030, Bulgarian Ministry of Health has established a National Programme for the Prevention and Reduction of Food Loss (2019-2024), which also contains an Action Plan with the next steps with regard to the prevention and reduction of food loss. One of the key points for prevention and reallocation of food losses and waste is a stimulus for donating food to people in need by donating excess food to food banks. In order to prevent buying excessive amounts of food, and only as much as the consumers need, food should be available in packages of different sizes. Foods with near-expiration dates and damaged products must be offered in retail outlets at reduced prices in order to be able to accessible to people in need.

The Bulgarian Food Bank (BSE) is the only organization in the country that redistributes unused food to people in need. BSE acknowledged that there is a growing positive trend in business attitude toward food donation. In 2016, 233 tons of food went through the food network of the Bulgarian Food Bank and reached 22,513 Bulgarians. Unfortunately, the quantities that BHB receives from food waste are less than 1% of the total edible food that is wasted.

1.5.2.3 Water reuse

Water is a finite resource and water scarcity affects 17% of EU territory(European Union, 2010). Currently, the new Regulation (EU) 2020/741 on minimum requirements for the reuse of water for agricultural irrigation which will apply from June 2023, is expected to promote water reuse in the EU. In the context of the Action Plan for the new circular economy (2020), the implementation of this new Regulation is included in Europe's priorities for the circular economy (EUROPEAN PARLIAMENT, 2020)

1.5.2.4 Reducing consumption, reuse and recycling

Reducing consumption, reusing and recycling all help to reduce waste, protect natural resources, save space and money. A recyclable product returns to raw material that can be used to create a new, different product.

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The recovery and sale of goods that can be collected from municipal waste is a kind of "natural" social protection measure and a source of income especially in times of economic hardship. In addition, the recycling of used objects contributes to the reducing the volume of waste, thus reducing the environmental crisis in each region.

1.5.2.5 Green and Blue Growth

A sustainable blue economy is essential to achieve the objectives of the European Green Deal. Pollution, overfishing and habitat destruction, combined with the effects of the climate crisis, all threaten the rich marine biodiversity on which the blue economy depends. All sectors of the blue economy such as fisheries, aquaculture, coastal tourism, maritime transport, port activities and shipbuilding should reduce their environmental and climate impact.

Tackling the climate and biodiversity crisis requires healthy seas and sustainable use of their resources to create alternatives to fossil fuels and traditional food production.

Pollution reduction will be achieved by moving to a circular economy, through renewed standards for the design of fishing gear, for the recycling of vessels και on decommissioning offshore platforms and taking measures to reduce plastic and microplastic pollution.

Preserving Europe's seas will help ensure sustainable seafood production such as the use of seaweed and other marine vegetation, stronger control of fisheries, and research and innovation in the field of cell-based seafood.

1.6 Circular Economy and SMEs

The shift towards a circular economy requires businesses and, by extension, Greek Small and Medium-sized Enterprises (SMEs) to rethink not only the use of their resources but also to redesign and adopt new business models based on life extension, decomposition, renovation, reconstruction, increased reuse and

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recycling of products (Kottaridi, 2020). Benefits of the circular economy for Small Businesses

The Circular Economy is a modern economic model of sustainable development, which if implemented in a cooperative and participatory way, can enhance social consistency and promote strong regional economies. According to the 2016 EEA study "Circular Economy in Europe" the following benefits are identified.

- Improved resource security and reduced dependence on imports thanks to reduced demand for raw materials.
- Reducing environmental impacts, including a drastic reduction in greenhouse gas emissions.
- Economic benefits: including new opportunities for growth and innovation, as well as savings associated with improved resource efficiency.
- Social benefits: ranging from the creation of new jobs at all skill levels to changes in consumer behavior, leading to better health and safety outcomes.

By adopting circular economy strategies and practices, entrepreneurs can realize all kinds of different benefits. These advantages depend on the strategy adopted, the extent to which processes are cyclical, the environment in which the company operates and its role in the value chain. To this end, six operational benefits for small businesses are identified (KMPG, 2018)such as:

i. Reduced exposure to the rise and volatility of resource prices.

The increasing scarcity of non-renewable natural resources (e.g., fossil fuels, metals and minerals) has resulted in rising resource prices and price volatility, which results in higher material costs for businesses. By adopting circular economy strategies and practices, businesses can reduce the amount of materials needed for their production and meet the needs of their customers.

ii. Circular thinking stimulates innovation.

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Provides a new perspective to examine the business model and operations of a business. Looking at this new perspective can offer new ideas and stimulate innovation. For example, looking for ways to reduce the amount of materials used in construction, the Dutch company BAM invented new building materials from plastic waste.

iii. Creates a green profile.

Consumers and businesses are increasingly aware of the environmental impact of the products they use. As a result, they are more attuned to sustainability when making their purchasing decisions. By adopting circular economy strategies and practices, businesses can reduce the environmental costs of their products and thus differentiate themselves from their competitors.

iv. Opens up new markets and opportunities for growth.

The transition to a circular economy can be facilitated by adopting a different business model. The sharing economy through integrated digital platforms such as Airbnb, Uber etc. is one such example. In Europe, Airbnb claims to produce around 0-30% less waste, use 50% less water and emit 90% less CO2 than hotels.

v. Creates environmental benefits.

Adopting circular economy strategies and practices is not only beneficial for businesses but also for the environment. To become more circular, businesses need to reduce their environmental impact:

- reducing the use of raw materials,
- reducing energy consumption and using only green energy,
- reducing drinking water consumption.

In this way, the introduction of a more circular economy is one way of meeting the requirements of compliance with EU rules and thanks to the so-called "trigger factors »(Eunomia Research & Consulting IKE, 2021). Indicatively:

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- Elimination of all known hazardous substances as soon as possible to facilitate future reuse and recycling (discouraging the use of older chemicals).
- Providing better information to preparation, reuse and recycling organisations e.g. through so-called "product passports".
- Better information, and financial support, to businesses that could develop Circular Economy business models.
- Better information for consumers, on issues such as durability and recoverability of products.
- Design for: circularity, durability, life extension and ease of repair and reconstruction - and recyclability and finally,

Digital technology and artificial intelligence (AI) to support Circular Economy business models, for example to facilitate product sharing/leasing and to monitor the condition of products in order to optimise maintenance and prolong their lifetime.

1.6.1 Obstacles encountered by Greek SMEs to join the circular economy

There are many obstacles that do not allow small businesses and, by extension, Greek small businesses to adopt circular economy business models (Geng and Doberstein, 2008; Ormazabal et al., 2016; Preston, 2012; Ritzén and Sandström, 2017; Rizos et al., 2016).

More specifically, they concern:

1. organisational culture and management towards environmental issues,
2. the lack of funds to support sustainable activities and innovation,
3. the lack of adequate state support/appropriate,
4. the lack of information on the benefits of the circular economy,
5. the high level of bureaucracy in monitoring and reporting on the performance of SMEs in the circular economy sector,

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6. the lack of technical capacity to facilitate the transition to new business models involving the application of sustainable production and consumption technologies, and
7. insufficient support from suppliers and consumers due to their low interest in environmental issues.

1.6.2 Proposals for tackling obstacles to the circular economy

1.6.2.1 Turning the circular economy into a driving force for SMEs

Many small businesses lack the skills and capabilities to exploit the potential benefits of circular design, circular production processes and circular business models. Essentially, it is a challenge for small businesses to integrate the circular economy into their business activity, given that the culture and their expertise are based on linear production business processes. Therefore, one proposal would be the creation of a national forum - "Circular Greece" - capable of bringing together small businesses, authorities and universities to collaborate by offering knowledge in various fields and contribute to the achievement of the cyclical transition of the Greek small business community.

In addition, an initiative can be created-funded where small businesses can obtain information on opportunities to implement the circular economy and the practical application of circular business models. In this context, such an initiative will strengthen know-how and skills in small businesses, create a network across the value chain and provide expert advice on circular business models.

1.6.2.2 Promoting research and development for circular solutions and technologies

The transformation to a circular economy requires investment in research, innovation, development, product design, production processes, remanufacturing, recycling, organic materials, circular business models and chemical-free products. In this context, funding from funds such as:

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- the technology transfer fund (TTfund) and
- the Accelerator Fund

In addition, cooperation between businesses and research centres will ensure that the results of research can be easily implemented will accelerate the transition to a circular economy while contributing to growth and employment.

1.6.2.3 Promoting finance for small circular businesses

Many small businesses wishing to make the transition to a circular economy face serious problems in finding finance. In this context, it is possible to use European financial instruments, such as:

- Horizon 2020: is the financial instrument that implements the 2020 Strategy initiative and aims to ensure Europe's global competitiveness,
- COSME: is the European Programme for the Competitiveness of Small and Medium-sized Enterprises,
- LIFE: The LIFE Programme is the European financial instrument for Environment and Climate Action,
- European Structural and Investment Funds (ESIF): the European Structural and Investment Funds aim to create jobs and a sustainable and healthy European economy,
- European Fund for Strategic Investments (EFSI): the European Fund for Strategic Investments is an initiative that aims to help address the current lack of investment in the EU

Furthermore:

1. The Product Environmental Footprint (PEF),
2. Organizational Environmental Footprint,
3. EU Eco-Management and Audit Scheme (EMAS),
4. EU Ecolabel,
5. Environmental Technology verification programme (CETV), and
6. European Resource Efficiency Knowledge Centre (EREK).

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1.6.2.4 Review of the Circular Economy Directive

With the existing legislation on the circular economy, the incentives for small businesses are not sufficient, making small businesses choose solutions that only involve recycling and not the design of a circular product.

In this context, it is appropriate to review the Eco-Directive, a decision that is capable of changing the entrepreneurial behaviour of small businesses. In addition, the provision of fiscal and financial incentives will significantly promote the transition of small businesses towards a circular economy, as the creation of cyclical products will be more profitable than recycling or remanufacturing the product itself.

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2 Environmental Impact

2.1 Farm to Fork Strategy

The European Green Deal sets a very ambitious goal to halt and reverse biodiversity loss by transforming our food systems, forest, land, water and sea use, energy, urban and industrial systems. It also highlights the critical importance of tackling climate change and reviving biodiversity.

The Farm to Fork Strategy (F2F) is at the heart of the EU Green Deal. It will enable the transition to a sustainable EU food system that preserves the food security and gives access to healthy diets sourced from a healthy food. It will reduce the environmental and climate impact of the EU food stem and will strengthen its resilience.

Figure 13. Farm to Fork Concept (European Commission)

The F2F strategy has concrete targets, which aim to transform the EU food system by 2030 with the following targets: reduction by 50% of the use of pesticides, 20% a reduction of the use of fertilizers, reduction by 50% in sales of antimicrobials used for farmed animals and aquaculture, 25% of agricultural land to be used with

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organic farming techniques. It offers strict measures to ensure that the healthy option is accessible for EU citizens. That is provided by improved labelling criteria.

Figure 14. 2030 EU food sustainability targets (European Commission)

European farmers, fishers and other aquaculture producers play a vital role in the transition to a sustainable food ecosystem. These policies will be supported in the Common Agricultural Policy and the Common Fisheries Policy through new sources of funding, which will facilitate the farmers, fishers and other aquaculture producers to learn sustainable practices. Additionally, by making sustainability Europe's trademark, it will open new business opportunities and diversify sources of income for European farmers and fishers.

EU's Farm to Fork strategy is not a specific legislative proposal in itself but an outline of new premises for the future food systems. The strategy sets out an action plan for non-legislative initiatives, amendments to existing legislation and new legislation, which will be submitted to the usual impact assessment and consultation process, followed by the bloc's legislative process. The targets and actions specified in the F2F strategy are assigned to four clusters: sustainable agri-food and food production; sustainable food processing and distribution; sustainable food consumption; food waste and food loss prevention.

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By 2023, the European Commission will present a proposal for a "legislative framework for sustainable food systems" that will aim to promote policy coherence at EU and national levels, meaning it will set common definitions and targets for all participants in the food system. There are around 37 different measures in the strategy, ranging from avoiding "marketing campaigns to advertise meat at very low prices" to "reducing dependence on long-haul transportation [of food]" to developing an integrated nutrient management action plan to address nutrient pollution and increase in sustainability of the livestock sector.

Some of the measures to be addresses by 2024 are:

1. Initiative to reward farming practices that remove CO2 from the atmosphere (by Q3 2021), i.e., development of a regulatory framework for certifying carbon removals based on robust and transparent carbon accounting.
2. Facilitate the placing on the market of sustainable and innovative feed additives; reduction of the dependency on critical feed materials (e.g., soya grown on deforested land) by fostering EU-grown plant proteins.
3. Legislative proposal and other measures to avoid or minimize placing of products associated with deforestation or forest degradation on the EU market.
4. Recommendations to each member state on the nine objectives of the Common Agricultural Policy (CAP) to be included in their strategic plans.
5. Clarification of the competition rules and monitoring the implementation of the unfair trading practices (UTPs) directive.
6. Action plan to reduce pollution from fertilizers.
7. Action plan for the organic sector for 2021-2026 to stimulate supply and demand for organic products.
8. Proposal for a Farm Sustainability Data Network (data and advice on sustainable farming practices).
9. Proposal for a revision of the existing animal welfare legislation, including transportation and slaughter.

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10. Using new methodology for measuring food waste and the data expected from Member States in 2022 to set a baseline and propose legally binding targets to reduce food waste across the EU.

2.1.1 Farm to Fork strategy implications for the climate

In order to achieve EU's goal of climate neutrality by 2050, all sectors will have to drastically reduce the greenhouse gas emissions. The agriculture sector is part of the EU's greenhouse gas reduction obligations for member states. Although the agriculture sector is the only major farm sector worldwide to have reduced its greenhouse gas emissions by 20% since 1990, it still accounts for about 10% of the EU's greenhouse gas emissions, of which 70% are due to animal production. Together with manufacturing, processing, packaging and transportation, the food sector is one of the main drivers of climate change. The farming sector's emissions have hardly gone down in the past decade and are projected, if they remain at the same level, to stagnate in the coming decade.

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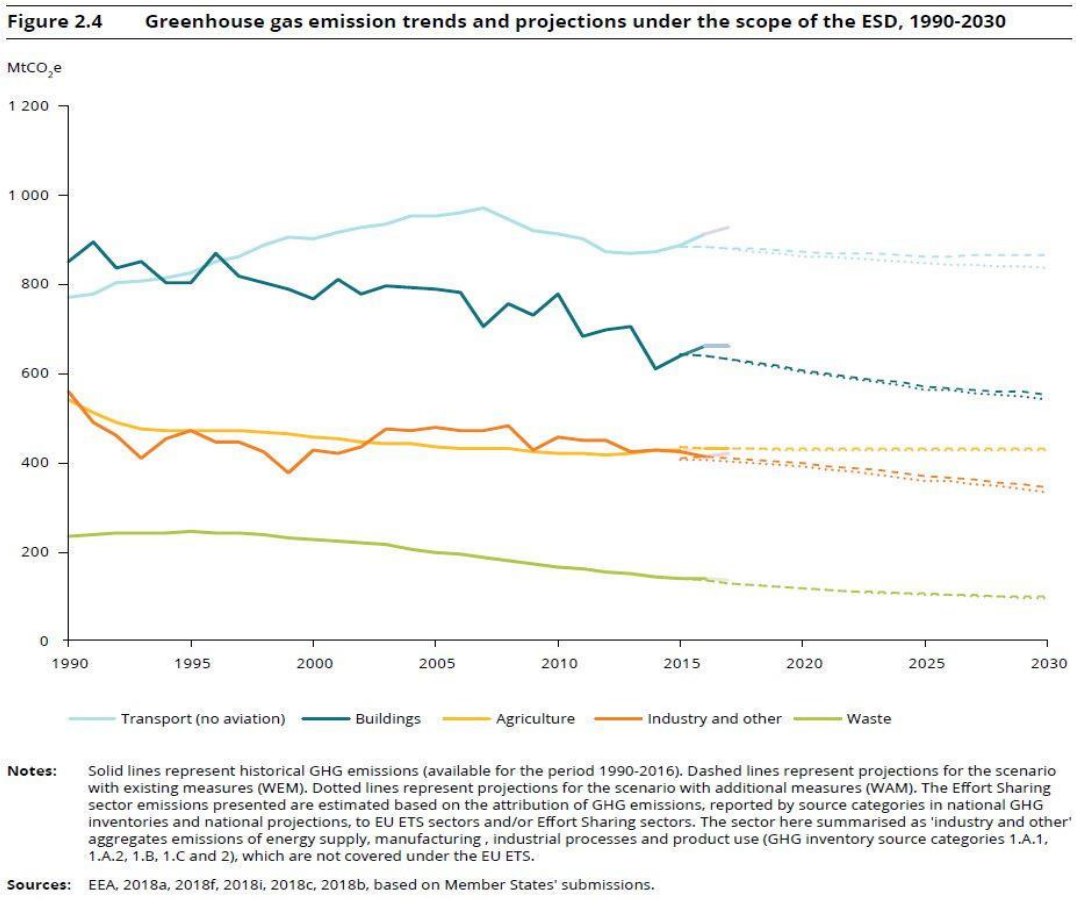

Figure 15. EU Greenhouse emission trend from 1990 to 2030 (projected) European Commission

The Farm to Fork strategy aims to accelerate the transition to a sustainable food ecosystem that will also reduce the risks associated with climate change. Even if some of its targets, such as the reduction of antimicrobial sales, are not directly related to a climate action, GHG emission reduction has to be achieved in all areas of the value chain, i.e., in the growing, storing, processing, packaging, transporting, eating and discarding of food. Parts of the F2F strategy – such as rewarding farmers for removing CO2 from the atmosphere, rules for imports associated with deforestation – are primarily aimed at reducing the GHG emissions; while others should incur emission reductions even if their main objectives lie elsewhere, e.g. higher animal welfare standards (leading to fewer animals overall), larger organic farming areas (increase carbon stored in soil), more power to small farmers vis-à-vis large food companies, reducing food waste and changing consumer habits of eating meat.

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The major challenge in reducing GHG in the food system remains in the many trade-offs that happen between the measures that aim to individually protect the environment, farm animals, consumers and the climate but fail to achieve all of these goals at the same time. Achievements in the social and economic sphere (affordable and healthy food, cutting red tape for small farms) may counteract the environmental objectives. Another example: policy actions promoting plant-based diets that help reduce the use of human-edible biomass in animal feed and scale back intensive farming on grasslands but they also result in higher GHG emissions from the animals. On a more general level, critics of F2F state that by using less fertilizer and farming more land organically, EU's food production capacity will be reduced, which will be compensated by less environmentally-friendly farming and land use change elsewhere, boosting the sector's overall GHG emissions. These trade-offs mean that the implementation of new rules and mechanisms must be carefully weighed since the priorities that the EU sets with the F2F strategy will settle the GHG sources and sinks in the bloc's food system for the next decade.

2.2 Greenhouse gas emissions from farming and food in Europe

Greenhouse gas emissions in the agriculture sector consist mainly of methane (enteric fermentation in ruminant animals, treatment of manure), and nitrous oxide (N2O – from spreading mineral and organic fertilizers, manure management).

Around 10% of GHG in the European Union come from the agriculture sector. Nearly 70% of the EU's farming sector emissions come from the animal sector. And 68% of total agricultural land in the EU is used for animal production.

Between 1990 and 2015, the emissions from the farming and food sectors declined by 20%, making it the only major farm sector in the world to have reduced its greenhouse gas emissions. These reductions affected both methane emissions from livestock, as well as N2O emissions from agricultural soils and are attributed to the Nitrates Directive and a reduction in cattle numbers. However, recent years have seen an increase in nitrous oxide emissions at EU level, mostly due to the intensified use of inorganic fertilizers on cropland and grassland.

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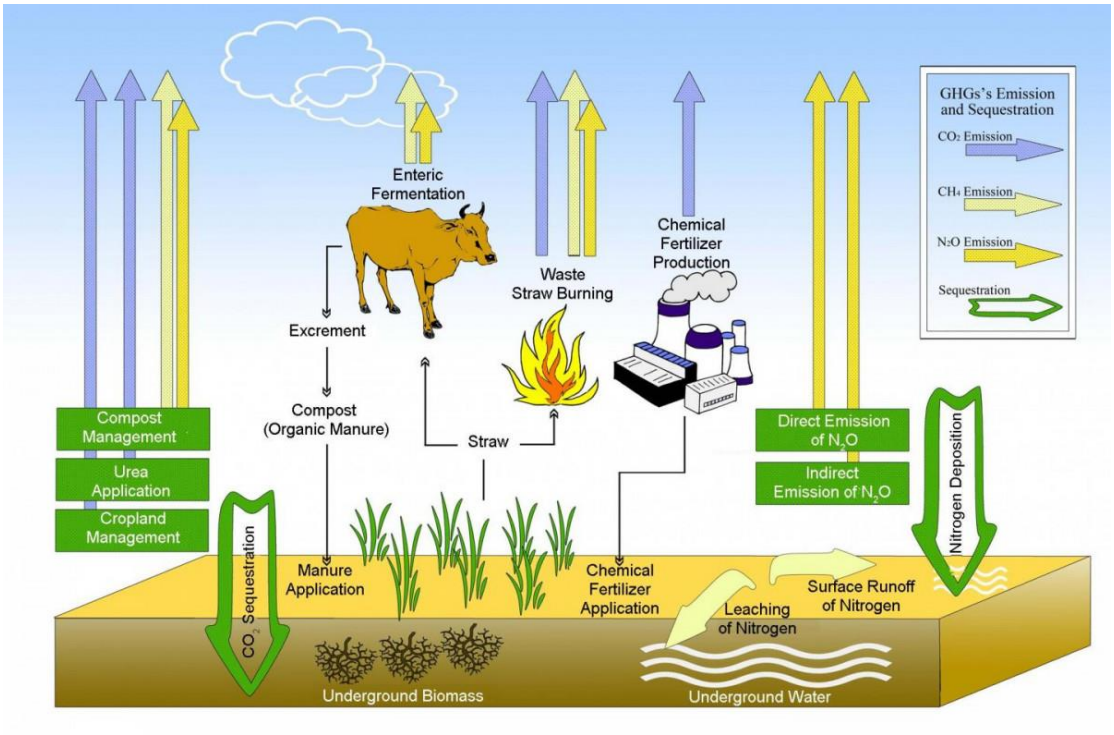

Figure 16. Source: Greenhouse emission from farming (Haitao Liu, J.L. et al 2015)

Defining greenhouse gas emissions from "food" is daunting task. It includes many emissions calculated under different categories during its journey from "farm to fork", i.e., manufacturing, processing, packaging, transportation, consumption, discarding. A different and not harmonized accounting approach (consumption based) is used to calculate the carbon footprint of peoples' diets. Researchers have estimated that GHG emissions from food consumption in the EU range from 610 to 1460 CO2-eq per person per year and that the consumption of animal products has the largest effect on the greenhouse gas intensity of diets. "If European diets were in line with dietary recommendations, the environmental footprint of food systems would be significantly reduced," the F2F strategy states.

The EU is still in a process of finding the best measurable methods to achieve greenhouse gas reduction in agriculture. The EU Commission will draw on the experience of pilot projects to identify the farming methods that can reliably increase the organic matter in soil and thereby its carbon uptake. Once the questions about measurement, monitoring, verification, additionality and costs of

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sequestering carbon in soils have been resolved, farmers could get an additional income from participating in carbon markets.

2.3 Ecological indicators in the food sector

The global agri-food sector is expected to provide safe and nutritious food to a growing world population which is projected to grow from 7.9 billion people today, to close to a 10 billion by 2050. Moreover, the agri-food sector also provides jobs and income for millions of people worldwide. The agri-food sector, and especially the agricultural sector provides income to millions of people in the rural areas. Most of the people who work in the agri-food remain in deep poverty. The population pressure, combined with growing incomes in the emerging and developing economies, will increase demand for animal and crop produce and products.

2.3.1 Triple challenge

The agri-food sector faces imminently three main challenges: securing food for a growing population, providing income to the farmers, and protecting the environment. Balancing all three challenges is challenging task, especially if the environment protection is considered.

The global food system has a large environmental imprint. Agriculture occupies nearly 40% of the earth's surface, which is far more than any other human activity. Furthermore, 70% of the global water is used for irrigation of agricultural crops. The agricultural sector contributes to around 11% of global greenhouse gas emissions, most of which comes from raising cattle.

Agricultural land can also lead to deforestation, additional GHG emissions, and a loss of biodiversity. In this part of the research, we will focus on the ecological impact and indicators in the agri-food industry. The summary of some of the main global environmental factors in the food and agriculture includes:

1. Food accounts for over a quarter (26%) of global greenhouse gas emissions.
2. 40% of the world's habitable land is used for agriculture.

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3. 70% of global freshwater withdrawals are used for agriculture.
4. 78% of global ocean and freshwater eutrophication (the pollution of waterways with nutrient-rich pollutants) is caused by agriculture.
5. Farm impacts in crop or livestock production (including the manufacturing of inputs such as fertilizers, or emissions from manure).
6. Animal feed production.
7. Food processing.
8. Transport: this includes transport from the farm up to retail.
9. Packaging.
10. Retail: energy consumption in retail stores, such as refrigeration.
11. Food is at the heart of tackling climate change, reducing water usage and pollution, reversing land deforestation, and protecting the wildlife.

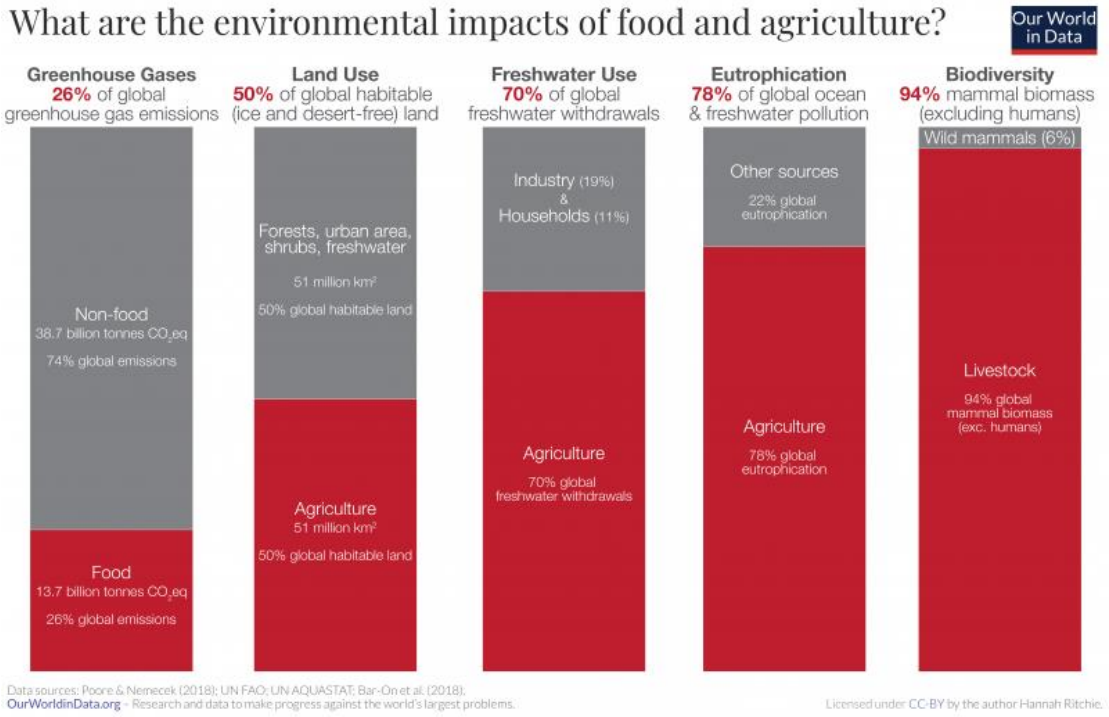

Figure 17. Environmental effects from agriculture sector production (Our World in Data)

2.4 Environmental impact from agriculture

2.4.1 CO2 and Greenhouse Gas Emissions

Food production is responsible for 25% of the world's greenhouse gas emissions.

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Reduction in the carbon footprint of the food is achieved by eating what is in the food and not eating local production.

2.4.2 Carbon footprint of food products

The global food system encompasses production, processing, and distribution. In Figure 18. Global greenhouse gas emissions from agri-food sectors (Our World in Data) the visualization shown– based on data from the meta-analysis by Joseph Poore and Thomas Nemecek (2018), published in Science – summarizes food's share of total emissions and breaks it down by source. There are four key elements to be factored in quantifying food GHG emissions. They are:

- Livestock and fisheries
- Crop production
- Land use
- Supply Chain

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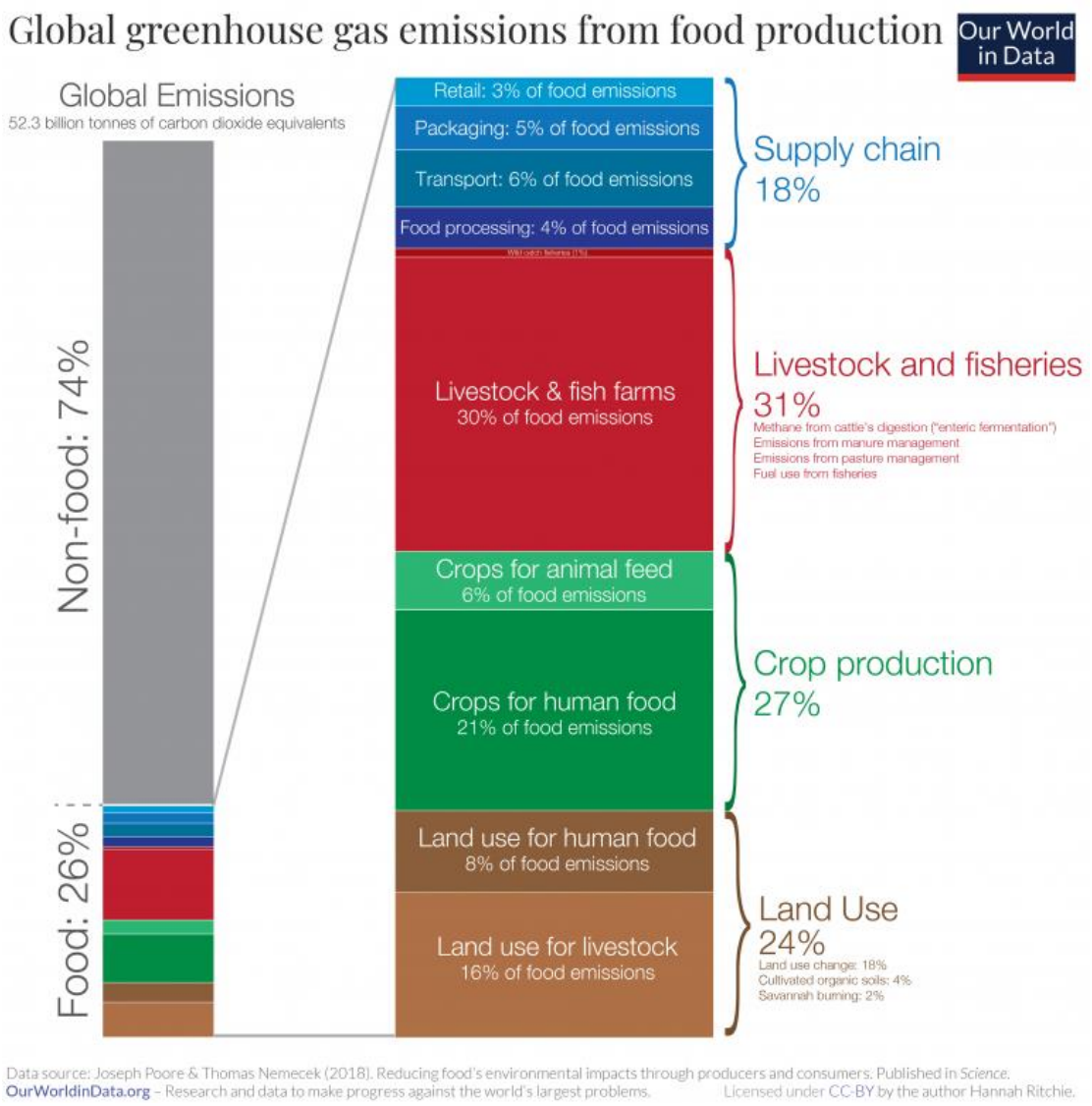

Figure 18. Global greenhouse gas emissions from agri-food sectors (Our World in Data)

2.4.2.1 Livestock & fisheries

Livestock & fisheries account for 31% of food emissions. Animals raised for meat, dairy, eggs and seafood production – contribute to emissions in several ways. Cattle for example, produces methane through their digestive processes. Manure management, pasture management, and fuel consumption from fishing vessels also fall into this category. 31% of emissions relates to on-farm 'production' emissions only: it does not include land use change or supply chain emissions from the production of crops for animal feed.

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2.4.2.2 Crop production

Crop production accounts for 27% of food emissions. 21% of food's emissions comes from crop production that goes to direct human consumption, and 6% comes from the production of food for animals. They are the direct emissions, which result from agricultural production – this includes elements such as the release of nitrous oxide from the application of fertilizers and manure; methane emissions from rice production; and carbon dioxide from agricultural machinery.

2.4.2.3 Supply Chains

Food supply chains account for 18% of emissions. Food processing, food transport, packaging and retail require energy and resource inputs. It is assumed that eating local food is key to a low-gas emission. Yet, food transport emissions are only 6% of the total food emission on a global scale. Whilst supply chain emissions may seem high, at 18%, it's essential for reducing emissions by preventing food waste. Food waste emissions are the largest component in this section: 25% of emissions from food production ends up as a waste either from supply chain losses or consumers. What are the current solutions: using durable packaging, longer refrigeration and food reprocessing can help to prevent food waste.

One of the biggest challenges to be solved in the food production chain is reduction of the GHG emissions. Food production is energy intense sector, which with the current resources of renewable energy cannot be solved. That is way the current way of research has suggested a combination of measures such change of diet, reduction of food waste, using technologies to make food production more efficient to address the energy gaps.

2.4.2.4 Land Use

Land use accounts for 24% of food emissions. Emissions from land usage for livestock accounts for 16% and crops for human consumption account for 8% in the GHG emissions. Deforestation and transforming land into cropland or pasture emits carbon dioxide.

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The world population has experienced explosive growth in the last few centuries and with that clearing forest and grassland for farming. That has led to a dramatic change in the biodiversity and the GHG emissions. Thousand years ago, just about 4% of the world non-barren land was used for farming. Presently, 50% of the non-barren land is used for farm activities. The remaining 50% consists of forests, grasslands, shrubs, and just about 1% is a built urban area on which cities, towns, villages and infrastructure are built. Land used for animal grazing and production to feed the cattle is 77% of the world farmland. Agricultural activities have the largest impact on the environment. Agricultural activities have had a tremendous impact on the GHG emissions, the quality of the land and the biodiversity. The greenhouse revolution has solved some of the hunger issues, however it has caused environmentally harmful effects. Circular economy looks to address all three issues.

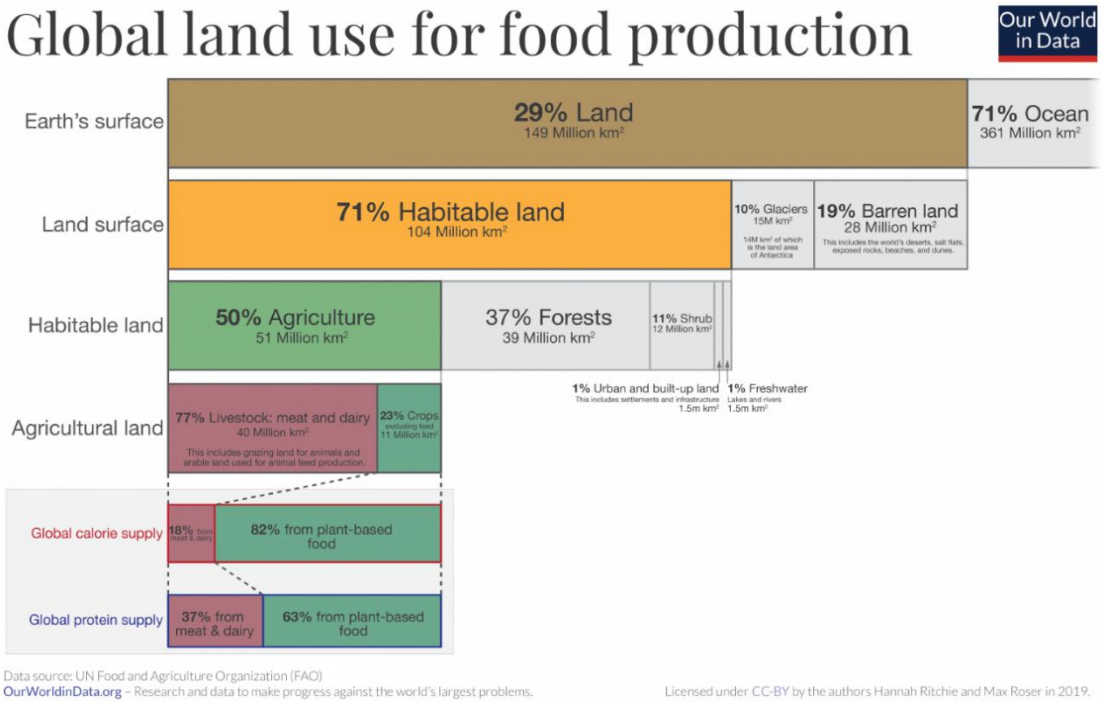

Figure 19. Global use of land for food production (Our World in Data)

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2.5 The carbon footprint of the EU diets

In research by Vilma Sandström et al. compare greenhouse gas emissions from the common diet across countries in the European Union. Factors, which are taken into account are GHG emissions from food production, land-use and trade (i.e., transport).

In the two charts below, we see comparisons of the carbon footprint of the average EU diets: first the total emissions from each source in the supply chain and second, shown as the breakdown by food item.

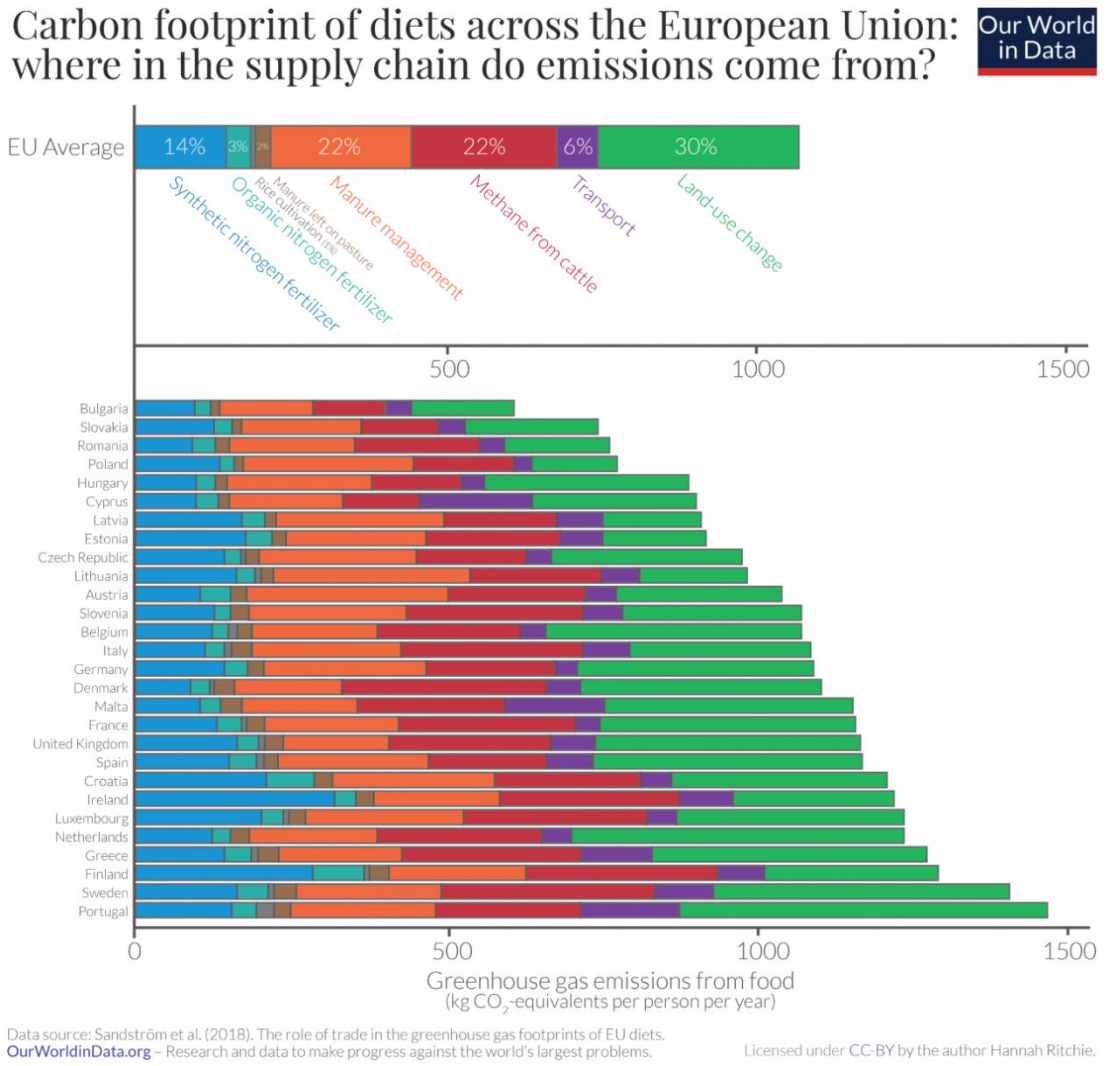

Figure 20. CO2 footprint from the EU diet by activity and member states (Our World In Data)

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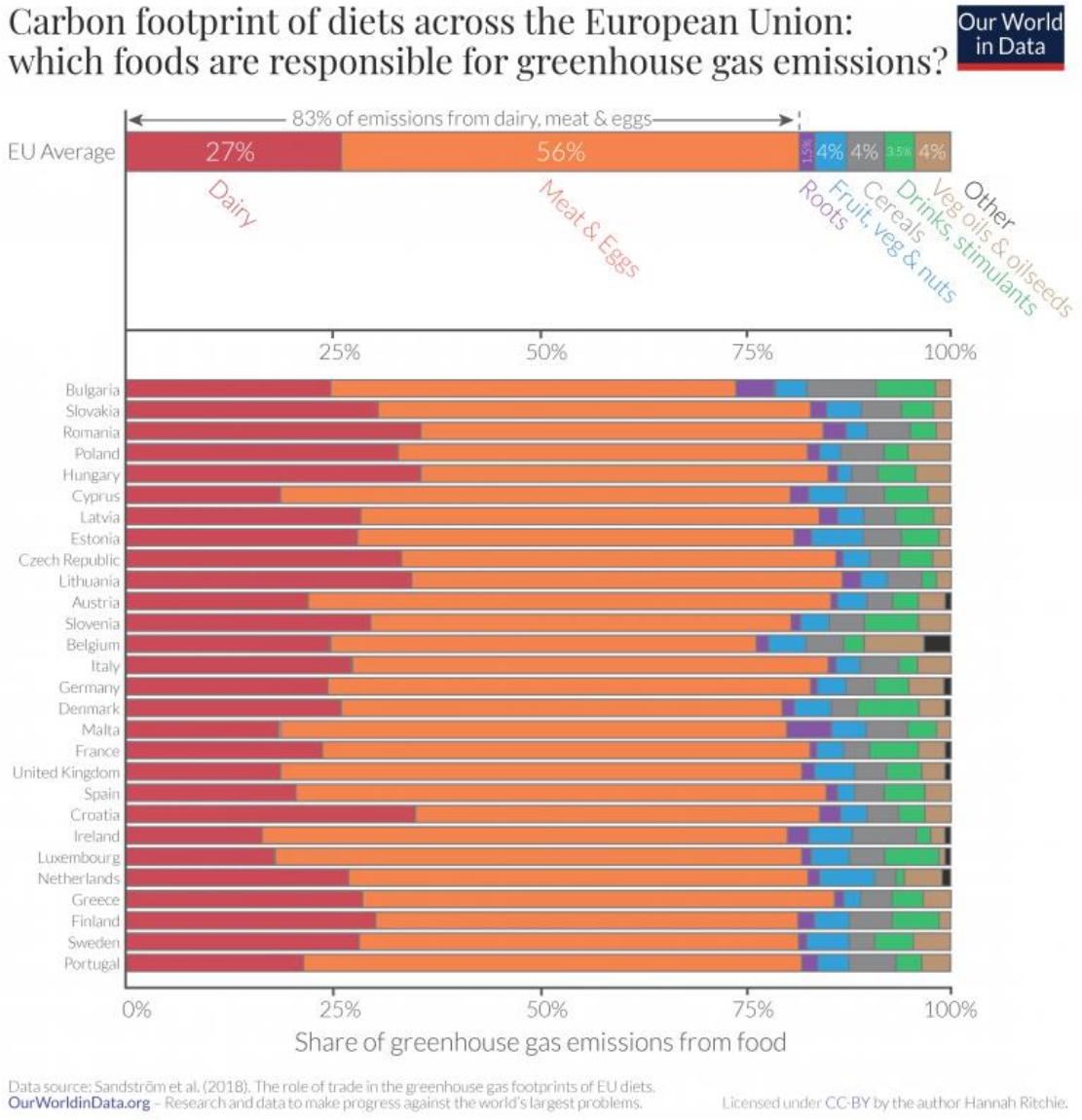

Figure 21. CO2 footprint from the EU diet by member states and diet components (Our World in Data)

The conclusions we can draw from this are the same. Bulk of the emissions result from land use change, or/and emissions at the farm level – it could be methane emissions from cattle; management of manure; or use of fertilizer. Only 6% of the GHG comes from transportation of food.

83% of the GHG emissions in the EU diet come from animal products such as dairy, meat and eggs. Plant related foods result in 17% of the GHG emissions results from plant-based foods. Most of the differences between countries comes from how much meat and dairy products they eat. By comparison, the environmental benefits from locally grown production are much smaller than eating a plant-based diet.

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Bulgaria has the smallest carbon footprint in the EU block. The biggest contributor to the carbon emissions is land use change, manure management, methane from cattle and synthetic nitrogen fertilizers.

If we look at the diet, the animal-based consumption is at the mark of 73% and is Europe's smallest. That comes from the fact that Bulgaria, despite the recent reduction in the fruit and vegetable production, Bulgarian diet is traditionally very rich in daily fruit and vegetable consumption.

2.5.1 Examples for food emissions

In the chart below published in an analysis in Science by Joseph Poore and Thomas Nemecek (2018) the authors look at the GHG emissions from 29 different food products below – from beef to nuts. In this study, the authors looked at data from more than 38,000 commercial farms in 119 countries. For each product you can see from which stage in the supply chain its emissions originate. It starts with land use to farming, animal feed, processing, transport, retail and packaging. It does not factor food waste.

In this comparison the total GHG emissions is calculated per kilogram of food product. CO2 is an important GHG, but not the only one – agriculture is a large source of the greenhouse gases methane and nitrous oxide. To capture all GHG emissions from food production researchers therefore express them in kilograms of 'carbon dioxide equivalents. This metric takes account not just CO2 but all greenhouse gases.

The chart shows that there are big differences in the GHG emissions of different foods: producing a kilogram of beef accounts for 60 kilograms of greenhouse gases in CO2-equivalents. Apples emit just 0.4 kilogram per kg. Another conclusion is that animal products have overall higher footprint than the plant products. Beef, lamb, mutton, and cheese have the highest GHG footprint in the food production chain. Poultry and pork have lower footprints but are still higher than majority of the plant-based foods.

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For most foods – and particularly the largest emitters – most GHG emissions result from land use change (shown in green), and from processes at the farm stage (brown). Farm-stage emissions include processes such as the application of fertilizers – both organic ("manure management") and synthetic; and enteric fermentation (the production of methane in the stomachs of cattle). Combined, land use and farm-stage emissions account for more than 80% of the footprint for most foods. The biggest contributor to the GHG emission is land use and farming.

Transport is a relatively small contributor for the emissions. For most food products, it accounts for less than 10%, and it's much smaller for the largest GHG emitters. In beef from beef herds, it is just 0.5%.

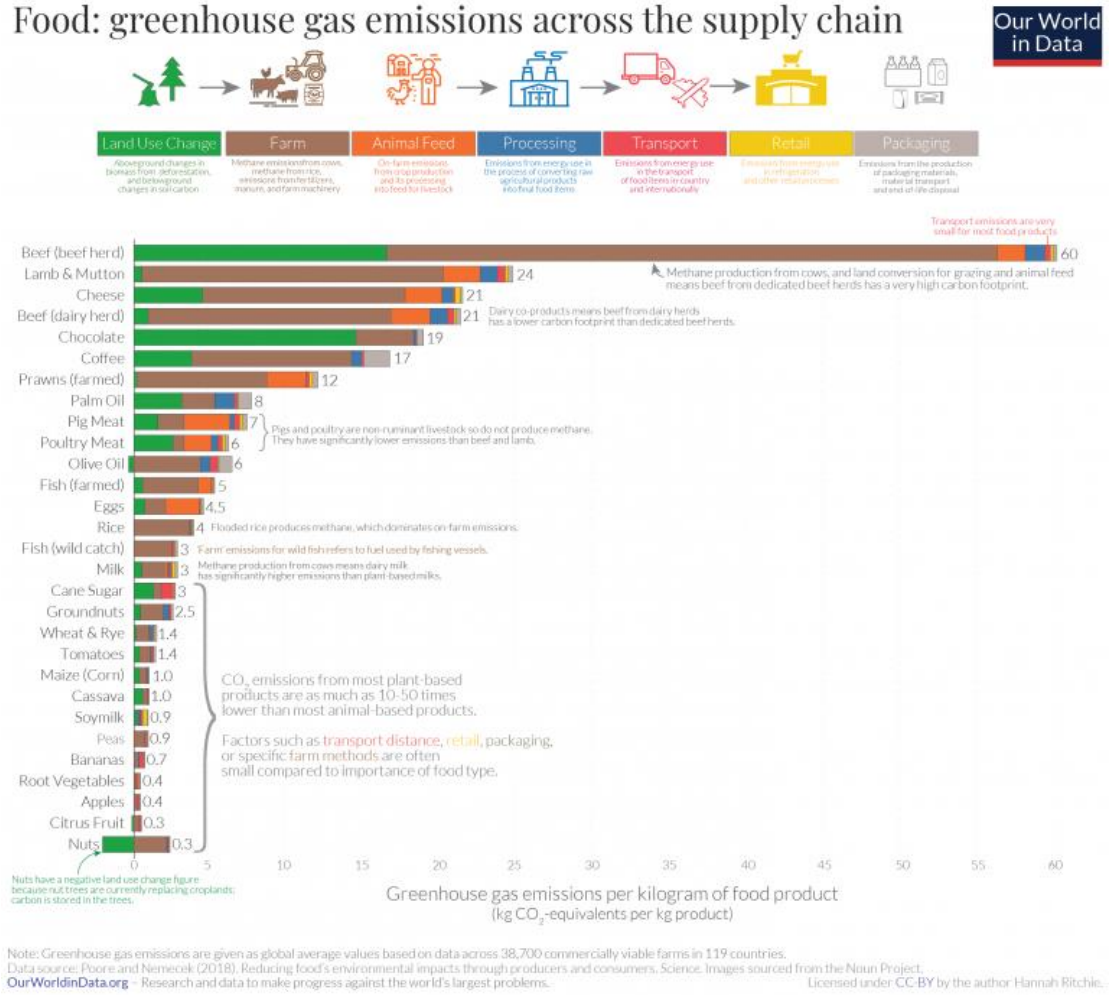

Figure 22. Greenhouse food emission by food items and production cycle (Our World in Data)

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2.5.2 Water Use

Agriculture and food production are very water intensive. Without water, food cannot be produced. However, not all food products require the same amount of water. We can look at these comparisons in Figure 22 based on mass: the freshwater withdrawals required to produce one kilogram of food product.

We see from the chart that there is no clear division in water consumption between the plants and animal production. However, cheese, beef, fish and seafood, lamb, mutton, and pig are on the top of the pyramid. If we translate into Bulgaria, which is rich in freshwater, the water pressure will be smaller than the average worldwide. Bulgaria production and diet are not dominated by beef, prawns, and mutton, which are on the top of the pyramid.

2.5.3 Pollution from food production (Eutrophying)

The pollution of water and ecosystems from the food raise and production with excess nutrients is a major environmental problem. The nitrogen overspill from agricultural production systems is a main contributor. These eutrophying emissions go into the waters and land around and pollute those areas with excess nutrients.

The biggest eutrophying polluters per kilogram are mostly animal products: beef, fish, prawns, cheese, lamb, mutton, pig, poultry. Rice is way below most of the animal products.

2.5.3.1 Pollution from food production Bulgaria compared to other EU countries

According to Eurostat data for the period 2008-2017, a total of 108 million euro was used in the EU-28 for nitrogen fertilizers, with use increasing on average for the union by 6%. Over the same period, Bulgaria increased use nearly 2-fold. The use of phosphorus fertilizers in total for the EU-28 decreased by 2% between 2008 and 2017, with the most significant happening in France (33%) and Poland (22%). Over the same period, use in Bulgaria has increased nearly 3-fold.

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According to data of the Executive Environment Agency, the total amount of mineral fertilizers used in Bulgaria for the period 2007-2016 increased from 221 thousand years ago to 221,000. Kg. at 484 thousand kg. (Figure 5.6), the most drastic being the difference in potassium fertilizers, which increased 3,4 times over the period, followed by phosphorus – 2,8 times. However, the highest share of nitrogen fertilizers, which in 2016 represented 74% of the total fertilizers used.

Although there has been an increase in the quantities of mineral fertilizers used, the phosphorus footprint measured as kg/ha of fertilizer area decreased by 50% for the period 2007-2016 (Figure 5.7). This is due to a large increase in the total number of forested areas from 174 thousand ha to 979 thousand. (nearly 6 times) and the lower rate of increase in tonnes used from 29607 tonnes to 82 566 tonnes (nearly 3 times). Nitrogen footprint, on the other hand, has increased by 2 times, from 90 kg/ha in 2007 to 154 kg/ha in 2016.

Although Bulgaria does not currently exceed the rate of fertilization with nitrogen fertilizers, the data on nitrogen balance show that there is an environmental risk of water contamination with nitrates. The nitrogen balance is measured in order to take account of the difference between the nitrogen imported and the nitrogen extracted from the soil. When inserting larger than necessary quantities of fertilizers, the result is an excess of nitrogen fertilizer. At EU-28 level, there is a persistent trend in reducing this surplus, growing in countries such as Austria, Romania, Cyprus, Hungary and Slovakia. The surplus nitrogen in the soil in Bulgaria increased by 75% in 2014 compared to 2005, or from 19 kg/ha to 28 kg/ha per year. However, Bulgaria is still among the countries with the lowest nitrogen surplus, which is well below the EU-28 average, 51 kg/ha per year as of 2015, France (42 kg/ha) and Poland (48 kg/ha) are approaching or exceeding the EU-28 average, but they have seen a negative trend towards reducing the nitrogen surplus.

The phosphorus balance follows negative values for Bulgaria, indicating a serious shortage. The gross balance of phosphorus in Bulgaria has decreased twice, from -3 to -6 kg/ha per year, which means that the phosphorus deficiency in the soil is

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increasing. In the EU-28, only Estonia has a larger deficit than Bulgaria (-7 kg/ha per year). By comparison, the phosphorus balance in Greece as well as France in 2015 is "0", which means that the amount imported is equal to the amount of manure extracted from plants.

In Bulgaria, phosphorus deficiency has an impact mostly on soil degradation due to nutrient deficiency but does not pose a risk to human health and food pollution. However, unbalanced fertilization can have a negative impact on soil quality and production. It can be summarized that, although below the European average, the increase in nitrogen fertilizers used in Bulgaria can create a risk of water contamination with nitrates. On the other hand, the presence of a deficiency in the phosphronal balance in soils can have a negative impact on soil quality and thus on production.

Food production accounts for 26% of global greenhouse gas emissions and food waste accounts for 6% of the world GHG emissions. Food waste is seen as food that has not been consumed. That results in wasted water, energy, land, labor, fertilizers and in sum translates into environmental cost.

In a study of the global food systems, published in Science in 2018, Joseph Poore and Thomas Nemecek (2018), estimated how much of the greenhouse gas emissions come from wasted food.

Figure 23. Greenhouse emission from food waste (Our World in Data)

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In the visualization in Figure 23 shows the emissions from wasted food in the context of global greenhouse gas emissions. In this chart, about 15% of the emissions come from food losses in the supply chain (lack of refrigeration; and spoilage in transport and processing), and about 6% is from food thrown away by retailers and consumer

3 Circular Economy Applications in the Agri-food sector

3.1 Good Practices in Greece

3.1.1 CLuBE

CLuBE is a non-profit legal entity established in 2014 among local actors and stakeholders of the Region of Western Macedonia. The aim of the cluster is to find potential collaborations among its members and to promote their activities through the implementation of new projects. The cluster is developing activities within the fields of bioenergy, bio-based circular economy and environment, in order to reinforce smart, green and circular economy in the region, namely through:

- Energetic utilization of by-products and residues of plant, animal, forestry and fishery production for households and industries and particularly for district heating systems for cities
- Expanding the share of biofuels in the energy mix of transportation fuels
- Co-firing with lignite in power stations that are currently active and/or future heating plants
- Optimizing efficiency of heating systems and improvement of energy efficiency for buildings.

CLuBE has already achieved the cooperation between 3 regional governmental authorities, 5 universities and technological institutes located in Northern Greece, and 12 companies which deal with heating, biomass and waste management and consulting. More new members are waiting to join. Through the cluster, successful examples are given of how long-term cooperation among small and large-scale actors can be successfully developed and continued (Kontogianni et al., 2018)

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3.1.2 Smart Specialisation Platforms

In the Region of Central Macedonia (RCM), agri-food is the thriving sector of Research and Innovation Strategies for Smart Specialisation (RIS3). RIS3 is an economic transformation agenda for agri-food and industrial modernization of EU regions and member states. RCM supports networking and collaboration between academic and research institutes with businesses so as new knowledge can be transferred in the food industry and bio-based sectors. The main goal is to empower food entrepreneurship and innovation, foster interregional collaboration between a diversity of partners and strengthen competitiveness of industries in order to respond better to emerging consumer demands. RCM is actively involved in three platforms and currently developing a new one. The three existing platforms are: High tech farming, Nutritional ingredients, and Traceability and big Data and the one that is being developed focuses on Personalized Nutrition. Furthermore, RCM is an active member at the European Region for Innovation in Agriculture, Food and Forestry (ERIAFF). The initiative of the RCM to participate at S3Platforms and establish a new bio-economy network has proven to successfully maximize the exploitation of the research and innovation potential available in the region (RIS3 One Stop Liaison Office, n.d.).

3.1.3 Social Plate

Social Plate is a project coordinated by the Central Market of Thessaloniki (CMT). CMT is a public company whose facilities include the fruit and vegetable market with 280 stores and the meat market with 24 stores. On an daily basis products are supplied to local food markets and markets of the Balkans from CMT. The aim of the project Social Plate is to provide food for the weak social groups, minimize food waste and create job opportunities for the long-term unemployed. The non-marketable products of CMT are separated into those that are suitable for consumption and those that are not. The consumable ones are then offered to the 75 agencies that participate in the project such as social grocery stores, non-governmental organizations, foundations and church kitchens. The delivery of the

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goods is handled by the organic waste management office of CMT with the aid of volunteers from the agencies that benefit. The agencies receive the recovered products and distribute them, either cooked or raw, to vulnerable social groups. The original packaging of the products is reused instead of discarded. Within fifteen months, the Social Plate team handled more than 345,000 kg of fruits and vegetables from the CMT facilities. 230,000 kg of those were recovered and offered to the beneficiaries and the rest was managed as organic waste. The Social Plate is the first organized practice for saving food with promising results in Greece (Interreg Europe, n.d.).

3.1.4 Biogas Lagada

Biogas Lagada produces biogas through anaerobic digestion of waste from livestock and agriculture farms in a private facility in Central Macedonia. The organic waste is collected from local farms for free, transported in the facility and digested on-site. The produced biogas is utilized in a Combined Heat and Power (CHP) unit. The generated electricity is provided to the national grid under an agreed cost per kWh, while the generated thermal energy covers the needs of the facility. The digestate is composted into soil amendment. The compost is mainly used by the owners of the facility who also own livestock farms and farmlands as well as in local farmlands. The facility processes annually 80,000 t of waste, including liquid cow, poultry and pork manure, cheese whey and olive mill by-products. The facility annually generates 8,400 MWh_{el}, enough to cover the needs of 1,500 households and 7,5000 t of organic fertilizer enough to nourish 500 ha of cultivation. This practice is an example of how bio-waste can be disposed sustainably, while minimizing the local CO_2 impact by an estimated 494,700 kg per year(Biogas Lagada S.A, n.d.).

3.1.5 BIO2CHP

The BIO2CHP unit is a power generator, at the size of a container, which converts organic residues into electric energy and heat. The energy production is accomplished by the combination of two technologies, gasification and gas

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engines, through an automated control system. Feedstocks that can be processed are solid agricultural residues, food industry residues, sewage sludge, etc. A working pilot has been successfully developed using grape pomace, peach kernels, olive kernels and almond shells. The unit allows small and medium industries in the agro-food sector to dispose their waste sustainably and generate energy for the needs of their facility at a price 3-4 times lower than the national grid. The 25 kW_{el} unit produces on a yearly basis 187,500 kWh electrical & 502,500 kWh thermal energy, consuming a total of 187.5 t of solid organic residues. The system transforms waste into a valuable commodity for the on-site heat and power generation, minimizing both energy and waste handling costs. It is estimated that for every 20 kW_{el} unit approximately 62 t of CO_2eq are saved per year, equivalent to the electrification of 9 households. BIO2CHP shows how decentralized, bio-based circular economy can be achieved for small and medium-sized enterprises (Bio-based Energy Technologies P.C. (BIO2CHP), n.d.).

3.1.6 EVYP

EVYP is a company in Thessaloniki that specializes in the production of fertilizers derived from the hydrolysis/extraction of exclusively plant origin non-GMO raw materials. The plants are hydrolyzed to extract L-amino acids and the final product is a highly concentrated liquid organic fertilizer. The product is unique because of high concentration of 16 L-amino acids of plant origin and is suitable for organic farming. The produced bio-stimulator and plant nutrition product, can be combined with all fertilizers and plant protection products and L-amino acids are directly absorbed by plants as the balanced correlation of L-amino acids is identical to plant's physiology. But most importantly the product is environmentally friendly, self-decomposed, leaving no residue. The company in charge is Greek Industry of Hydrolyzed Protein LLP and the project has been developed in cooperation with Aristotle University of Thessaloniki. The raw materials come from farming residues (harvest, pruning) and vegetable residues (e.g. peas, green beans), gristmills residues, etc. of neighboring facilities and farmlands, introducing circular economy

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practices in the area. The final beneficiaries are citizens and farmers purchasing the product to use it for organic farming. The product has been granted the European Patent in 2011 due to the innovative composition and production method. Also 10% of annual revenue is invested in research. Its development in collaboration with the Aristotle University of Thessaloniki shows how private and public sector collaboration may lead to innovation (Kontogianni et al., 2018).

3.1.7 Ecosystem by Dimiter

In Western Macedonia, a large variety of aromatic and pharmaceutical plants like saffron, oregano and siderites are cultivated systematically. From the total production, around 65% is discarded even though its bio-reactive value is similar to that used commercially. Hellenic Agricultural Organization (HAO) Dimiter has started up an ecosystem in the area in order to produce and test animal breeding products by utilizing the crop residues of aromatic and pharmaceutical plants. The ecosystem consists of two industries that produce, process, package and sell spices, herbs, aromatics, beverages, and animal breeding products (Bagatzounis Markos & Sons S.A., Greek Feed Industries EL.VI.Z) and two university labs (Nutrition Lab of Aristotle University of Thessaloniki, Lab of Pharmacognosy and Chemistry of Natural products of National and Kapodistrian University of Athens). The aim is to finally commercialize these products in order to satisfy the addressed needs of animal breeders. These needs are urgent, especially since the prohibition of antibiotic growth promoters in animal breeding as feed additives in the EU. Animal breeders are now searching for natural additives to substitute these antibiotics and research has shown significant antimicrobial effects of several aromatic and pharmaceutical plants. The built ecosystem is a successful example of how scientific research and market needs can be connected, resulting in improvement of resource efficiency and increase in job opportunities. The final outputs are animal breeding products of high value certified and licensed for commercial distribution. So far, at least three farms purchase the product. The

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ecosystem will continue the cooperation in order to produce more innovative products, such as beverages for human consumption (Interreg Europe, n.d.).

3.1.8 American Farm School (AFS)

AFS is an independent, nonprofit educational institution of all levels located in Thessaloniki since 1904. The mission of AFS is to educate people of all ages in the latest aspects of agriculture, science and the food industry, while preparing them for prominent roles in community life. This mission is accomplished by teaching sustainable agricultural and business practices. It is the first institution in southeastern Europe for education and research in agriculture, food systems, environmental studies and other life sciences associated with sustainability. AFS owns a large-scale Educational Farm, which serves as a laboratory for hands-on education and applied research. The farm includes the Holstein Friesian dairy herd; a poultry unit using the newest methods; greenhouses; vegetable gardens; vineyards; fruit and olive trees. Moreover, AFS has extensive field crops at its satellite farm. AFS implements handling practices to address the matter of waste treatment, especially in a peri-urban area, minimizing the environmental impact. A holistic model to treat and recycle solid and liquid waste generated from the production is employed. AFS has accomplished to spend very little on manure management since a biogas company takes it under a mutually beneficial agreement. Other sustainable practices are the use of recycled water for fertigation from May to September and recycling of plastic, glass, aluminum and paper. In addition, fertilizer is produced by composting plant material and returned to the fields for the enrichment of soil in nutrients and organic matter. The innovative processes followed at the AFS can assist to reduce carbon footprint of agricultural and bio-stream activities. Also, it is proved that innovation can effectively contribute to the development of green services and numerous green jobs (Kontogianni et al., 2018)

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3.1.9 LAVIS

LAVIS is a company that provides services for the holistic management of animal by-products. LAVIS was founded in 1981 in the region of Thessaly. On a daily basis, animal by-products are processed and upgraded into high-quality products such as bone meal, poultry meal and animal fat. These products are the most important sources of protein for animal diets and are widely used in animal feed industry. They can also be used as raw materials for the production of fertilizers and bioenergy. The animal by-products are supplied by slaughterhouses and markets of the area at an agreed price (LAVIS S.A., n.d.).

3.1.10 ELDIA

ELDIA is a waste management and recycling industry established in Thessaloniki. The company provides solutions for issues concerning solid waste management and disposal of industrial and commercial enterprises, local government and organizations of the public sector. The offered solutions are based on the principles of circular economy. In particular, expired animal and plant-based food from food industries, wholesale and retail markets are firstly divided into two fractions: an organic fraction and mixed packaging materials. The organic fraction is then driven to bioreactors for the production of biogas, while the packaging materials after sorting are forwarded to recycling. The company converts used pallets and pruning residues into an alternative fuel source (i.e. biomass), utilizing special equipment such as crushers and sieves. Through these actions, ELDIA aims to: reduce the volume of food waste ending up at landfills as an answer to the continuously increasing production of waste, maximize the utilization of materials deriving from waste sorting and use recyclable materials with significant financial gains for enterprises. ELDIA, in order to address these issues uses the latest methods and technologies (ELDIA S.A., n.d.).

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3.1.11 Revive

Revive is a company established in Central Macedonia, that collects, processes and offers used cooking oils for industrial use i.e., in the production of biofuels and bio-lubricants in an environmentally sound way and in accordance with the EU legislation. The company is staffed by engineers and technicians specialized in biofuels and bio-lubricants technology. The produced biodiesel offers increased lubrication and is environmentally friendly as it is biodegradable, non-toxic, contains almost zero sulfur, leads to reduced soot emissions and reduced carbon dioxide emissions resulting in mitigation of the greenhouse effect. Emissions of biodiesel are 40-50% lower than those of diesel except for nitrogen oxides. At the same time, with this kind of management of used cooking oils, the amount of fossil fuels and lubricants that the country imports is reduced, contributing to the energy balance and saving fossil resources. Moreover, the pollution of water is prevented (S.A., n.d.).

3.1.12 Tsakiris Family

Tsakiris Family is a company established in the region of Central Macedonia, specializing in egg production. The company owns 12 poultry farms with a production that exceeds 4 million eggs per month and an egg pasteurizer. Additionally, the company owns and manages the fields of the grains that are fed to the hens. Tsakiris Family has adopted practices based on circular economy principles. First of all, soiled and expired eggs that cannot be sold go under pasteurization and are then sold to industries that reform them in other useful products. Secondly, the waste from the hens is forwarded to a biogas plant from which electricity is the final product. The organic residue of the process is used as fertilizer in the grain fields. This way the company is zero waste and minimizes the burdens on the environment, setting an example of how livestock residues can be utilized to generate useful products such as energy and fertilizers (TSAKIRIS FAMILY S.A., n.d.).

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3.1.13 Oikotechnia Gropalis

Oikotechnia Gropalis is a family business in Central Macedonia that has adopted the principles of circular economy in every step of the production. The business produces jam, compote, sauces, etc. from fruit and vegetables that are cultivated in fields owned by the family. Circular economy is put to practice by the utilization of pruning and seeds from peaches for the production of heat that covers part of the household needs. In addition, the waste of packaging material is minimized by using glass jars that are returnable for refill. The residues of the production process that include peels and stalks are composted into fertilizers for the nutrient enrichment of the fields or into animal feed. Oikotechnia Gropalis sets the example of how circular economy in every business scale can be applied (Avoukatos, n.d.).

3.1.14 Kyklopas oil mill

Kyklopas is a family owned olive mill, situated in Makri, Northern Greece. The family owns 12,000 olive trees and 2,000 organically cultivated trees of the local Makri olive variety. They produce Kyklopas Extra Virgin Olive Oil, one of the most awarded Greek olive oils. Since 2004, the company applies sustainable management on every phase of the production. On a daily basis, after oil extraction, the liquid waste is transferred to a biogas plant where electrical and thermal energy are produced. The residues of this process are then returned to the cultivation as fertilizer, after pasteurization. Part of the fallen leaves are used by animal breeders of the area as animal food. The rest of the leaves and pruned branches are used to make compost which is then returned to the olive groves. The olive kernels are partly turned into kernel oil and the rest are used for the heating of the oil mill. Finally, all the packaging is made of recyclable materials. The benefits of these actions are both quantitative, as a result of fertilizer and energy saving and qualitive, as the products are free of chemical substances (Kyklopas Estates, n.d.).

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3.1.15 Bizios Dairy

Bizios is a dairy company that specializes in the production of cheese products. The factory is located in the suburbs of Elassona city, in the region of Thessaly. It has a daily capacity of processing 120,000 kg of milk. Recently, the factory proceeded to the construction of an anaerobic bioreactor unit that is able to process 565 m^3 of liquid waste that is produced on a daily basis and has a high COD charge. The bioreactor uses an innovative technology of membranes for the generation of 5,176 Nm^3 of biogas, with a potential electricity generation of 1.28 MW. The unit achieves the decontamination of the waste at a degree that exceeds 99%, allowing the direct disposal of the wastewater to a recipient for the purpose of irrigation. It is important to point out that by this approach the biological treatment of the liquid waste can be omitted, reducing dramatically the management and operating costs of the company (Energy Industry, n.d.).

3.1.16 Association of Greek Food Industries

3.1.16.1 Food Rescue & Supply

The Association of Greek Food Industries (SEVT) participates in a number of initiatives at national level to reduce food waste and support the most disadvantaged social groups. It works closely with the organization "MPOROUME" through the "Food Rescue & Supply" program, whose mission is to reduce food waste and increase food supply to charities and beneficiaries. Vision of the «MPOROUME» is the development of a social movement to reduce food waste and at the same time increase food support for people in need based on voluntary contributions (Eunomia Research & Consulting IKE, 2021).

3.1.16.2 Foods of Love

Food waste reduction programme in a supermarket chain. Implementing an organized program of donating canned food to organizations and individuals in need through the « Foods of Love ». Investigation of food waste throughout the supply chain in collaboration with Harokopeio University, in order to study food

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waste produced throughout the supply chain (Eunomia Research & Consulting IKE, 2021).

3.1.16.3 Other programs

The Association of Greek Food Industries (SEVT) is a member of Food Drink Europe and participates in a number of European projects (LIFE FOODPRINT, PEFMED, EUMERCI, CIRCforBIO, ICCEE). Other collaborative initiatives include, the Association of Greek Industries for the Production of Materials and Packaging (SY.VI.P.Y.S.) which is a member of the international SAVEFOOD initiative under the auspices of FAO and UNEP.

The Association of Greek Food Industries (SEVT) also collaborated with 3 companies in the food and beverage sector (EZA S.A., TSAKIRIS A.E. and ASPIS K. DEES GREEK JUICES GREEK JUICES A.S.A.) collecting bio-waste through their production process for the production of biofuels (Eunomia Research & Consulting IKE, 2021).

3.1.17 Association of Wine Producers of Northern Greece

Life-cycle perspective for low-impact winemaking from the Association of Wine Producers of Northern Greece aims to make available an online tool LCA-LCC, specific to the wine production chain, which allows wine producers to (re)evaluate their wine-making process, in order to identify the environmental impacts and costs for each stage of the process (Eunomia Research & Consulting IKE, 2021).

3.1.18 AGEK-EPSA Synergy

The reuse of industrial wastewater from factories is an action based on the requirements and needs of the industrial sector. The AGET IRAKLIS factory in Volos receives biologically treated water discharged from EPSA's production plant through pipelines. This water for is then reused in the cement manufacturing process. If this process did not take place, the water from the soft drink industry's facilities would end up at sea. This results in significant water savings for AGET,

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which total 30,000 m3 per year, preserving this valuable asset for the benefit of the environment and the preservation of the natural capital (Alexakis, 2021).

3.1.19 FISHBONE

FISHBONE project tackles waste management from the filleting of trout. For the utilization of this waste, the utilization of fish bone for the production of hydroxyapatite is proposed, which is an attractive option for use as a biofuel (Ministry of Environment and Energy, 2021).

3.1.20 WASTES-to-BIOPOLYMERS

The WASTES-to-BIOPOLYMERS project aims to develop environmentally friendly and economically viable processes for the biotransformation of food industry waste into bioplastic products. In particular, it aims at the recovery of wastewater from the production of cheese products (whey serum) and from the juicing of fruit and vegetables (sugary fractions). The produced biopolymers will be moulded into final pores food packaging, such as plastic bottles and cups, coating films, etc., completing the circular approach of the emerging technology ("Wastes-to-Biopolymers," 2022).

3.1.21 ANATHREPSI

The transition from a linear to a circular economy is the main motivation for the ANATHREPSI project, which aims to investigate and optimising the performance of innovative membrane technologies for efficient water and nutrient recovery (N-NH3, P-PO4) from the liquid anaerobic digestion effluent of the food industry ("ANATHREPSI," 2022).

3.1.22 Summary of Good Practices

Table 2. Good practices of circular economy in the agri-food sector of Greece

No	Name	Description	Location

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1	CluBE	Platform for public sector, research and entrepreneurship cooperation in the field of bio-based circular economy	Western Macedonia
2	Smart Specialisation Platforms	Participation and co-creation in a number of platforms to promote modernization and smart specialization strategies in agri-food sector	Central Macedonia
3	Social Plate	Minimization of food waste by offering food to weak social groups	Central Macedonia
4	Biogas Lagada	Generation of electricity and production of soil enhancer through anaerobic digestion of agricultural and livestock farm waste	Central Macedonia
5	BIO2CHP	Generation of electricity and heat through gasification of organic residues	Central Macedonia
6	EVYP	Production of liquid solution of highly concentrated L-amino acids derived from the hydrolysis/extraction of exclusively non-GMO plants	Central Macedonia
7	Ecosystem by Dimiter	Production of innovative bio-reactive animal breeding products and beverages for human consumption from non-commercial by-products	Western Macedonia
8	AFS	Boundary organization training people of all ages in bio-based circular economy	Central Macedonia

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9	LAVIS	Production of raw materials for animal feed and fertilizers from animal by-products	Thessaly
10	ELDIA	Waste management and recycling solutions based on circular processes	Central Macedonia
11	Revive	Collection of used cooking oils for the production of biofuels and biolubricants	Central Macedonia
12	Tsakiris Family	Zero waste and eco-friendly company specializing in egg production	Central Macedonia
13	Oikotechnia Gropalis	Family business operating under the principles of circular economy	Central Macedonia
14	Kyklopas oil mill	Sustainable management of olive mill's waste	Thrace
15	Bizios Dairy	Biogas production from liquid waste of dairy production	Thessaly
16	Association of Greek Food Industries	Participation in various programs on (i)waste prevention and food redistribution and (ii) food waste reduction	Greece
17	Association of Wine Producers of Northern Greece	Life-cycle perspective for low-impact winemaking	Northern Greece
18	AGEK-EPSA	Reuse of industrial wastewater	Thessaly

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19	FISHBONE	Utilization of fish bone for the production of biofuel	Greece
20	WASTES-to-BIOPOLYMERS	Biotransformation of food industry waste into bioplastic products.	Greece
21	ANATHREPSI	Water and nutrient recovery from liquid anaerobic digestion effluent of the food industry	Greece

3.2 Good Practices in Bulgaria

3.2.1 Eco-Innovation in Bulgaria

Bulgaria is last in the EU28 in terms of eco-innovation performance by a large margin and with a score of 34. Bulgaria has the potential to move from a modest to a moderate eco-innovator only if it manages to fill in structural gaps in the eco-innovation system starting from the inputs but also working on different related systems such as science and innovation; support to SMEs and the energy system. The policy landscape is extremely important and besides formally including eco-innovation and circular economy in strategic documents, it needs to enforce radical measures for improving environmental performance and triggering eco-innovations.

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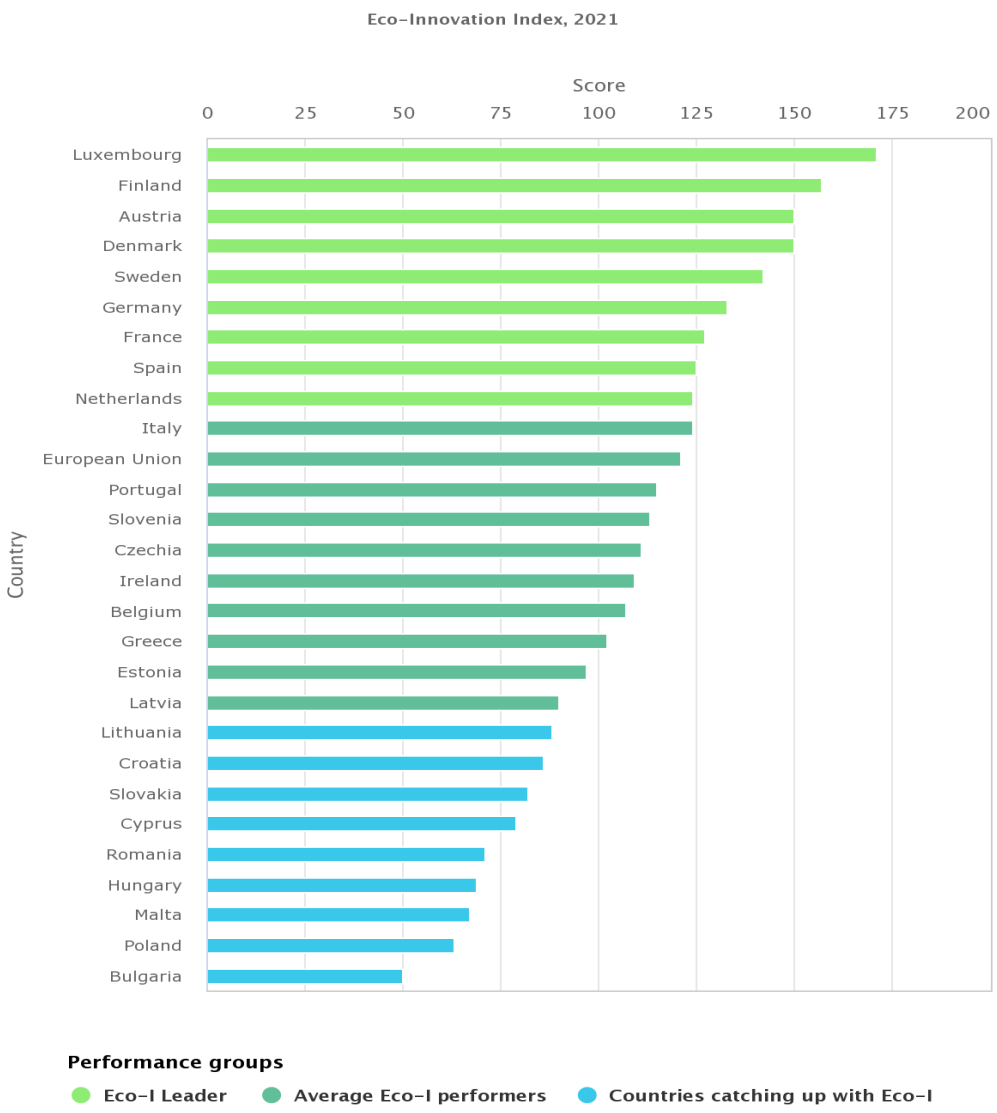

Figure 24. Eco-innovation Index in EU countries (2021)

The reasons for such low performance are to be further explored mainly in the less tangible aspects of social capital; availability of support structures and business intermediaries; and the overall structure of the economy. Only some elements of the circular economy have been integrated in the Bulgarian strategic and policy landscape. The potential of new circular business models has not been explored yet despite certain successes with some waste streams such as plastic packaging and WEEE. A lot of progress is yet to be made in terms of water savings and water reuse. Green Public Procurement is not playing the role it should in terms of triggering the offer of green products and services. Despite the relatively high number of companies certified with environmental management systems, this has

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not led to significant uptake in terms of green product offer and eco-innovation. Nevertheless, it has to be mentioned that there are promising new start-ups in the area of the collaborative economy and the bio-economy.

3.2.2 Regional characteristics and trends in the farms in Bulgaria

In all regions in Bulgaria, there is a steady downward trend in reduction in the number of agricultural holdings. The number of farms in the North-West region dropped more than 4 times and the North-Central region nearly 3 times. For the period 2010-2016 that trend is slower in the South-Central region, South-West, and South-East region. In these areas, the number of farms reduced by half. Based on a study of 2016, the largest number of farms was concentrated in the South-Central region - 64,500 farms, followed by the South-Western region with 42,780 farms. The largest farms by size are located in the North-Western region, followed by the Northeast. The South-Central and South-West regions have the smallest average sizes of agricultural holdings - about 2 times lower than the average size of agricultural holdings in the country. This is due to geographical characteristics of those regions. The small size of farms in these areas brings the question of their sustainability.

In all regions there is a tendency to increase the average number of livestock units on farms, however, the concentration of production is uneven. For the analyzed period, the most dynamic are the processes of increase in the average number of livestock units in farms in the Southeast region In the South Central and South-West regions. In 2016, the number of livestock units on a farm in the South-West region was two times lower than the national average, and in the South-Central region was 20% lower the national average.

As a result of the consolidation of the farms and concentration of the production, there is an increase in the economic size of agricultural holdings for all regions, but with different rates of change. The highest growth in the increase in the economic size was achieved by farms in the North-West region with an increase of more than six times, followed by farms in the North Central and Northeast region - an increase

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of about five times. The comparative analysis for 2016 clearly shows the division of the country in terms of economic size of farms in the north-south direction. In the Northern regions, farms are characterized by a higher economic size than farms in the Southern regions. However, we must point out that in the Southeast region, the economic size of farms is higher than the national average - 25 thousand euros Standard Production. Farms in the South-Central and South-West regions are characterized by significantly lower economic potential - less than EUR 10,000 Standard Production, while the average economic size of farms in the country has over EUR 18,000 Standard Production.

3.2.3 Circular Economy in Agri-Food sector in Bulgaria

3.2.3.1 Biomyc

Biomyc is a start-up biotech company that is revolutionizing packaging in Bulgaria. The company offers packages fully compliant with the principles of the circular economy. One of the technologies that Biomyc is using is transforming waste from agro-production. The packaging products are fully biodegradable and can be used in the restaurant industry as disposable utensils, in beverage industry for transportation. The packaging is also used in the electronics and machinery as well as cosmetics. Once discarded, the packaging it is recovered as it completely degrades, turning into manure, and we can even compost them ourselves.

Biomyc started its activities in June 2017 as an R&D company that aimed to bring sustainable products to the market. The initial goal was to develop a biodegradable alternative to styrofoam using agricultural residue and the root structure of mushrooms as a binder.

By 2018 Biomyc had completed its in-lab technology, and built a team and was able to win several awards and to participate in the prestigious EIT Accelerator program. While reaching out to potential customers, Biomyc found a big demand for sustainable packaging. Companies needed different complex packaging solutions. That discovery led to an increase in the portfolio of the services and products with the aim of bringing sustainable products to market sooner.

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Biomyc achieves that by:

1. establishing solid relationships with manufacturers and producers of sustainable packaging
2. dedicating its scientific department to development of methods for circular solutions

Biomyc current goal is to create a production facility for sustainable packaging in Bulgaria by 2022 that will meet EU wide demand and take advantage of the good manufacturing conditions in the country. Biomyc uses entirely sustainable process that does no harm to the environment. Using agricultural residue and the root structure of mushrooms, this packaging solution can be tailor-made and shaped to the client's specification. Its products are:

- Product Packaging for the Food and Beverage industry. The packaging is entirely biodegradable and made of agricultural residue.
- Transport Packaging for electronics, food and beverages. The packaging can give the products extra thermal and impact protection during delivery with tailor-made shapes and sizes according to customer specifications.
- New, eco-friendly and tailor made. The packaging solution is created from recycled paper and wood sawdust. It can be molded in various shapes and sizes.

Additionally, Biomyc offers wide choice for **single use** ware for **restaurants, cafes and fast-food shops**. The products come in a variety of colors and present an **eco-friendly** and **economically viable** alternative to plastic products.

3.2.3.2 Nasekomo

Nasekomo is the first biotechnology company in Bulgaria to produce food from Black Soldier Fly (Hermetia illucens). The final products are insect protein, oil and fertilizers for the feed and the agriculture industries. Their team found a successful solution how from organic food waste, using a natural mechanism, to produce food again. For the moment, the insect product is a concentrated protein, suitable for

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feeding on aquatic crops and pets. The fertilizer, used in the agriculture, is made from Black Soldier fly larvae castings and food fibers. It is a perfect choice for soil nutrition and remediation. Rich in organic matter, essential minerals, and chitin, the fertilizer contributes to healthy crops and strengthens the natural defenses of plants. The fertilizer is also suitable for growing vegetables.

By feeding insects with local agricultural by-products, it contributes to creating an environmentally positive local loop. Nasekomo's proprietary robotized insect rearing technology and selective breeding programs will enable the company to produce at large scale premium insect protein meal at a competitive price.

Nasekomo's in-house developed fully automated technology allows for scalable and cost-efficient production of insect products. Nasekomo is focused on robotizing production processes by implementing technology that is aimed at automating a currently very labor-intensive manufacturing environment. Nasekomo is revolutionizing the human food chain by producing animal feeds from organic waste thanks to insect's tremendous biological powers. Since its inception, the company has secured a total of EUR 5 million funding to develop its technologies. The venture Capital funds Morningside Hill and New Vision 3 backed by the Fund of Funds in Bulgaria participated in the investment. In addition, private investors from the UK, France, South Africa and Bulgaria also joined the investment round.

Despite being incorporated only 3 years ago, Nasekomo is already scaling up its insect rearing facilities. The scale-up will enable Nasekomo to implement circular economy on a large scale.

"We have spent the last 3 years developing unique solutions for the insect rearing market. Nasekomo has leveraged robotics, A.I. and big data which allow us to produce insect protein efficiently. We will not only be competitively producing large volumes, but also addressing the challenges of our world related to animal feed", states Marc Bolard, co-founder and technology lead.

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“Insects are part of the natural diet for many animal species. They now represent an opportunity to become a sustainable solution to supply the proteins that the world is increasingly consuming. Instead of increasing wild fish catch in oceans and deforesting to plant soy, we can feed insects with local agricultural by-products with extremely limited water consumption, and produce high-quality sustainable proteins for fish, poultry, pigs and pets. This local-loop vertical farming has clear environmental benefits and will build greater resilience of the European food chain. Thus, our business model is not only profitable but will have massive positive impacts on society in the long term”, adds Olga Marcenac, co-founder.

Nasekomo brings automated solutions to enhance the sustainability of the agriculture sector, which has a great potential in the region. By integrating robotization into insect farming, they are putting Bulgaria ahead on the sustainable biotech innovation map in the region and globally.

The investment will allow Nasekomo to grow its presence on the market and to increase its productivity by using robotics and data analytics. The company will also launch a new selective breeding program in order to provide the planet with continuously improving efficiency in transforming waste into insect-based products.

Nasekomo will be looking for additional funding in order to expand its production capacity. They will be looking for about 30 new AI specialists, biologists, and production personnel. Company’s founders are exploring licensing and franchising opportunities and conducting tests for new products such as insect oil, which could be used in animal antibiotics.

3.2.3.3 Blagichka – the first zero-waste restaurant

In Blagichka restaurant, one can enjoy offers from the lunch menu – on site or by delivery. Take away orders come in reusable boxes. Patrons can also bring their own container for the delivery. The menu has several-courses – always a salad, one or two main dishes, and a dessert. Everything is fresh, prepared on site the same day, and with carefully selected products. The daily menu changes but it often has a

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quiche, pancakes, fish, meat dishes, muffin or cake. Everything that goes through the kitchen in a package is reused, or comes in its own box, jar or reusable bag. Whatever is not recovered goes to the metal bins for separate collection. The rest of the food waste (excluding meat and dairy) goes to the nearby composter with detailed instructions how to dispose organic waste. The size of the composting station is large, so there is more time until the compartment is filled. The result of the compost, after careful stirring and constant replenishment, is a natural soil that is used to fertilize the garden nearby.

The founder Blazhka Dimitrova, said that she copes well with the prejudice of the locals to live environmentally friendly and to transform their waste habits: "With the opening of the restaurant, it was difficult to convince everyone that such a place is possible to exist. I do not hide that we also have a packaging that we fail to reuse, but then we necessarily recycle it – we also have a mini recycling station in the restaurant. And despite this, we rarely generate more than 1% waste."

3.2.3.4 Harmonica

The story of Harmonica began in 2006, when three friends started working with the first two organic cow farms in Bulgaria. They had no idea about managing business – they just wanted to offer their families real food. At that time, there were mostly low-quality food imitations in the stores – at the expense of a quality, the environment and health. The idea for organic farming in Bulgaria was completely unknown, and the support for the endeavor was non-existent. Harmonica started with organic yogurt, which gave hope and confidence that they can change things for the better. In their work, the founders found that agriculture and food production are at the epicenter of the big environmental problems facing our generation – loss of biodiversity, climate change, and pollution. Harmonica's founders understand that many of the solutions exist and Harmonica is part of a global wave of change.

Now their job is to look for solutions to these problems through everything Harmonica does. The first circular economy project is to use bread from the shops,

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which is difficult to sell such as stale bread that would otherwise be thrown away as unnecessary. Harmonica buys that stale bread and turns it into "liquid bread" – craft beer, which is sold in 3 options: light ale, dark ale and wheat beer. "Out of nothing – something" is Harmonica's initiative for wholesome and quality food, made from "waste". 20% of all wheat in it is from bread, which is used before it becomes unnecessary – as part of the initiative "Out of nothing – something" for wholesome and quality food made from "future waste". The company wants to find another way to use edible food with a short shelf life, and bread is a daily example. Thus, instead of losing already produced food, they searched and found a way to give new life to several hundred kilograms of unsold bread in Sofia. Next, they will focus on the waste from the vegetable exchanges, all the productions that they can cover and organize in an initiative for clean, tasty, complete and quality food.

3.3 Good Practices in Europe

A 2018 report for the European Commission entitled «Impact of Circular Economy Policies on Labour Markets» concludes that a cyclical economy could add 0.5% to Europe's GDP and generate net growth 700.000 jobs - particularly in Central and Eastern European Member States - by shifting the workforce from current resource extraction activities to recycling plants, as well as labour-intensive repair and reconstruction units.

Reducing the environmental footprint is one of the key incentives for the effective transition to the Circular Economy with the following benefits: reduce greenhouse gas emissions by 500 million tonnes (between 2015 and 2035) and savings of €465 in energy bills per year/per household (by 2020).

3.3.1 Fungi Futures

A best practice for waste management is the “Fungi Futures” Established in 2010 and based in Devon (South West England Region, United Kingdom) Its products are related to the urban mushroom farm, with the innovative product "GroCycle Box" for growing oyster mushrooms at home within 14 days. The substrate for the

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mushroom cultivation is produced from espresso coffee grounds collected from local cafes. More than 30 tonnes of coffee residues have been recycled and 7,000 kg have been produced mushrooms in four years. More than 10,000 individual packs have been distributed ("GroCycle - Grow Mushrooms The Easy Way," 2022).

3.3.2 Ecovative design

The Ecovative design is an American company that produces packaging materials from organic materials such as mushrooms, agricultural waste. By using these materials, the packaging materials are biodegradable and can thus be returned to the soil as a nutrient after use. In addition, minimal energy consumption is required for the production of the products (the plant part of the mushroom) as the micelle grows within six days ("Ecovative," 2022).

3.3.3 Good Food Brussels

Good Food Brussels connects initiatives across the food chain, increasing their visibility and encouraging partnerships("Good Food Brussels," 2022). With the aim of increasing local food production and reducing food waste, the platform and this procedure was based on the results of the Network URBACT "Sustainable Food in Urban Communities" ("Sustainable Food in Urban Communities | URBACT," 2022).

3.3.4 Circular Ocean

Good practice for Green and Blue Growth is the treatment of plastic litter in the sea through "Circular Ocean". This project brings together regions from the Northern Region and the Arctic to tackle marine plastic litter - a common problem for coastal communities. The aim is for local businesses and entrepreneurs to find ways to reuse old nets and ropes, as well as other forms of marine waste ("Circular Ocean," 2022).

3.3.5 Globe Hope

The Finnish company Globe Hope specializes in unique garments made from leftover and waste textiles and uses materials such as vintage fabrics, advertising

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banners, sails, vintage army blankets and vintage army raincoats. Vintage textiles are found in flea markets, textile sorting centers and textile factories. In addition, Globe Hope turns materials into a wider variety of clothing in addition to bags and accessories ("Globe Hope.," 2022).

3.3.6 Desko

Desko has completely refocused their business model and operations to be more circular by rebuilding. Unlike a traditional linear model of resource extraction, manufacturing and selling furniture, Desko uses a three-level buyback system. Desko furniture sold, repurchased, remanufactured and resold up to 3 times extending their useful life and providing more revenue to the company for the same quantity produced ("Desko: Transforming the furniture industry with buy-back strategies - Insights - Circle Economy," 2022).

3.3.7 Summary of Good Practices

Table 3. Good practices of circular economy in the agri-food sector of Greece

No	Name	Description	Location
1	GroCycle Box	Mushroom growing at home based on CE principles	United Kingdom
2	Ecovative	Packaging materials from organic materials	US
3	Good Food Brussels	Platform that connects initiatives across the food chain aiming to increase local food production and reduce food waste	Brussels
4	Circular Ocean	Reuse of old nets, ropes and other forms of marine waste	EU
5	Globe Hope	Garments made from leftover and waste textiles	Finland

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6	Desko	Buy-back system that extends lifetime of product	NA

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4 The Status Quo of Circular Economy Practices and their Environmental Impact in Greece

4.1 Survey Design

In October – November 2021, the literature review took place on CE and the Environmental Impact. The Initial scope of the survey as well as an initial survey was drafted in November 2021 and reviewed internally by PB3 and the external expert to produce Draft 2. This draft was sent out to the partnership in late November 2021. The subcontractor amended the survey in light of these comments (Draft 3) and PB3 made a few adjustments (Draft 4).

Following a Partnership meeting, Draft 5 was produced, after discussions (via teleconference) and recommendations from the partnership (via email). The questionnaire was translated (in Greek and Bulgarian from English), to find any linguistic modifications that needed to be made. After the survey was put into Google Forms, final adjustments were made in order to ensure online usability and the readability of the survey (Draft 6). Finally, the survey was launched in mid-February 2021 by the Greek partners.

The questionnaire was a structured questionnaire in order to illicit precise answers (as the language barrier and the comparability of the results between the countries were also an issue). The replies were gathered over a period of 1 month (February-March 2022). The surveys were sent out via email to over 2000 companies of the Agri-food Sector, that operate in different fields, in the Greek side of the Cross Border area. 205 surveys were gathered.

The survey needed around 7-9 minutes to be completed, including the introductory questions and the specific deliverable's questions. The deployment method was online survey using Google Forms. Each Beneficiary had their own Google Form.

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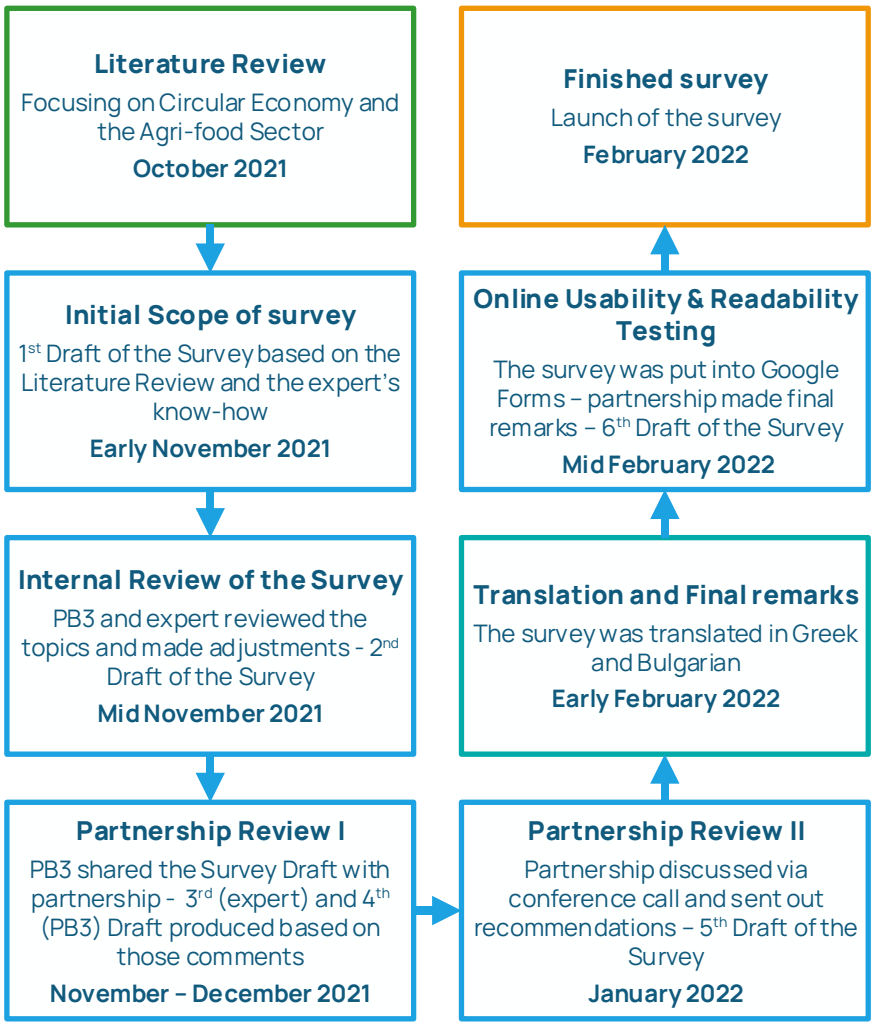

Figure 25. Survey Design

The survey is presented in the annexes

4.2 Statistical Analysis

4.2.1 Descriptive statistics

For all the questions included in the survey, the frequency and the relative frequency of the responses were calculated. These values were presented using a set of pie charts, bar charts, radar charts, and geographical maps, as well as tables. During this first stage of the analysis, no processing of the data was applied, so as to ensure a clear and unbiased view of the raw data collected and the respective information content.

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4.2.2 Inferential statistics

4.2.2.1 Chi-square test of independence

Given the qualitative nature of the data collected, the analysis had to technically deal with nominal and ordinal variables. In this context, the level of association between two variables were assessed based on the appropriate chi-square test of independence. The necessary contingency tables were also created allowing for the interpretation of the results. Pairwise z-tests were employed to perform the corresponding post-hoc analysis in order to detect particular differences between proportions for the statistically significant cases.

4.2.2.2 Data processing

In some cases, the values of a variable were processed, e.g., recoded by merging two values into a new one, to address low frequency values, ensure the reliability of the respective statistical testing, and facilitate and enhance the interpretability of the results towards a more straightforward and clear understanding of the subjacent outcomes. The following recoding actions were applied:

- *Location of a company*. Two values were considered for this variable: (1) Thessaloniki, and (2) Other, including all Central-East Macedonia locations other than the municipality of Thessaloniki.
- *Number of employees*. Values "50-100" and "101-250" were merged (recoded) into a new value labeled "›50".
- *Annual revenue*. Values "2.000.000€-10.000.000€" and "›10.000.000€" were merged (recoded) into a new value labeled "›2.000.000€".
- *Engagement with suppliers towards CE*. The recoding of this Liker-type variable was made as follows: Values 1 and 2 merged into a new value labeled "Low", value 3 recoded into a new value labeled "Moderate", and values 4 and 5 were merged (recoded) into a new value labeled "High".
- *Customers' pressure for CE*. The recoding of this Liker-type variable was made as follows: Values 1 and 2 merged into a new value labeled "Low", value

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3 recoded into a new value labeled “Moderate”, and values 4 and 5 were merged (recoded) into a new value labeled “High”.

4.2.3 Cluster analysis

4.2.3.1 K-Modes algorithm

The K-Modes clustering (Huang, 1997), which is an unsupervised machine learning method and more specifically a modified version of the standard k-means clustering process optimized to cluster categorical data, was employed in an effort to classify the companies into groups of similar characteristics. The elbow method based on the matching dissimilarity criterion, as well as the average silhouette width criterion were used to select the optimal number of clusters. The selection of the initial centers of the clusters were performed using Monte Carlo simulation for a number of random initial seeds.

4.2.3.2 Data processing

The recoding of the variables that were employed in the chi-square tests, was also applied to cluster analysis. Furthermore, a second process was implemented to reduce the number of the CE measures (variables) down to three variables, i.e., one variable to represent the general CE measures (initial number of questions: 8), one variable to represent the energy-related CE measures (initial number of questions: 5), and one variable to represent the water-related CE measures (initial number of questions: 4). The overall process is presented in Annex 3.

4.2.4 Statistical analysis software

The statistical analysis of the results was performed using: (i) the MS Office 365 Excel (commercial software) for processing the data, calculating descriptive statistics, and creating the graphs, (ii) the IBM® SPSS® Statistics 23 (commercial software) for processing the data, performing the chi-square hypotheses testing, creating the contingency tables, and conducting the corresponding post-hoc analysis, and (iii) the R programming language (open-source programming environment) (R Core Team, 2022) for implementing the K-Modes clustering

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methodology, estimating the optimal number of clusters, and developing the customized solution (code) for deciding the initial cluster centers. The following R packages were used: klaR, dplyr, factoextra, and ggplot2.

4.3 Analysis of the Results

4.3.1 Part A: General Information

4.3.1.1 General information of respondents

Gender. The frequency and the relative frequency of the gender of the respondents are presented in Figure 26. The sample included 205 participants. Both genders were sufficiently represented as 55% of the participants were males and 45% were females.

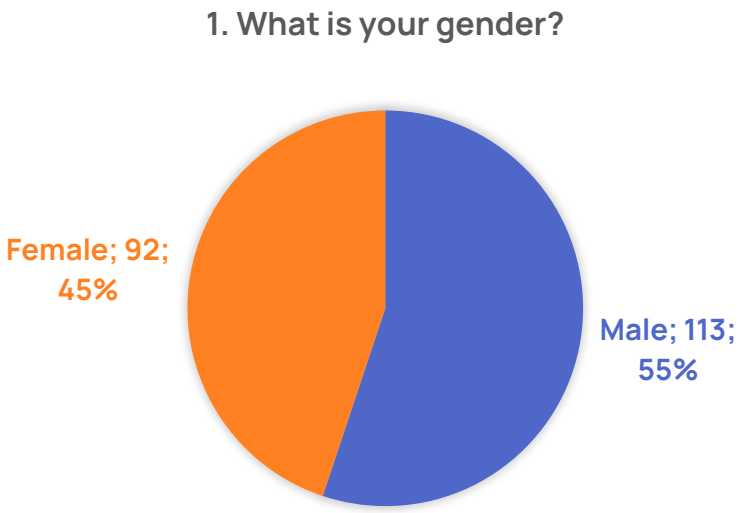

Figure 26. Frequency and relative frequency of the gender of the respondents (Part A: Question 1)

Age. The frequency and the relative frequency of the age of the respondents are presented in Figure 27. Most of the participants (78%) were aged between 25 and 54 years old.

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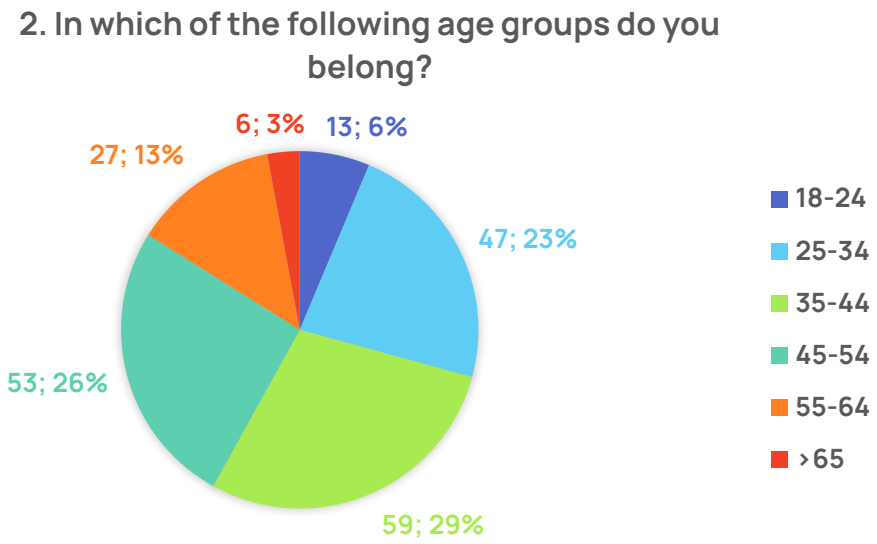

Figure 27. Frequency and relative frequency of the age of the respondents (Part A: Question 2)

Education. The frequency and the relative frequency of the educational level of the respondents are presented in Figure 28. Most of the participants (65%) hold either a College/University degree or a Master's/PhD degree.

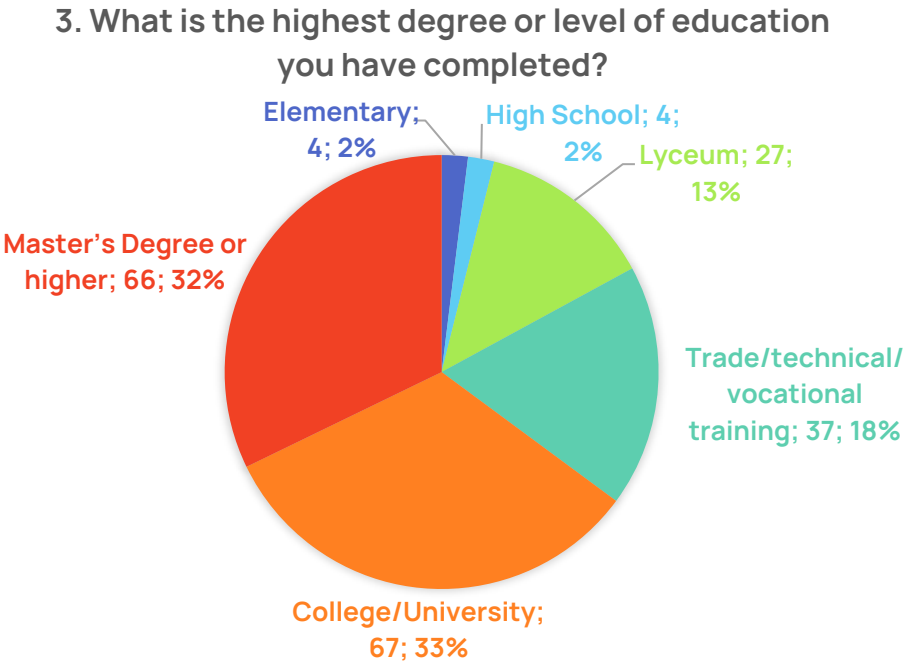

Figure 28. Frequency and relative frequency of the educational level of the respondents (Part A: Question 3)

Position. The frequency and the relative frequency of the company position held by the survey respondents are presented in Figure 29. 25% of the participants were

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freelancers, whereas 26% were owners, and 49% were personnel of different types (laborers, technical staff, administrative staff).

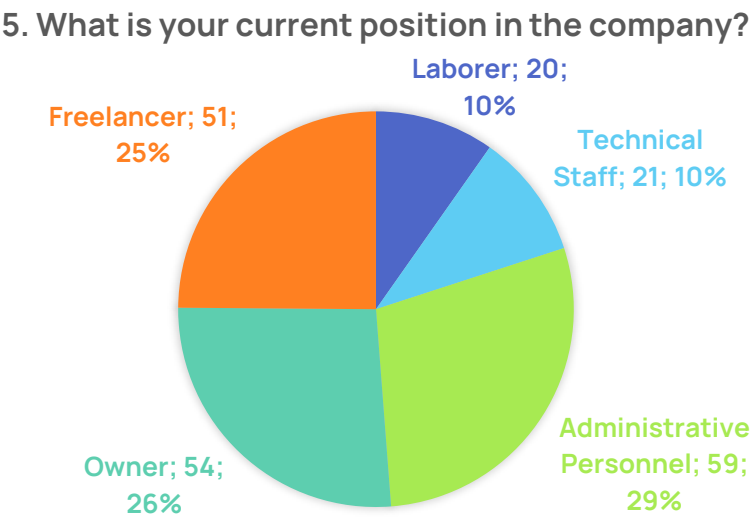

Figure 29. Frequency and relative frequency of the company position held by the respondents (Part A: Question 5)

4.3.1.2 General information of companies

Location. The location of the companies that participated in the survey is presented in Figure 30. Two-thirds of the companies (65%) were located in the broader area of the municipality of Thessaloniki, whereas one-third (35%) of them were spread across the area of Central-East Macedonia and Thrace.

Figure 30. Location of the companies (Part A: Question 4)

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Years of operation. The frequency and the relative frequency of the number of operating years of a company are presented in Figure 31. Half of the companies were either starting companies or they had an operating history of up to 10 years (51%), whereas the other half (49%) had an operational history of 10 years or more.

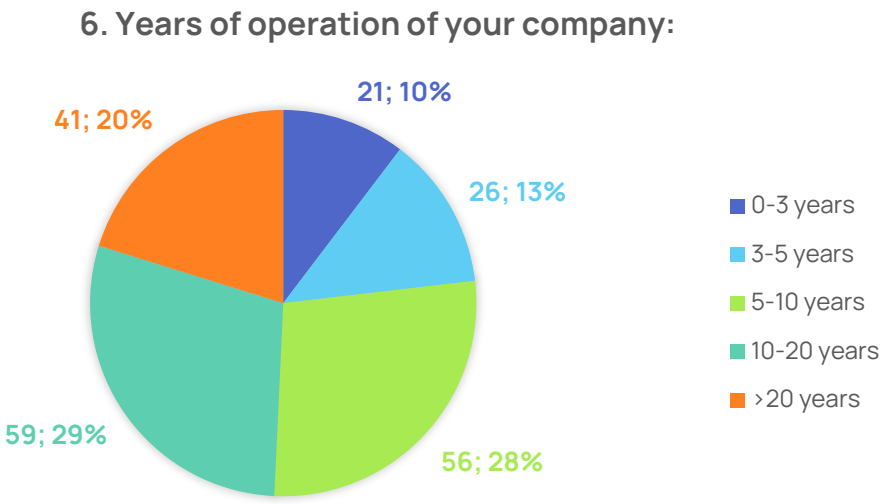

Figure 31. Frequency and relative frequency of the number of operating years of a company (Part A: Question 6)

Operational field. The frequency and the relative frequency of the field that the companies operate in are presented in Figure 32. Three-fourths of the companies (74%) are either producers, service providers, or they are involved in processing activities, whereas one-fourth of them are involved either in the logistics, the trading, or the packing industry.

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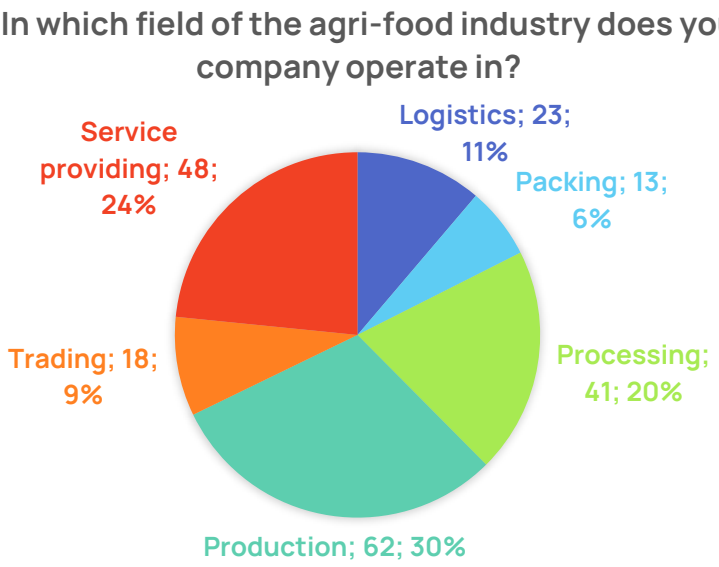

Figure 32. Frequency and relative frequency of the operational field of the companies (Part A: Question 7)

Number of employees. The frequency and the relative frequency of the number of employees of the companies that participated in the survey are presented in Figure 33. Most of the companies (61%) were small-sized, having less than 10 employees.

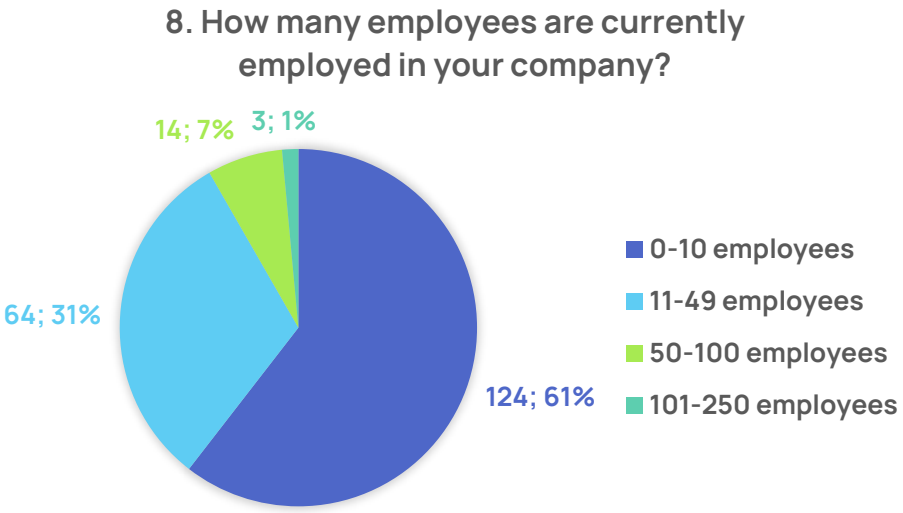

Figure 33. Frequency and relative frequency of the number of employees of the companies (Part A: Question 8)

Annual revenue. The frequency and the relative frequency of the annual revenue of the companies are presented in Figure 34. Most of the companies (55%) exhibit

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annual revenues lower than 500.000€. 15% of the companies appear to have annual revenues higher than 2.000.000€. Finally, 13% of the respondents did not provide this kind of information related to their financial status.

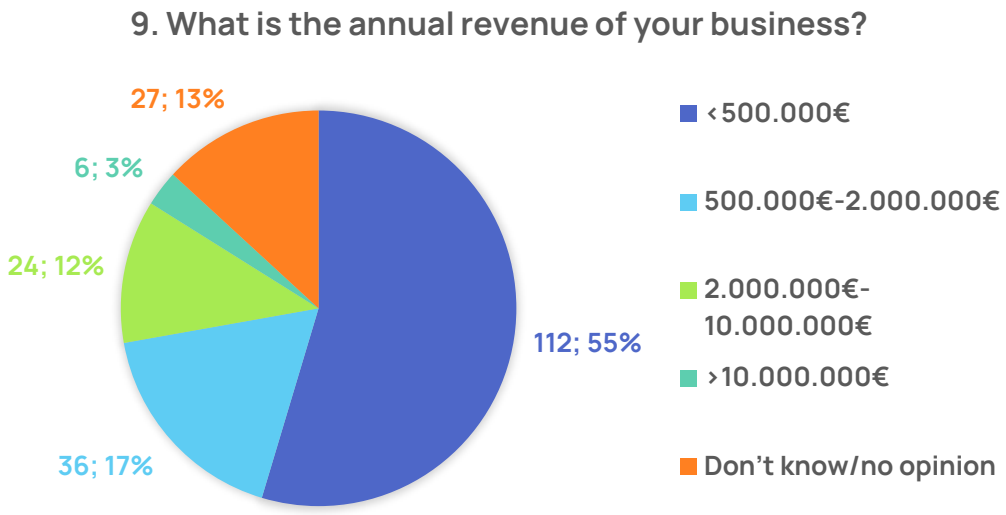

Figure 34. Frequency and relative frequency of the annual revenue of the companies (Part A: Question 9)

4.3.2 Part B: Circular Economy and Environmental Impact (D.3.2)

4.3.2.1 Type of waste

Type of waste. The companies participated in this study have mostly recyclable waste (68%) (Figure 35). Some of them also appear to have – though to a lesser extent, which varies from 27% to 40% – organic waste (i.e., biodegradable materials from either a plant or an animal), solid waste (i.e., glass and ceramics, plastic, paper, metals, and tins that are not being recycled), and liquid waste (e.g., wastewater, dirty water, grease or oil, sludges, waste detergents). Perhaps due to the nature of the agri-food sector, just a minority of the companies that responded to this question (5%) appear to have hazardous waste (e.g., flammable, corrosive, toxic and reactive materials, dangerous or potentially harmful to human health or the environment).

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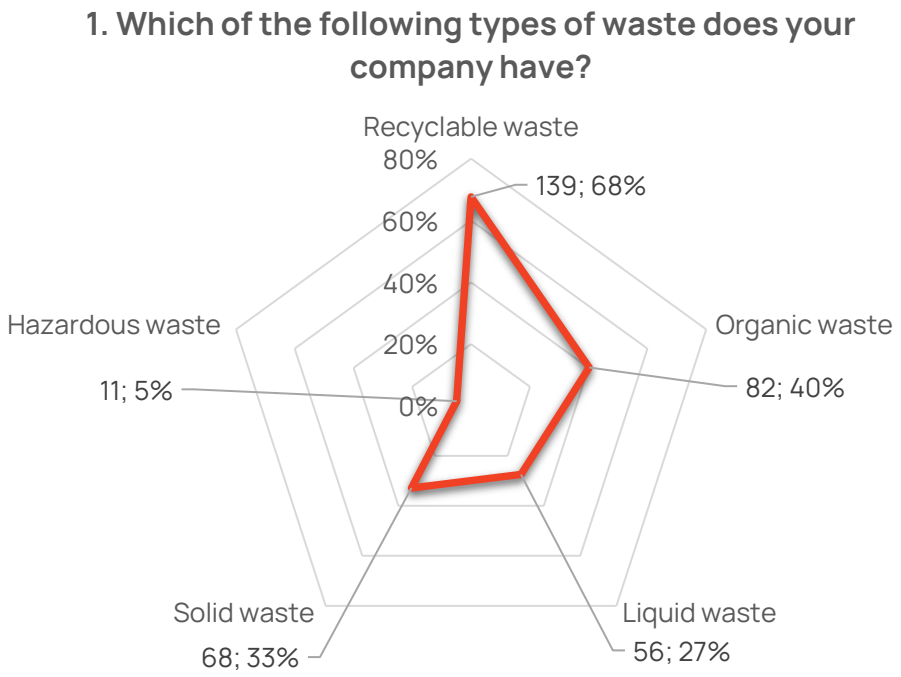

Figure 35. Radar chart (frequency and relative frequency) of Question 1 (Part B)

It seems that there is a statistically significant association, which is more or less expected, between the type of waste that a company has and the field that the company operates in, for recyclable waste $x^2(4, N = 205) = 17.5$, $p < 0.01$, for organic waste $x^2(4, N = 205) = 68.8$, $p < 0.01$, for liquid waste $x^2(4, N = 205) = 11.1$, $p = 0.05$, and for solid waste $x^2(4, N = 205) = 12.2$, $p < 0.01$ (the results are presented in detail in Annex 3, Table 21 to Table 24). For example, production and processing industries are the two main producers of organic waste, given that – according to the outcomes of the survey – 71% and 53% of the companies, respectively, responded that they have this type of waste. The overall results are summarized in Table 4.

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Table 4. Relative frequency of the companies within each operating field that have the particular type of waste

	Type of waste				
Field of operation	Recyclable*	Organic*	Liquid*	Solid*	Hazardous
Production	50%	71%	37%	18%	10%
Packing	85%	15%	31%	39%	0%
Processing	63%	53%	37%	44%	7%
Logistics	83%	4%	17%	26%	9%
Trading	72%	11%	11%	39%	0%
Service Providing	81%	15%	17%	44%	0%

4.3.2.2 Circular Economy and strategic priorities

Circular-Economy-related strategy. According to the responses of the participants, it seems that only a minority of 13% of the companies do explicitly mention Circular Economy as part of their strategic priorities, whereas there is another 32% that also mention relevant concepts as part of their strategic priorities (e.g., materials circulation, new business models that follow the principles of circular economy, not just resource efficiency). However, most of the companies (55%) does not seem to include any of the Circular Economy concepts and practices among their strategic priorities. Figure 36 shows the frequencies and relative frequencies of the responses.

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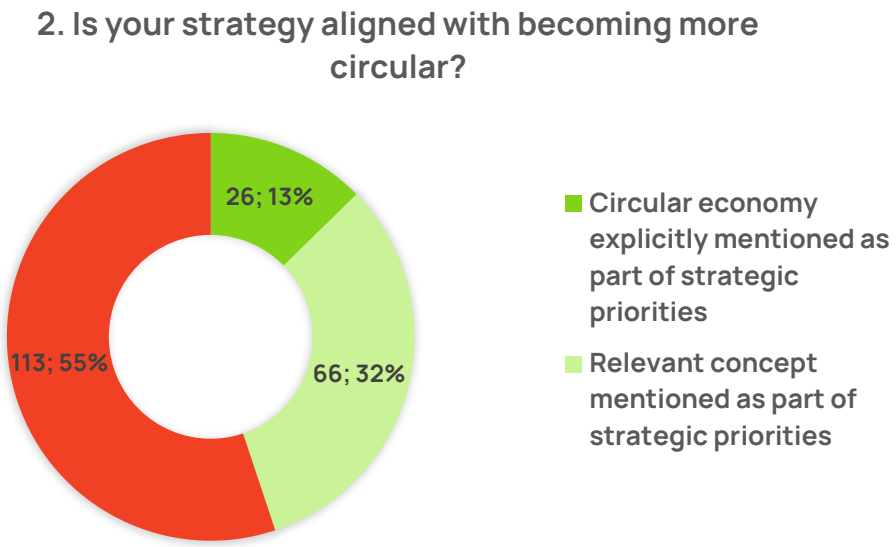

Figure 36. Pie chart (frequency and relative frequency) of Question 2i (Part B)

The location of a company, the number of years in business, as well as the field that the company operates in, do not seem to have a significant impact on whether a company aligns its strategy with becoming more Circular, or not. On the other hand, it seems that bigger companies, i.e., companies with more than 50 employees, mention Circular Economy more frequently as part of their strategic priorities than smaller companies do, i.e., companies with less than 50 employees, $x^2(4, N = 205) = 10.9$, $p = 0.03$; the relative frequency of the companies that do consider CE priorities as part of their strategic plans are 11%, 9%, and 35% for companies with 0-10, 11-50, and >50 employees, respectively. This is also the case with companies of annual revenues higher than 2.000.000€, which are also associated with higher prioritization of CE concepts and practices as part of their strategic planning compared to companies with lower annual revenue (lower than 2.000.000€), $x^2(4, N = 205) = 9.3$, $p = 0.05$; the respective percentages are 5%, 14%, and 23% for companies with <500.000€, 500.000-2.000.000€, and >2.000.000€ annual revenue, respectively.

An interesting point here is that the companies which stated that they feel higher pressure from their customers "to be more Circular" are the ones that are more frequently associated to the involvement of CE priorities in their strategic plans,

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whereas companies with lower levels of pressure are mostly the ones that do not consider CE priorities as part of their strategic plans, $x^2(4, N = 205) = 26.9$, $p < 0.01$; the respective percentages are 3%, 21%, and 23% for companies with low, moderate, and high pressure by their customers, respectively. This is also the case as regards the relationship of the companies with their suppliers, as it seems that the engagement with suppliers towards increasing sourcing based on CE principles is associated to higher levels of establishing CE-related priorities at the strategic level, whereas companies with lower levels of CE-related engagement with their suppliers are more frequently the ones that do not consider CE as part of their strategic plans, $x^2(4, N = 205) = 28.8$, $p < 0.01$, the respective percentages are 4%, 15%, and 27% for companies with low, moderate, and high level of engagement with their suppliers on CE issues, respectively.

The contingency tables associated to the statistically significant results are presented in detail in Annex 3, Table 25 to Table 28).

4.3.2.3 Circular Economy measures

The third question in this second part of the survey aimed to investigate whether companies are currently implementing or are interested in implementing some of the most widely known Circular Economy measures. The measures examined were classified into three groups, namely, Generic CE measures, Energy-related measures, and Water-related measures.

Generic CE measures. The average percentage of implementation for a measure that belongs to this generic CE group of measures is as low as 19%. However, on average, 37% of the companies stated that they are interested in implementing such measures, though not currently implementing any of them. On the other hand, only 8% of the companies exhibit a completely negative position with respect to the implementation of general CE measures, by stating that "they are not interested in implementing such measures". It is worth mentioning that approximately more than one-third of the respondents (36%) think that such measures are not applicable to their business.

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The recycling of waste (either of packaging or other sources of waste), which is perhaps the most well-known general CE-related practice, is the most popular measure among the generic CE good practices that have been included in the questionnaire, given that this measure has been already adopted and is being implemented by 61% of the companies. The use of reused and recycled inputs then follows, being implemented by one-fourth (24%) of the companies. All the other practices, including the repurpose of waste (i.e., use of waste to produce another product), the use of regenerative Inputs (produced in ways to have a positive impact to nature), the use of upcycled Inputs (from by-products that would have otherwise been wasted), the design of a waste management plan, the circular product design (i.e., the product is designed along CE principles), and the use of biofertilizers (for production) are being implemented by less than 15% of the companies, on average. The overall results are summarized in the bar charts of Figure 37.

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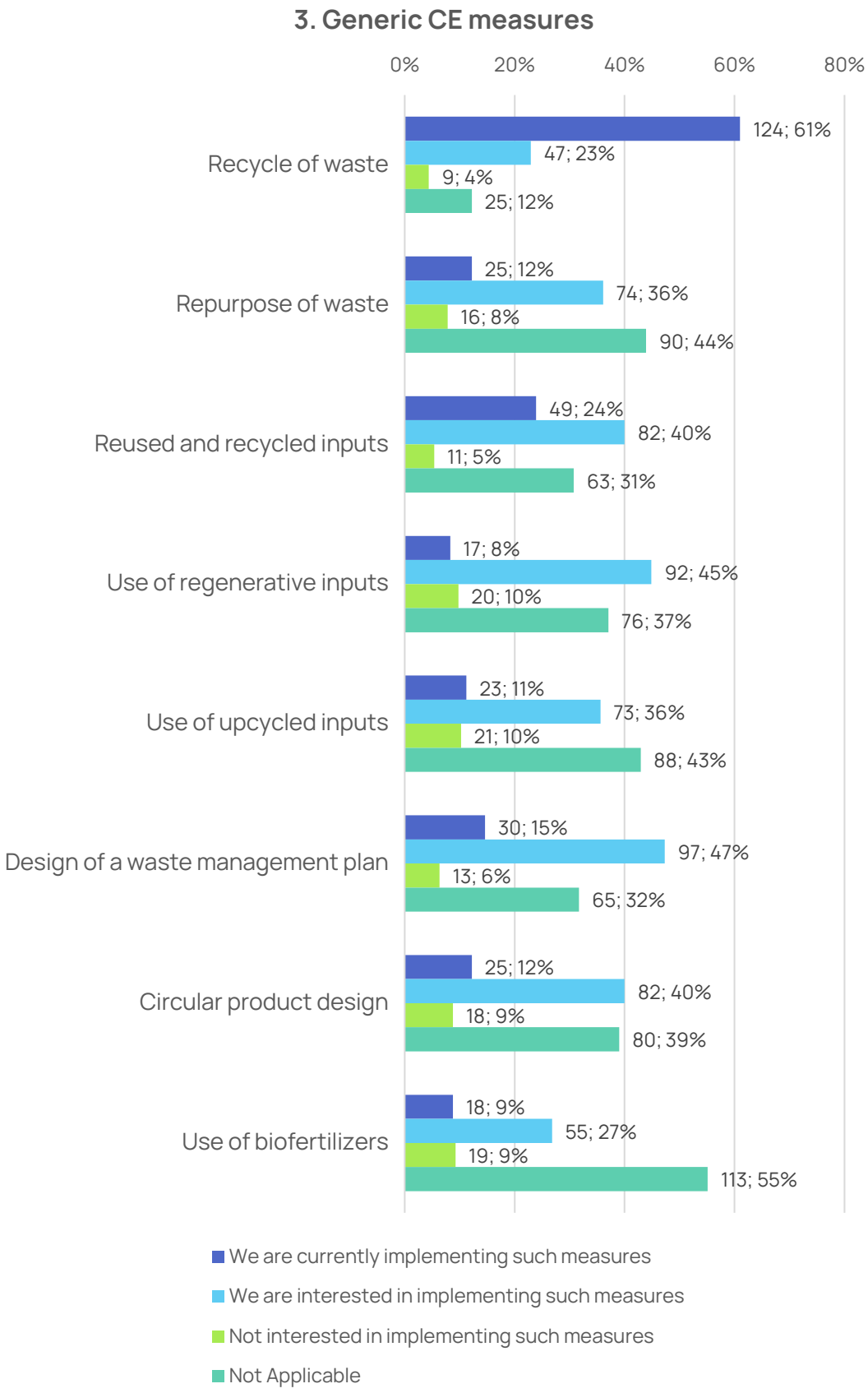

Figure 37. Bar chart (frequency and relative frequency) of Question 3i (Part B)

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Energy-related CE measures. With respect to the energy-related CE measures, the average percentage of companies that implement each measure is as low as 12%, lower than the respective ratio for the generic measures. Another 39% of the companies appear to be interested in implementing such measures, though not currently implementing any of them. 11% of the companies does not seem to be interested in implementing such measures. Similarly to the case of the generic measures, approximately one-third (37%) of the respondents think that such measures are not applicable to their business.

The monitoring of their energy consumption is the most popular measure among the respective energy-related CE good practices, since 31% of the companies currently implement this measure. The monitoring of the emissions then follows, being implemented by 15% of the companies. All the other practices, including the use of renewable energy resources other than biofuels or energy recovery (e.g., solar or wind power), the energy recovery from waste, and the use of biofuels, are implemented by 9% or less of the companies, on average. The overall results are summarized in the bar charts of Figure 38.

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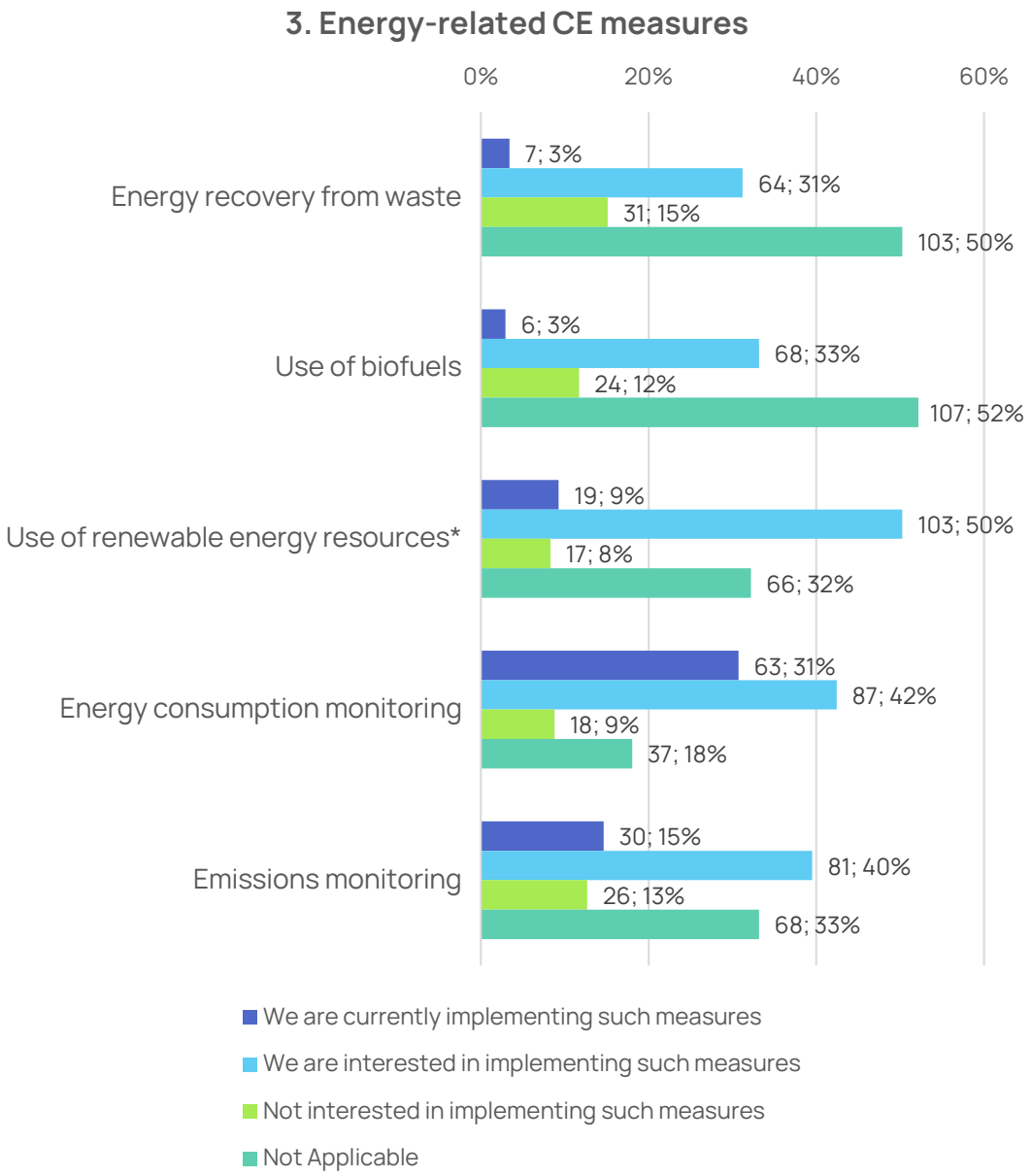

Figure 38. Bar chart (frequency and relative frequency) of Question 3ii (Part B)

Water-related CE measures. The water-related CE measures appear to have less reach to companies compared to the generic CE and energy-related measures. The average percentage of companies that implement each measure within this group of measures is only 6%, and just another 27% appear to be interested in implementing such measures but does not currently implement one. 13% of the companies do not seem to be interested in implementing such measures, and finally, more than half of the companies (54%) think that the proposed water-related CE measures are not applicable to their business.

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All water-related measures including the use of water from rainwater harvesting, the cascading use of water (i.e., direct use of untreated wastewater, in a manner that is safe for the environment and human health), the use of internally recirculated water, and the use of seawater or non-potable water from freshwater areas that are not classified as water-stressed, exhibit an implementation rate of 9% or lower, on average. The overall results are summarized in the bar charts of Figure 39.

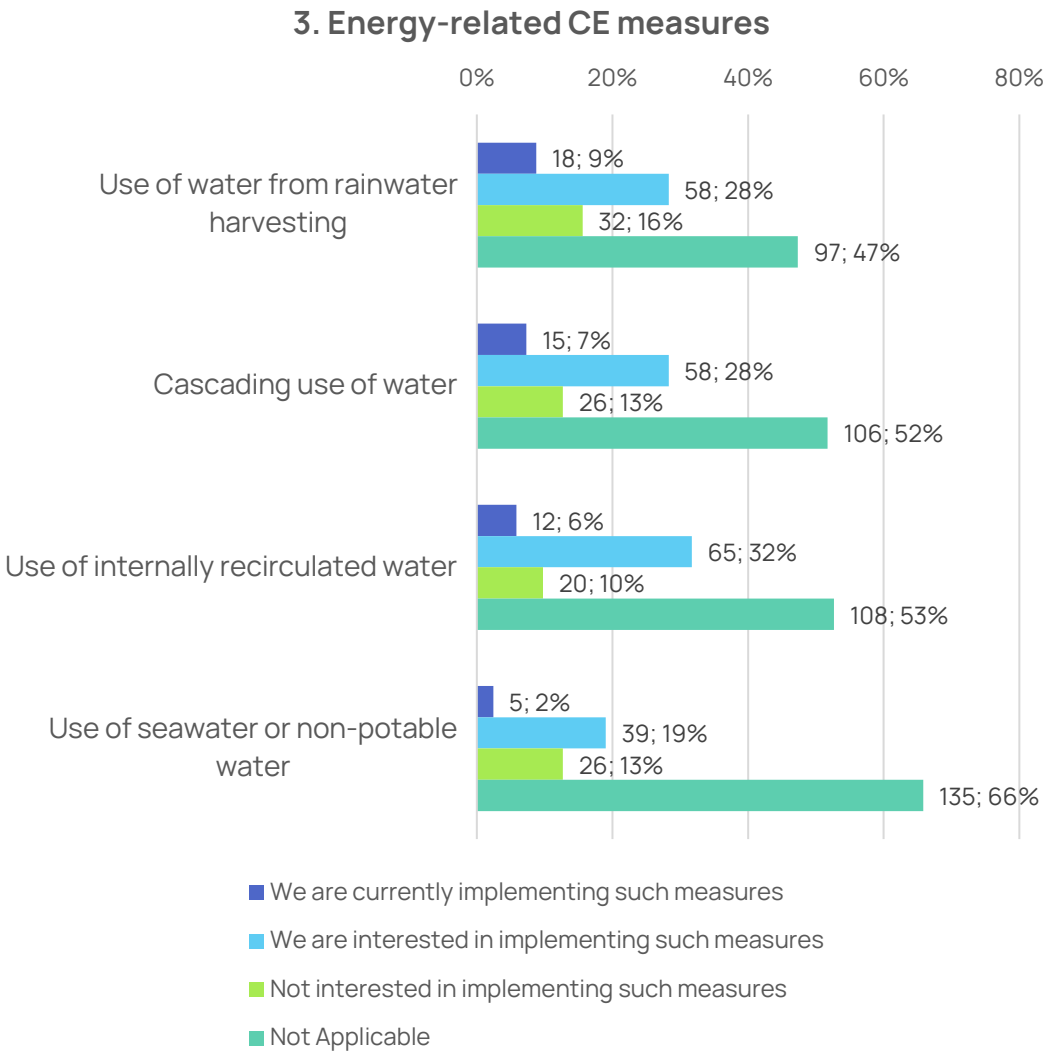

Figure 39. Bar chart (frequency and relative frequency) of Question 3iii (Part B)

4.3.2.4 Environmental impact assessment

In terms of the assessment of their environmental impact, approximately one out of three companies (29%) employs, one or more, assessment procedures to

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assess this impact, e.g., via life cycle analysis, environmental footprint, etc., as presented in Figure 40.

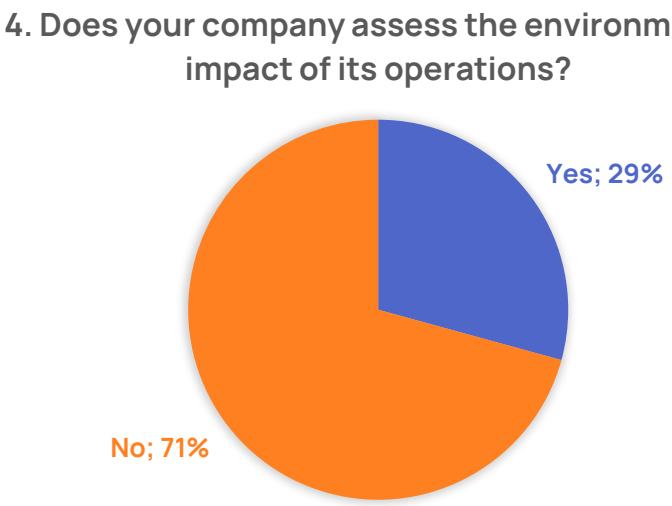

Figure 40. Pie chart (frequency and relative frequency) of Question 4 (Part B)

In terms of demographics, the assessment of a company's environmental impact does not seem to depend on the company's location, the number of years in operation, and the field that the company operates in. As regards the impact of the number of employees on the respective decision-making, it seems that as the size of the companies gets bigger it is more frequent to meet a company that assesses its environmental impact, though the corresponding hypothesis is not statistically significant; the relative frequencies of the companies that assess their environmental impact are 25%, 33%, and 47%, respectively, for companies with 0-10, 11-50, and >50 employees. However, there seems to be statistically significant evidence that the assessment of the environmental impact depends on the annual revenue of a company, so that the higher the annual revenue of the company the higher the probability to assess its environmental impact, $x^2(4, N = 205) = 14.8$, $p < 0.01$; the respective percentages are 21%, 25%, and 57% for companies with <500.000€, 500.000-2.000.000€, and >2.000.000€ annual revenue, respectively.

The environmental impact assessment also seems to be related to the company's level of engagement with its suppliers to promote sourcing based on CE principles,

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since higher frequencies of companies assessing their environmental impact are observed as we move to higher levels of engagement of the companies with their suppliers, $x^2(4, N = 205) = 20.2$, $p < 0.01$; the corresponding percentages of companies that assess their environmental impact are 15%, 36%, and 49% for companies with low, moderate, and high level of engagement with their suppliers, respectively. The behaviour of a company as regards its environmental impact assessment seems to also depend on the pressure put by customers on companies to become more Circular, $x^2(4, N = 205) = 13.0$, $p < 0.01$; the respective percentages are 18%, 35%, and 47% for companies with low, moderate, and high level of customers' pressure, respectively.

The assessment of the environmental impact appears to also depend on the level of the CE-related strategic planning of the company, since we observe that companies where Circular Economy is explicitly mentioned as part of their strategic priorities are associated to a higher probability of performing environmental impact assessment actions, $x^2(4, N = 205) = 53.3$, $p < 0.01$; the respective percentages are 10%, 46%, and 73% for companies with low, moderate, and high level of CE-related strategic planning, respectively.

The contingency tables associated to the statistically significant results are presented in detail in Annex 3, Table 29 to Table 32).

4.3.2.5 Circular Economy training

Training of employees on CE issues. As regards the training on Circular Economy issues, only one out of four companies offer this opportunity to its personnel, as presented in Figure 41.

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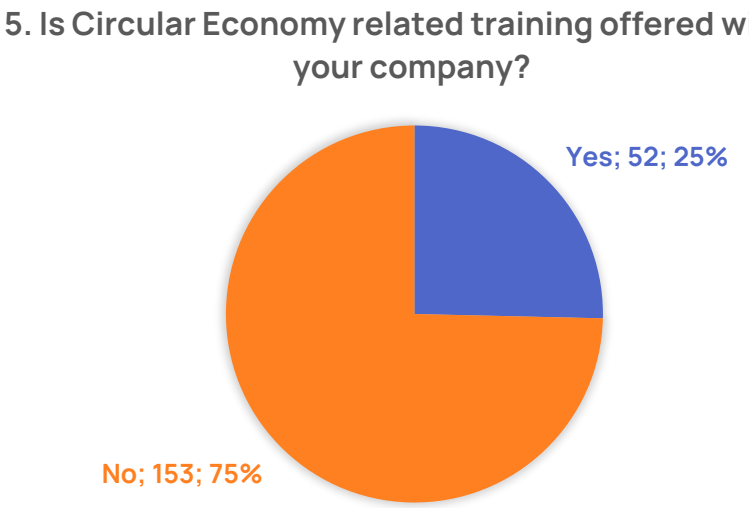

Figure 41. Pie chart (frequency and relative frequency) of Question 5 (Part B)

For 29 of the 52 companies (56%) that train their employees on Circular Economy issues, the training is provided by an external organization, whereas for the rest 44% training is internally performed. For 48% of the companies, the attendance of the training sessions is mandatory. In most of the cases (62%), when training is available, all levels of employees seem to have access to the associated sessions. The pie charts in Figure 42 present some more detailed information on the companies' training processes, attendance, and availability.

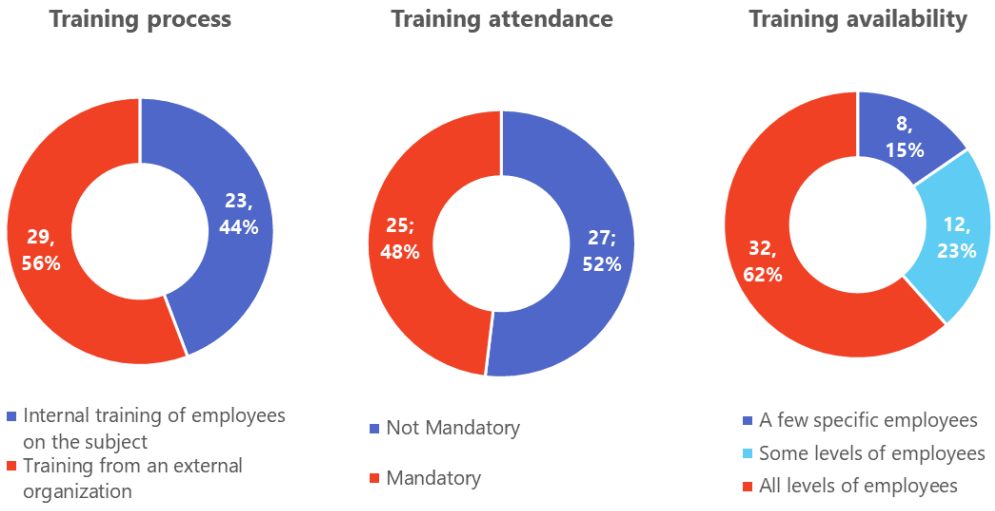

Figure 42. Pie chart (frequency and relative frequency) of Question 5i, Question 5ii, and Question 5iii (Part B)

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The location of a company and the number of operating years does not seem to affect its CE-related training actions. The field of operations seems to have a role on training, as some significant differences are observed among industries, $x^2(4, N = 205) = 16.0$, $p = 0.01$; indicatively, the highest percentage of companies that offer CE-related training sessions is observed in Trading (50%) and the lowest one in Production (11%). It also seems that as the size of the companies gets bigger it is more frequent to meet a company that offers CE-related training sessions to its personnel, $x^2(4, N = 205) = 16.0$, $p = 0.01$; the relative frequency of the companies that offer training are 22%, 27%, and 47% for companies with 0-10, 11-50, and >50 employees, respectively. There also seems to be statistically significant evidence that the training offers are related to the annual revenue of a company, since the probability of offering CE-related training for a company is associated to higher annual revenue, $x^2(4, N = 205) = 11.8$, $p < 0.01$; the respective percentages are 20%, 22%, and 50% for companies with <500.000€, 500.000-2.000.000€, and >2.000.000€ annual revenue, respectively.

The offer of training sessions seems to be also related to the level of engagement with suppliers to promote CE-based sourcing, as we observe higher frequencies of companies offering training sessions as we move to higher CE-related engagement levels with their suppliers, $x^2(4, N = 205) = 31.0$, $p < 0.01$; the respective percentages are 7%, 38%, and 45% for companies with low, moderate, and high level of engagement with their suppliers, respectively. The offer of training sessions seems to also depend on the pressure put by customers on companies to become more Circular, $x^2(4, N = 205) = 20.6$, $p < 0.01$; the respective percentages are 11%, 40%, and 37% for companies with low, moderate, and high level of customers' pressure, respectively.

The offer for training also depend on the level of the CE-related strategic planning of the company, since we observe that companies where Circular Economy is explicitly mentioned as part of their strategic priorities tend to offer training sessions more frequently, $x^2(4, N = 205) = 21.5$, $p < 0.01$; the respective

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percentages are 18%, 24%, and 62% for companies with low, moderate, and high level of CE-related strategic planning, respectively.

The contingency tables associated to the statistically significant results are presented in detail in Annex 3, Table 33 to Table 37).

4.3.2.6 Engagement with suppliers towards Circular Economy

Engagement with suppliers towards CE. One-fourth of the companies (24%) appear to be relatively highly to highly engaged with suppliers to increase sourcing based on Circular Economy principles (i.e., scores 4 and 5 of the respective Likert-type scale). 30% of the companies are moderately engaged with their suppliers as regards a sourcing approach that is based on circular economy principles. Finally, approximately half of the companies that participated in this study (46%) exhibit a low level of engagement with their suppliers to increase the share of sourcing that is based on Circular Economy principles (i.e., scores 1 and 2 of the respective Likert-type scale). Frequencies and relative frequencies of the responses are presented in the bar chart of Figure 43.

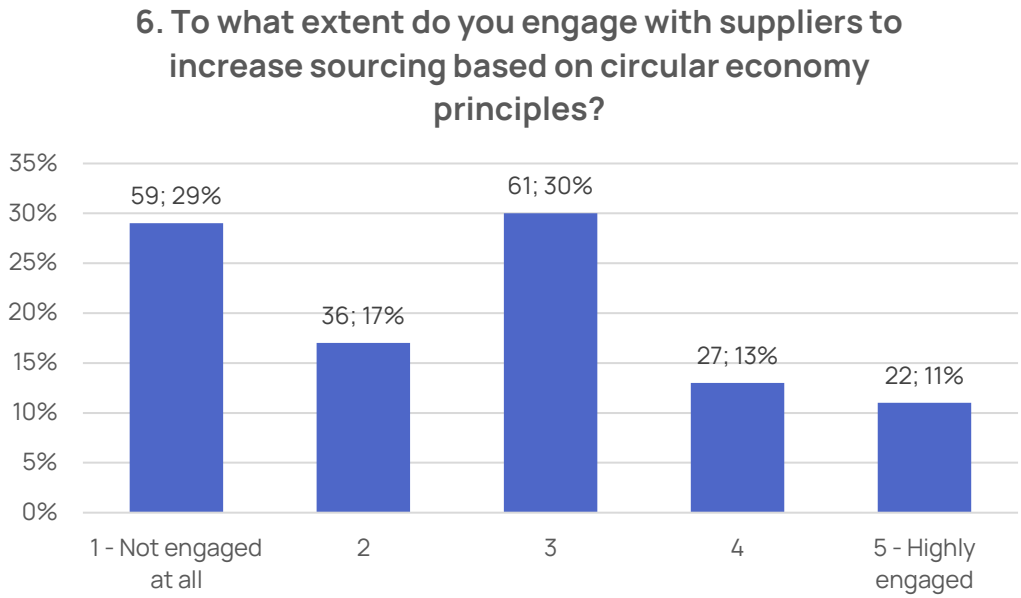

Figure 43. Bar chart (frequency and relative frequency) of Question 6 (Part B)

In terms of demographics, the level of engagement of a company with its suppliers to increase sourcing based on CE principles does not seem to depend on the

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location of the company, the number of its operating years, and the field where the company operates in. However, there seems to be statistically significant evidence that the bigger the company is the higher the level of CE-related engagement with its suppliers, i.e., companies with more than 50 employees appear to be moderately to highly engaged with their suppliers as regards the adoption of CE-related principles in sourcing than smaller companies do, $x^2(4, N = 205) = 10.9$, $p = 0.03$; the relative frequency of the companies moderately/highly engaged with their suppliers are 48%, 55%, and 88% for companies with 0-10, 11-50, and >50 employees, respectively. This is also the case with companies of annual revenues higher than 2.000.000€, which are also associated with moderate/high CE-related engagement with their suppliers compared to companies with lower annual revenue (lower than 2.000.000€), $x^2(4, N = 205) = 9.3$, $p = 0.05$; the respective percentages are 45%, 59%, and 77% for companies with <500.000€, 500.000-2.000.000€, and >2.000.000€ annual revenue, respectively.

The contingency tables associated to the statistically significant results are presented in detail in Annex 3, Table 38 to Table 39).

4.3.2.7 Customers' pressure towards a Circular Economy transformation

Customers' pressure for CE. With respect to the relationship with their customers, one-fifth of the companies (21%) appear to be highly pressured by their customers to make their company more Circular (i.e., scores 4 and 5 of the respective Likert-type scale). For 31% of the companies, the pressure put on them by customers to become more CE-friendly is rather moderate. Finally, approximately half of the companies (49%) feels low pressure or no pressure to enhance its Circular Economy related profile and actions (i.e., scores 1 and 2 of the respective Likert-type scale). Frequencies and relative frequencies of the responses are presented in the bar chart of Figure 44.

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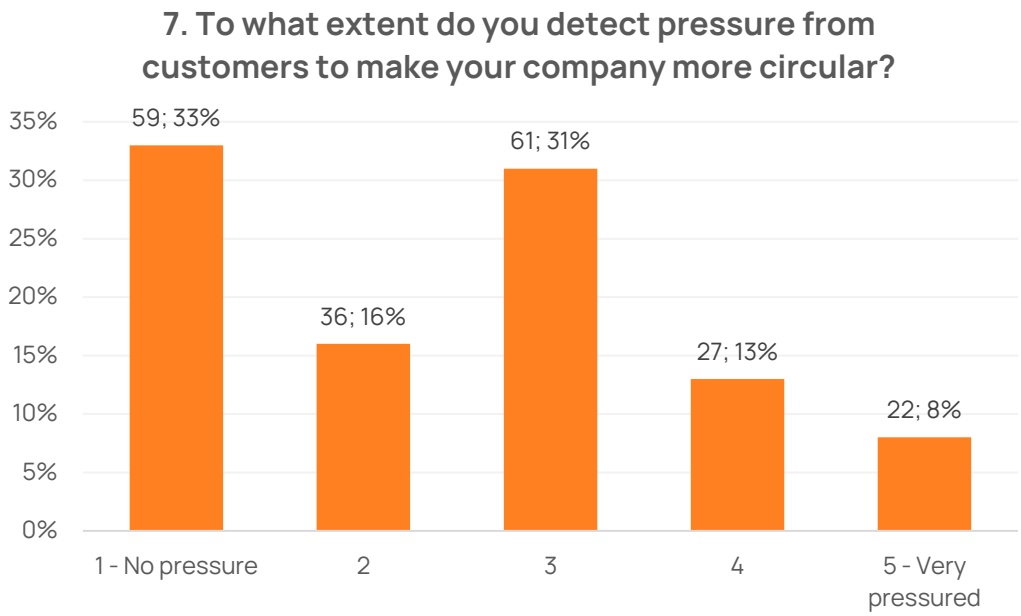

Figure 44. Bar chart (frequency and relative frequency) of Question 7 (Part B)

In terms of demographics, the level of pressure put on a company by its customers to become more Circular does not seem to depend on the location of the company and the field where the company operates in. On the other hand, the customers' pressure on a company to become more Circular appears to be higher for companies with 5-10 years of operation, and the lowest for the 3-5 years old companies, $x^2(4, N = 205) = 21.3$, $p = 0.01$; the respective percentages of moderate/high pressure are 53%, 27%, 67%, 56%, and 39% for companies with 0-3, 3-5, 5-10, 10-20, and <20 years of operation, respectively. This pressure for CE transformation seems to be higher for bigger companies (>50 employees), $x^2(4, N = 205) = 16.3$, $p < 0.01$; the relative frequency of the companies that are moderately/highly pressured by their customers 46%, 53%, and 88% for companies with 0-10, 11-50, and >50 employees, respectively. The pressure put by customers to make the company more Circular is also higher for companies of annual revenues higher than 2.000.000€, and lower for small companies (annual revenue lower than 500.000€), $x^2(4, N = 205) = 16.6$, $p < 0.01$; the respective percentages for moderate/high pressure are 42%, 58%, and 77% for companies with <500.000€, 500.000-2.000.000€, and >2.000.000€ annual revenue, respectively.

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The contingency tables associated to the statistically significant results are presented in detail in Annex 3, Table 39 to Table 42).

4.3.3 Clustering of companies

This paragraph aims to capitalize on the data collected in order to group the companies that participated in the study in clusters of similar characteristics/attributes, in an effort to build a set of Circular Economy profiles for the companies, and thus offer a better understanding of the Circular Economy status of the companies located and operating in the Greek region. As regards the selection of the optimal number of clusters to be created, the implementation of the average silhouette width approach indicated an optimal number of four clusters, whereas the implementation of the elbow method appeared to indicate a number of nine clusters (the two graphs are presented in Annex 3, Figure 65 and Figure 66). Therefore, considering the trade-off between the complexity of the interpretation of the outcomes, on the one side, and the assurance of a sufficient resolution level for the analysis and the conclusions drawn, on the other side, a number of six clusters was decided to be created as an efficient compromise between the two criteria.

The results of the respective K-Modes clustering algorithm, along with the necessary interpretation of the outcomes, are summarized in Table 5.

Table 5. Extraction of the main Circular Economy group profiles of the companies located and operating in Northern Greece based on K-Modes cluster analysis

Attribute	Group #1	Group #2	Group #3	Group #4	Group #5	Group #6
Cluster size	38	40	41	31	25	28
Location	Other (mostly) +	Other + Thessaloniki	Thessaloniki	Thessaloniki	Thessaloniki	Thessaloniki

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	Thessaloniki					
Years of operation	Mixed	> 10	5 - 20	0 - 50 + 10 -20	> 10	> 10
Field of operation	Production (mostly)	Processing (mostly) + Production + Logistics	Service Providing (mostly) + Production + Logistics	Service Providing (mostly) + Processing	Processing + Service Providing + Packing	Production
Number of employees	0 - 10	Mixed	0 - 50	0 - 10	11 - 50	0 - 10
Annual revenue	< 500.000 €	Mixed	< 500.000 €	< 500.000 €	500.000 € - 2.000.000€	< 500.000 €
CE strategy	Low	Moderate	Moderate	Low (mostly) + Moderate	Low	Low
CE assessment	No	No (mostly) + Yes	Yes	No	No	No

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CE training	No	No (mostly) + Yes	Yes + No	No	No	No
Suppliers CE-related issues	Low	Moderate	High (mostly) + Moderate	Low	Low	Low
Customers' pressure on CE issues	Low	Moderate	High (mostly) + Moderate	Low	Low	Low (mostly) + Moderate
Implementation of general CE measures	Low	High	High (mostly) + Moderate	Low	High	High
Implementation of energy-related CE measures	Low	High	High (mostly) + Moderate	Low	High + Moderate	High
Implementation of water-	Low	High (mostly) +	Low	Low	Low (mostly) + High	High

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related CE measures		Moderate				

A brief description of the six group profiles is presented in the following paragraphs.

Group/Profile #1. This group mostly includes small-sized producers, from new companies to mature ones, that are mainly located in the wider area of Central-East Macedonia. In general, companies in this group do not consider CE priorities as part of their strategic plans. The assessment of their environmental impact is very limited or there is no assessment at all, while they do not provide any training opportunities to their employees on Circular Economy issues. The pressure by their customers for CE transformation is low, as well as their engagement with suppliers to increase sourcing based on CE principles. The members of this group do not implement any kind of CE-related measures.

Group/Profile #2. This group includes companies of different size and annual revenue mostly originating from the processing industry, while it also includes companies which operate in production and logistics. The companies are located all over Central-East Macedonia, including the municipality of Thessaloniki. The companies of this group usually do consider CE priorities during their strategic planning. However, most of them do not perform any kind of assessment of their environmental impact, and also they do not provide training sessions to their personnel on Circular Economy issues. They are moderately engaged to their suppliers to increase sourcing based on CE principles, and at the same time, they feel moderate pressure by their customers as regards their transformation towards a more Circular Economy friendly organization. The companies of this group appear to implement basic circular Economy measures of different types, i.e., generic, energy-related, and also water-related CE measures, to a certain extent.

Group/Profile #3. This group mainly includes small-sized and relatively mature service providers, as well as production and logistics companies that are located in

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the municipality of Thessaloniki. In these companies, Circular Economy priorities are considered as part of their strategic planning. The companies in this particular group have established mechanisms for assessing their environmental impact and they offer training sessions on circular Economy to their employees. They are quite highly engaged to their suppliers to increase sourcing based on CE principles, whereas they feel quite high pressure by their customers with respect to their CE transformation process. These companies implement generic and energy-related CE measures to a certain extent, but their water-related policies are rather weak, if there are any.

Group/Profile #4. This group includes small-sized companies, either at their first steps or of middle age, which are mainly service providers and processing industries located in the municipality of Thessaloniki. For a limited number of companies in this group, CE priorities are part of their strategic plans, however, they perform very limited or no environmental impact assessment and training actions. The companies in this group does not feel significant CE-related pressure by their customers, and also their engagement with suppliers to increase sourcing based on CE principles is very low. The members of this group do not implement any kind of CE-related measures.

Group/Profile #5. This group mostly includes medium-sized and relatively mature companies operating mainly in the processing industry, as well as service providing and packing companies, located in the municipality of Thessaloniki. In these companies, CE priorities are not usually part of their strategic plans, and they have very limited environmental impact assessment and training actions. The companies in this group does not feel significant CE-related pressure by their customers, and also their engagement with suppliers to increase sourcing based on CE principles is low. The members of this group appear to implement generic and energy-related CE measures to a certain extent, whereas the picture as regards the water-related measures is mixed, with most of the companies not implementing such measures.

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Group/Profile #6. This group includes mainly small and relatively mature production companies located in the municipality of Thessaloniki. In these companies, CE priorities are not usually part of their strategic plans, and they have very limited CE assessment and training actions. Their engagement with suppliers to increase sourcing based on CE principles is low, whereas the pressure by customers as regards CE issues is low to moderate. However, according to their responses, most of them appear to implement generic, energy-related and water-related CE measures to a certain extent.

4.4 Discussion

A sample of 205 companies in total was examined in the survey, where both genders were sufficiently represented. Most of the participants were aged between 25 and 54 years old, holding either a College/University degree or a Master's/PhD degree. Half of the respondents were freelancers or owners of the company, and half of them were employees.

The companies were mainly located in the broader area of the municipality of Thessaloniki. Half of them were either starting companies or they had an operating history of up to 10 years. Most of the companies were either producers, service providers, or they were involved in processing activities; companies involved in the logistics, trading, and packing industries were also included in the sample. Most of the companies were small sized with less than 10 employees, and also most of them had an annual revenue lower than 500.000€.

Recyclable waste is the most popular type of waste among companies, followed by organic, solid, and liquid waste, which are met less frequently, while the cases of hazardous waste were limited, probably due to the nature of the Agri-food industry. As expected, the type of waste was found to be associated with the type of the industry that a company operates in. For example, production and processing industries are the two main producers of organic waste. Recyclable waste was popular among all types of industries. As a result, the future of CE in this sector hides within facing these types of waste.

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At the strategic level, the Circular Economy profile of the companies appears to be weak, given that most of the companies do not have their strategy aligned with Circular Economy and they do not include any of the Circular Economy concepts and practices among their strategic priorities. Only a minority of the companies consider Circular Economy priorities as part of their strategic planning. However, many of them mentioned some relevant concepts as part of their strategic plans. In general, bigger companies, in terms of the number of employees and revenues, appear to set CE-related strategic priorities more often compared to small business. The pressure put by customers towards the CE transformation of the companies seems to be a motivation for the strategic enhancement of their Circular Economy content. Companies that do include CE priorities as part of their strategic plans are more often engaged with suppliers towards increasing sourcing based on CE principles.

In general, the implementation level of Circular Economy measures is low among companies. The generic CE measures are the most popular ones, exhibiting an average implementation rate of approximately 20%. The recycling of waste is the most widely implemented measure among the generic CE good practices. The energy-related CE measures have an implementation rate of 12% on average. Energy consumption monitoring is the energy-related CE solution of choice. The average percentage of companies that implement each measure within the water-related CE group of measures is only 6%. However, many companies appear to be interested in implementing Circular Economy measures in near future, though not currently implementing any of them. In several cases, the respondents think that some of the measures are not applicable to their business.

In terms of the assessment of their environmental impact, approximately one out of three companies employ some kind of procedures to assess this impact, e.g., via life cycle analysis, environmental footprint, etc. This means that most of the companies do not assess their environmental impact, and this may be caused due to lack of information and/or unavailability of easy-to-access tools. The

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assessment of the environmental impact is positively related to the size and the revenues of a company. Companies that include CE-related priorities to their strategic plans, and also companies that feel their customers' pressure to become more CE friendly, as well as companies with a high level of engagement with their suppliers in terms of CE-related issues, appear to have a higher probability of implementing some kind of assessment as regards their environmental impact.

As regards the training on Circular Economy issues, only one out of four companies offer this opportunity to its personnel. This training is either provided by an external organization, or it is internally performed, and it may either be mandatory or not. In most of the cases, when training is available, all levels of employees have access to the associated sessions. The highest percentage of companies that offer CE-related training sessions is observed in Trading and the lowest one in Production industries. As regards the impact of varied factors on the training availability for a company, the remarks that could be made are similar to the case of the environmental impact assessment. i.e., training in CE issues appears to be positively related to the size and the revenues of a company, to the level of inclusion of CE-related priorities in its strategic planning, as well as to the pressure put by customers towards a CE transformation of the companies, and the level of the CE-related engagement with their suppliers.

The engagement of the companies with their suppliers to increase sourcing based on Circular Economy principles is – in general – low to moderate. Though, companies with more employees and higher revenues appear to be more heavily engaged with their suppliers for CE sourcing purposes. Moreover, the pressure "to become more Circular" put on companies by their customers is low to moderate. This pressure for a Circular Economy transformation increases for bigger companies, i.e., for companies with more employees and higher revenues.

Finally, three basic axes of Circular Economy behaviour can perhaps be shaped based on the outcomes of this survey, i.e., (i) companies that are not aware of the Circular Economy concept and do not implement any kind of CE actions as part of

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their strategic planning and operations, (ii) companies that do not include CE priorities in their strategic planning, and generally are not highly involved with the Circular Economy concept but they do implement several CE-related measures within the context of their operations, and (iii) companies that are aware of the circular Economy concepts and practices and they consciously implement CE-related measures and solutions moving towards their CE transformation.

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5 The Status Quo of Circular Economy Practices and their Environmental Impact in Bulgaria

5.1 Methodology

The analysis is based on a survey conducted among Bulgarian companies from the farming, food, and beverage sectors. The companies included in the survey operate on the Bulgarian market and have different activities. The study has applied statistical, sociological, and analytical methods. The aim of the survey is to get an idea about the attitude of the Bulgarian companies to transform and apply the principles of circular economy.

The leading hypothesis of the survey is that majority of the Bulgarian employers have a very general idea of the advantages of the circular economy and underestimate its possibilities. SMEs are severely hampered in the implementation of innovative, environmentally friendly, and resource-efficient technologies, which worsens their future competitiveness. The role of the state in creating positive governance attitudes for the implementation of the principles of circular production is needed. Industrial symbiosis is already applied by some individual enterprises in Bulgaria, but there is no targeted state policy. The survey covers 307 companies.

The primary information is received through questionnaires covering a total of 31 questions. The other questions concern general information about the company activity. All surveys are electronically filled in. The participants in the survey are marketing directors, managing managers, business owners or department directors.

The task was to gather primary empirical information on enough companies from farming, and food and beverage sectors, allowing adequate conclusions to be drawn about the level of the application of the principles of circular and green economy in Bulgaria. The criteria for the selection of the companies are the number

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of employees and the nature of the activity (sector in which the company operates).

Another part of the questions is aimed at gathering information about the existence of environmentally responsible practices, including conducting an internal company policy for the use of environmentally friendly technologies and leading to resource savings. We received responses from 51 companies.

5.2 Analysis of surveys

5.2.1 Part A: General Information

5.2.1.1 General information of respondents

Gender

Table 6. "What is your gender?" results

	Frequency	Percent	Cumulative Percent
Woman	63	54.78%	55%
Man	52	45.22%	100%
Total	115	100.00%	

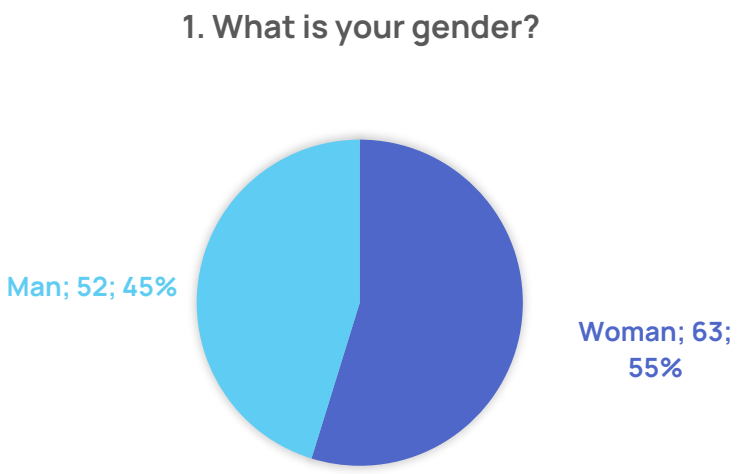

Figure 45. Frequency and relative frequency of the gender of the respondents (Part A: Question 1)

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Age

Table 7. "In which of the following age groups do you belong?" results

	Frequency	Percent	Cumulative Percent
18-24	5	4.35%	4%
25-34	15	13.04%	17%
35-44	32	27.83%	45%
45-54	31	26.96%	72%
55-64	24	20.87%	93%
>65	8	6.96%	100%
Total	115	100.00%	

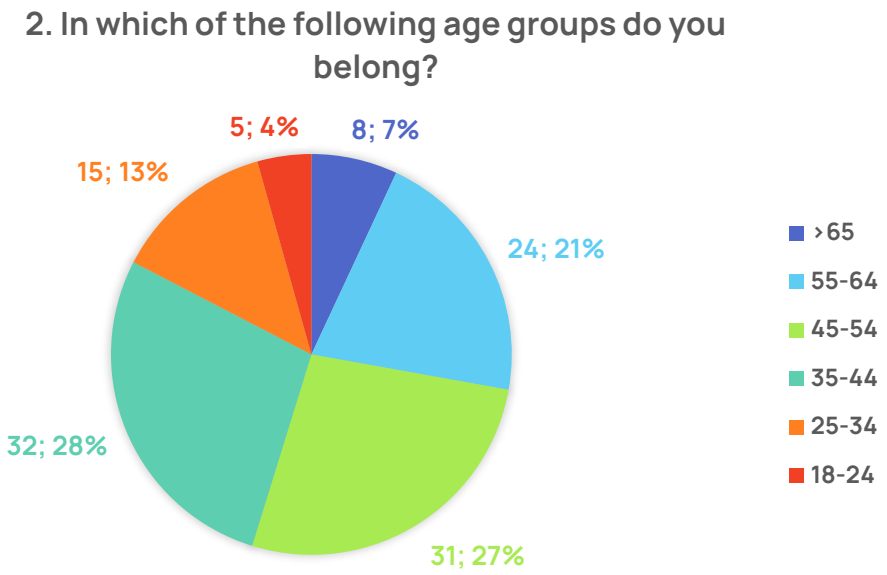

Figure 46. Frequency and relative frequency of the age of the respondents (Part A: Question 2)

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Education

Table 8. "What is the highest degree or level of education you have completed?" results

	Frequency	Percent	Cumulative Percent
Elementary	4	3.48%	3%
High School	30	26.09%	30%
Lyceum	1	0.87%	30%
Trade/technical/vocational training	19	16.52%	47%
College/University	42	36.52%	83%
Master's or higher	19	16.52%	100%
Total	115	100.00%	

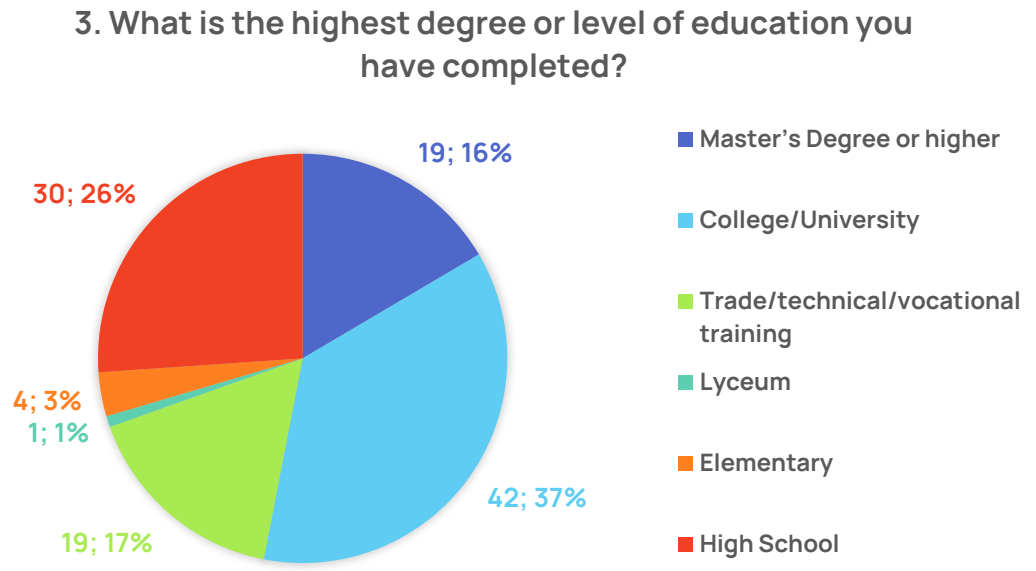

Figure 47. Frequency and relative frequency of the educational level of the respondents (Part A: Question 3)

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Location

Table 9. "Where is your company located?" results

	Frequency	Percent	Cumulative Percent
Blagoevgrad	85	73.91%	74%
Smoljan	2	1.74%	76%
Khardzali	19	16.52%	92%
Haskovo	9	7.83%	100%
Total	115	100.00%	

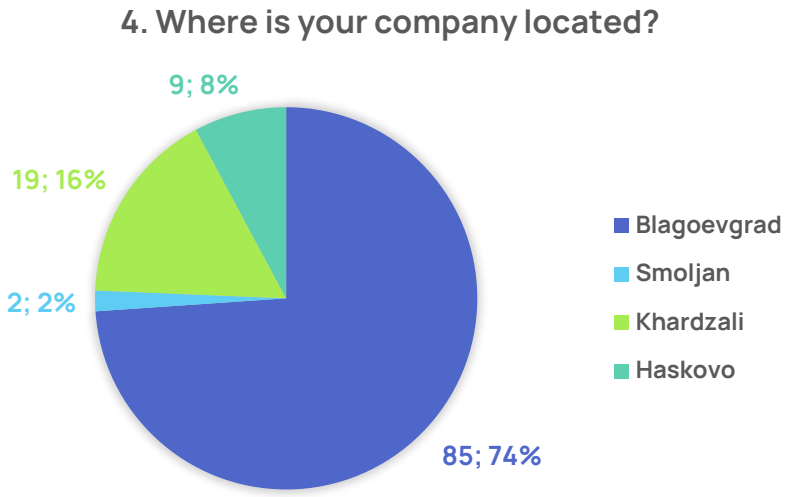

Figure 48. Location of the companies (Part A: Question 4)

Position

Table 10. "What is your current position in the company?" results

	Frequency	Percent	Cumulative Percent
Freelancer	5	4%	4%
Owner	59	51%	56%

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Administrative Personnel	31	27%	83%
Technical staff	12	10%	93%
Laborer	8	7%	100%
Total	115	100%	

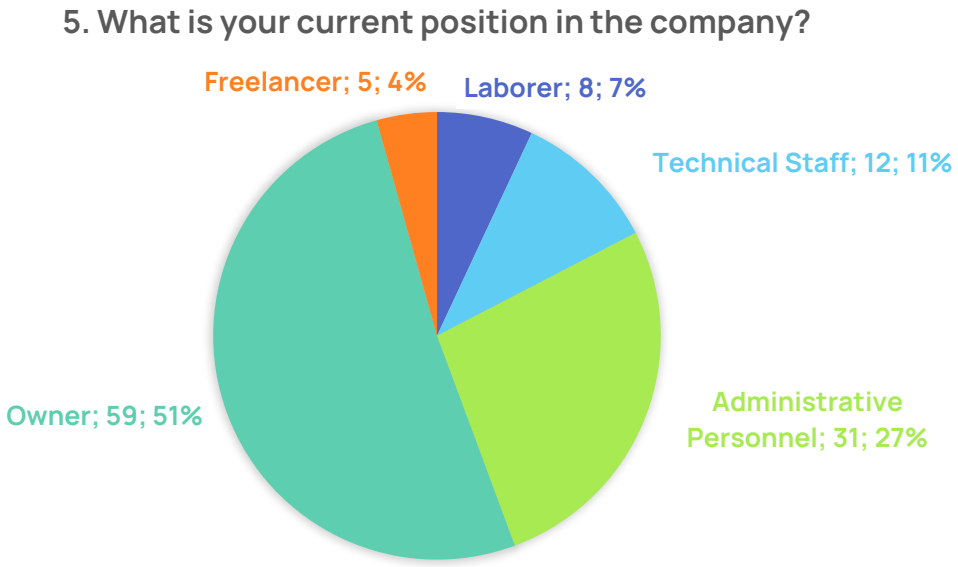

Figure 49. Frequency and relative frequency of the company position held by the respondents (Part A: Question 5)

Years of operation

Table 11. "Years of operation of your company" results

	Frequency	Percent	Cumulative Percent
0-3	14	12%	12%
3-5	23	20%	32%
5-10	31	27%	59%
10-20	28	24%	83%
20+	19	17%	100%
Total		100%	

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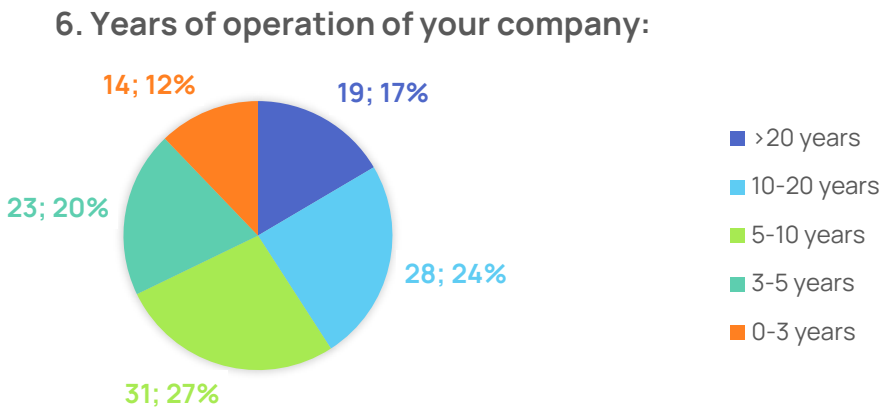

Figure 50. Frequency and relative frequency of the number of operating years of a company (Part A: Question 6)

Operational field

Table 12. "In which field of the Agri-food industry does your company operate in?" results

	Frequency	Percent	Cumulative Percent
Production	77	37%	37%
Packing	28	14%	51%
Processing	25	12%	63%
Logistics	21	10%	79%
Trading	41	20%	93%
Service providing	15	7%	100%
Total	207	100%	

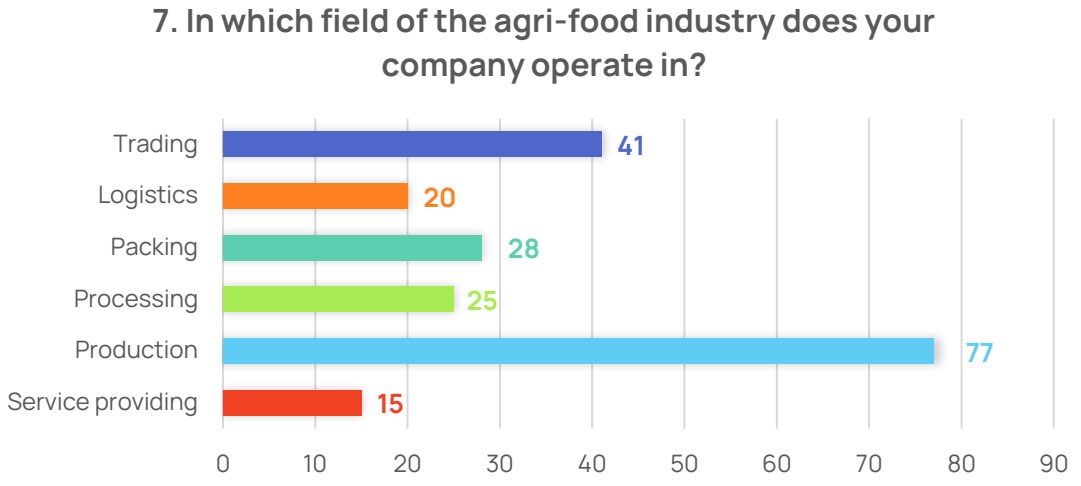

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Figure 51. Frequency and relative frequency of the operational field of the companies (Part A: Question 7)

Number of employees

Table 13. "How many employees are currently employed in your company?" results

	Frequency	Percent	Cumulative Percent
0-10	86	75%	75%
11-49	26	23%	97%
50-100	3	3%	100%
101-250	0	0%	100%
Total	115	100%	

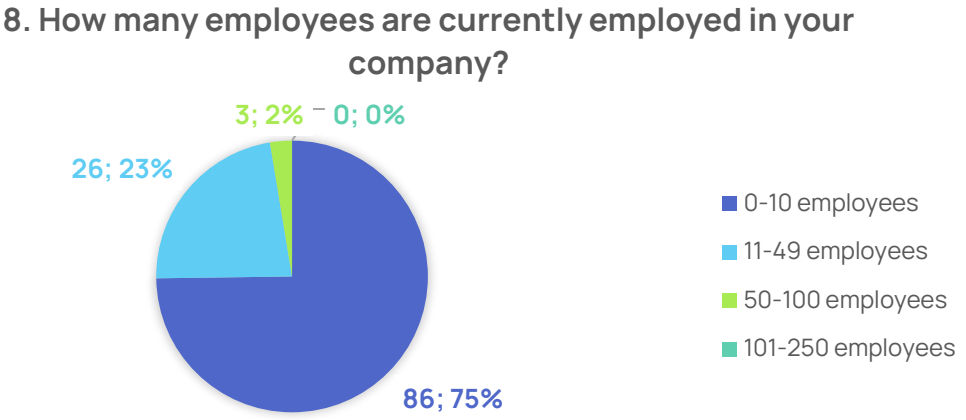

Figure 52. Frequency and relative frequency of the number of employees of the companies (Part A: Question 8)

Annual Revenue

Table 14. "What is the annual revenue of your business?" results

	Frequency	Percent	Cumulative Percent
<500.000€	74	64%	64%
2.000.000€-10.000.000€	29	25%	90%
500.000€-2.000.000€	3	3%	92%
>10.000.000€	0	0%	92%

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Don't know/no opinion	9	8%	100%
Total	115	100%	

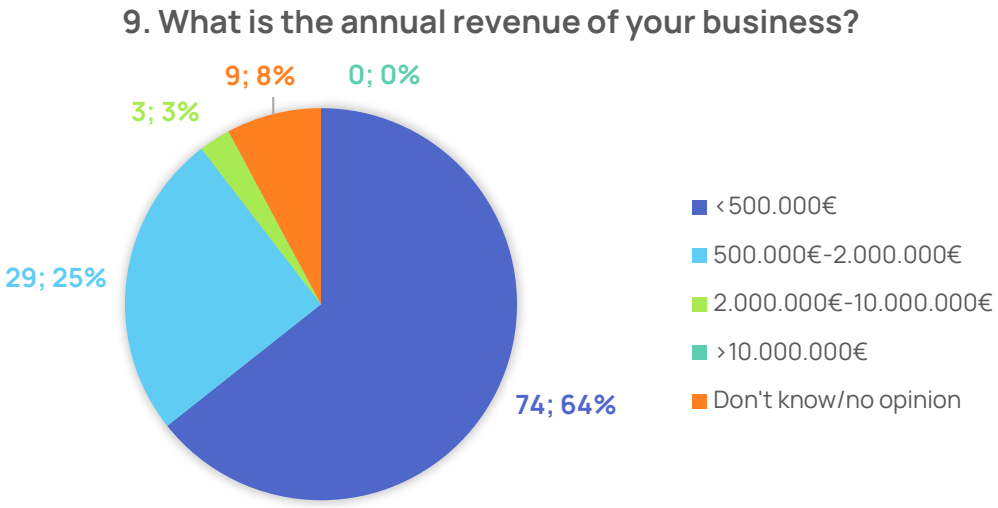

Figure 53. Frequency and relative frequency of the annual revenue of the companies (Part A: Question 9)

5.2.2 Part B: Circular Economy and Environmental Impact (D.3.2)

5.2.2.1 Type of waste

Type of waste. The companies participated in this study have mostly organic waste waste (i.e., biodegradable materials from either a plant or an animal) (36%) (Figure 54). Some of them also appear to have – though to a slightly lesser extent, recyclable waste and liquid waste (e.g., wastewater, dirty water, grease or oil, sludges, waste detergents) at 24%, while solid waste (i.e., glass and ceramics, plastic, paper, metals, and tins that are not being recycled) is at 14%. Perhaps due to the nature of the agri-food sector, just a minority of the companies that responded to this question (2 %) appear to have hazardous waste (e.g., flammable, corrosive, toxic and reactive materials, dangerous or potentially harmful to human health or the environment).

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Table 15. "Which of the following types of waste does your company have? (more than one answer is possible)" results

	Frequency	Percent	Cumulative Percent
Recyclable waste	58	22%	22%
Organic waste	86	33%	55%
Liquid waste	59	23%	78%
Solid waste	51	20%	98%
Hazardous waste	4	2%	100%
Total	**258**	**100%**	

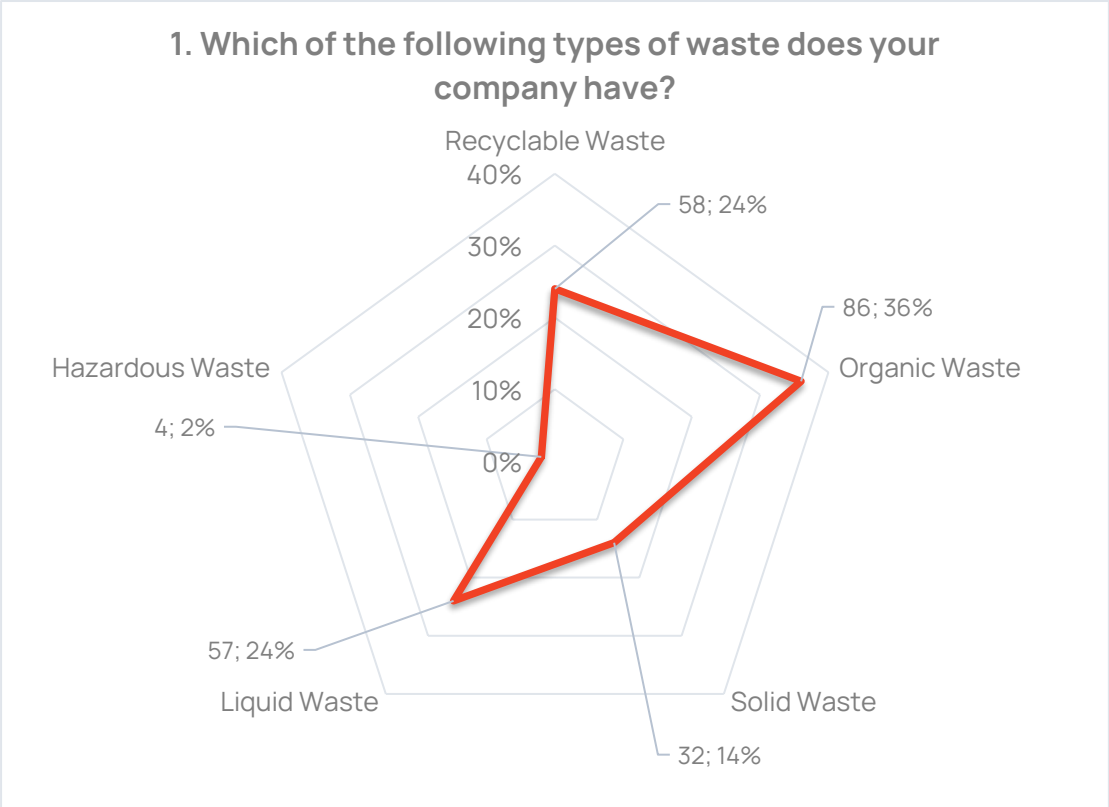

Figure 54. Radar chart (frequency and relative frequency) of Question 1 (Part B)

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5.2.2.2 Circular Economy and strategic priorities

The location of a company, the number of years in business, as well as the field that the company operates in, do not seem to have a significant impact on whether a company aligns its strategy with becoming more Circular, or not. On the other hand, it seems that bigger companies, i.e., companies with more than 50 employees, mention Circular Economy more frequently as part of their strategic priorities than smaller companies do, i.e., companies with less than 50 employees, $x^2(6, N = 115) = 38.011$, $p < 0.01$; the relative frequency of the companies that do consider explicitly CE priorities as part of their strategic plans are 2.4%, 0%, and 33.3% for companies with 0-10, 11-50, and >50 employees, respectively. This is also the case with companies of annual revenues higher than 2.000.000€, which are also associated with higher prioritization of CE concepts and practices as part of their strategic planning compared to companies with lower annual revenue (lower than 2.000.000€), $x^2(46, N = 115) = 16.284$, $p = 0.012$; the respective percentages are 4.1%, 0%, and 33.3% for companies with <500.000€, 500.000-2.000.000€, and >2.000.000€ annual revenue, respectively.

Table 16. "Is your strategy aligned with becoming more circular?" results

	Frequency	Percent	Cumulative Percent
No relevant mentions of circular economy	103	89.57%	89.57%
Relevant concept mentioned as part of strategic priorities	8	6.96%	96.52%
Circular economy explicitly mentioned as part of strategic priorities	4	3.48%	100.00%
Total	115	100.00%	

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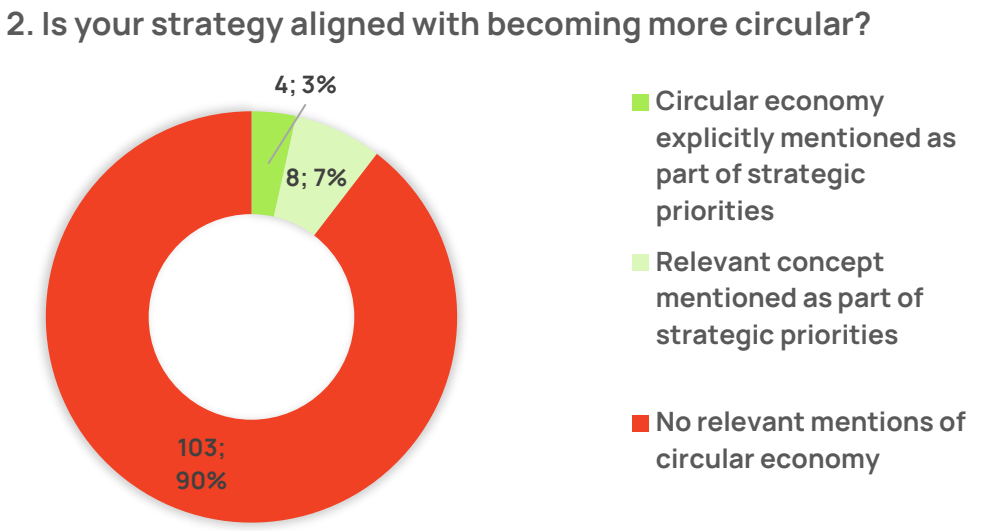

Figure 55. Pie chart (frequency and relative frequency) of Question 2i (Part B)

5.2.2.3 Circular Economy measures

Generic CE measures. The average percentage of implementation for a measure that belongs to this generic CE group of measures is as low as 16%. At the same time, on average, 30% of the companies stated that they are interested in implementing such measures, though not currently implementing any of them. It is worth mentioning that approximately more than half of the respondents (54%) think that such measures are not applicable to their business, which could also bring light as to why CE has not yet been adopted by many companies in Bulgaria.

The utilization of reused and recycled inputs is the most popular measure among the generic CE good practices that have been included in the questionnaire, given that this measure has been already adopted and is being implemented by 29% of the companies. The use of use of biofertilizers then follows, being implemented by one-fourth (26%) of the companies, which makes sense since 1/3 (67%) of the companies are in production, while the recycling waste (either of packaging or other sources of waste) and repurpose of waste (i.e., use of waste to produce another product) are coming close at 23%. Finally, the use of upcycled Inputs (from

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by-products that would have otherwise been wasted) is implemented by 17% of the respondents, while the use of regenerative Inputs (produced in ways to have a positive impact to nature, the design of a waste management plan and the circular product design (i.e., the product is designed along CE principles) are being implemented by around 5% of the companies.

	We are currently implementing such measures		We are interested in implementing such measures		Not Applicable	
	numbers	**%**	**numbers**	**%**	**numbers**	**%**
GENERIC						
Recycle of waste (either of packaging or other sources of waste)	27	23%	42	37%	46	40%
Repurpose of waste (i.e. use of waste to produce another product)	27	23%	37	32%	51	44%
Reused and Recycled Inputs	33	29%	37	32%	45	39%
Use of Regenerative Inputs (produced in ways to have a positive impact to nature)	7	6%	26	23%	82	71%
Use of Upcycled Inputs (from by-products that	19	17%	37	32%	59	51%

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would have otherwise been wasted)						
Design of a Waste Management Plan	6	5%	46	40%	63	55%
Circular Product Design (i.e., the product is designed along CE principles)	0	0%	30	26%	85	74%
Use of Biofertilizers (for production)	30	26%	20	17%	65	57%

Energy-related CE measures. With respect to the energy-related CE measures, the average percentage of companies that implement each measure is as low as 14%, very close the respective ratio for the generic measures (16%). Another 43% of the companies appear to be interested in implementing such measures, though not currently implementing any of them. Similarly to the case of the generic measures, approximately one-third (37%) of the respondents think that such measures are not applicable to their business.

The use of renewable energy resources other than biofuels or energy recovery (e.g., solar or wind power) is the most popular measure among the respective energy-related CE good practices, since 24% of the companies currently implement this measure. The monitoring of the energy consumption then follows, being implemented by 16% of the companies, closely followed by energy recovery from waste at 14%. Use of biofuels and emissions monitoring, are implemented by 8% of the companies.

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	We are currently implementing such measures		We are interested in implementing such measures		Not Applicable	
	numbers	%	numbers	%	numbers	%
ENERGY						
Energy Recovery from waste	16	14%	32	28%	67	58%
Use of Biofuels	9	8%	56	49%	50	43%
Use of Renewable Energy Resources other than biofuels or energy recovery (e.g. solar or wind power)	28	24%	58	50%	29	25%
Energy Consumption Monitoring	18	16%	56	49%	41	36%
Emissions Monitoring	10	9%	28	24%	77	67%

Water-related CE measures. The water-related CE measures appear to have less reach to companies compared to the generic CE and energy-related measures. The average percentage of companies that implement each measure within this group of measures is only 7%, and just another 26% appear to be interested in implementing such measures but does not currently implement one. More than two-thirds of the companies (67%) think that the proposed water-related CE measures are not applicable to their business.

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All water-related measures other than the use of seawater or non-potable water from freshwater areas that are not classified as water-stressed, which none of the companies are currently implementing and only 13% are interested in implementing, have a percentage of implementation of 13% or less. These solutions include the use of water from rainwater harvesting, the cascading use of water (i.e., direct use of untreated wastewater, in a manner that is safe for the environment and human health) and the use of internally recirculated water.

	We are currently implementing such measures		**We are interested in implementing such measures**		**Not Applicable**	
	numbers	**%**	**numbers**	**%**	**numbers**	**%**
WATER						
Use of water from rainwater harvesting	15	13%	41	36%	59	51%
Cascading use of water (i.e.. direct use of untreated wastewater, in a manner that is safe for the environment and human health)	8	7%	32	28%	75	65%
Use of internally recirculated water	10	9%	32	28%	73	63%
Use of seawater or non-potable water from freshwater areas that are not	0	0%	15	13%	100	87%

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classified as water-stressed						
Emissions Monitoring	4	3%	19	17%	92	80%

5.2.2.4 Environmental Impact Assessment

In terms of demographics, the assessment of a company's environmental impact does not seem to depend on the company's location, the number of years in operation, the company's revenues and the field that the company operates in. As regards the impact of the number of employees on the respective decision-making, there is statistically significant evidence that it affects this metric with $x^2(3, N = 115) = 21.016$, $p < 0.01$. The relative frequencies of the companies that assess their environmental impact are 5,9%, 0%, and 33,3%, respectively, for companies with 0-10, 11-50, and >50 employees.

The environmental impact assessment also seems to be related to the company's level of engagement with its suppliers to promote sourcing based on CE principles, since higher frequencies of companies assessing their environmental impact are observed as we move to higher levels of engagement of the companies with their suppliers, $x^2(3, N = 115) = 15.861 < 0.01$; the corresponding percentages of companies that assess their environmental impact are 2.5%, 5%, and 30% for companies with low, moderate, and high level of engagement with their suppliers, respectively. The behaviour of a company as regards its environmental impact assessment seems to also depend on the pressure put by customers on companies to become more Circular, $x^2(3, N = 115) = 13.0$, $p = 0.017$; the respective

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percentages are 3%, 15%, and 25% for companies with low, moderate, and high level of customers' pressure, respectively.

The assessment of the environmental impact appears to also depend on the level of the CE-related strategic planning of the company, since we observe that companies where Circular Economy is explicitly mentioned as part of their strategic priorities are associated to a higher probability of performing environmental impact assessment actions, $x^2(2, N = 115) = 14.286$, $p < 0.01$; the respective percentages are 50%, 0%, and 5% for companies that explicitly mention CE, companies that mention a similar concept and companies that have no relevant mentions of CE respectively.

Table 17. "Does your company assess the environmental impact of its operations (e.g. via life cycle analysis, environmental footprint?" answers

	Frequency	Percent	Cumulative Percent
Yes	7	6.09%	6.09%
No	108	93.91%	100.00%
Total	115	100.00%	

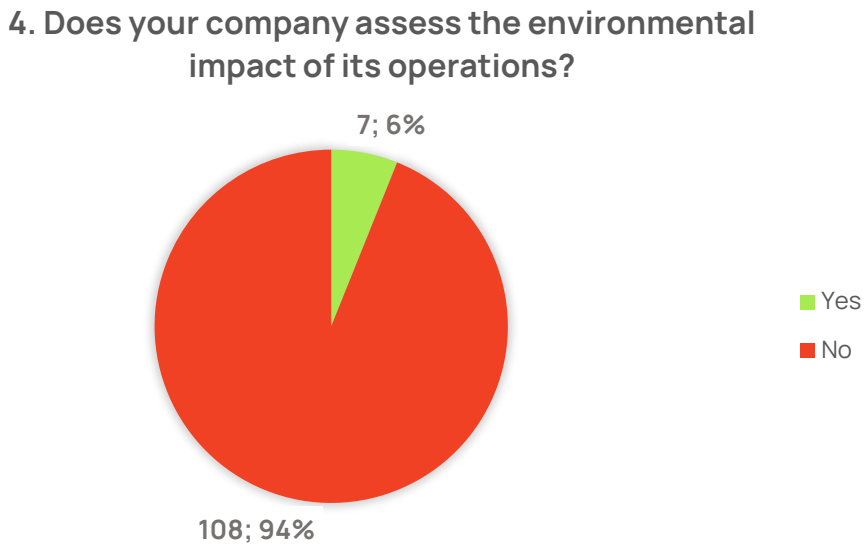

Figure 56. Pie chart (frequency and relative frequency) of Question 4 (Part B)

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5.2.2.5 Circular Economy Training

The location of a company, the number of operating years, the field of operations as well as the size of the company (depending on the number of employees) and the annual revenue of the company do not seem to affect its CE-related training actions. The offer of training sessions also seems to not be related to the level of engagement with suppliers to promote CE-based sourcing, or on the pressure put by customers on companies to become more circular.

The offer for training appears to only depend on the level of the CE-related strategic planning of the company, since we observe that companies where Circular Economy is explicitly mentioned as part of their strategic priorities tend to offer training sessions more frequently, $x^2(2, N = 115) = 9.2$, $p = 0.01$; the respective percentages are 6.8%, 12.5%, and 50% for companies with no mention of CE, mention of a similar concept, and explicit mention of CE in their strategic priorities respectively.

Table 18. "Is circular economy related training offered within your company?" results

	Frequency	Percent	Cumulative Percent
Yes	**10**	**9%**	**1%**
No	**105**	**91%**	**100%**
Total	**115**	**100%**	

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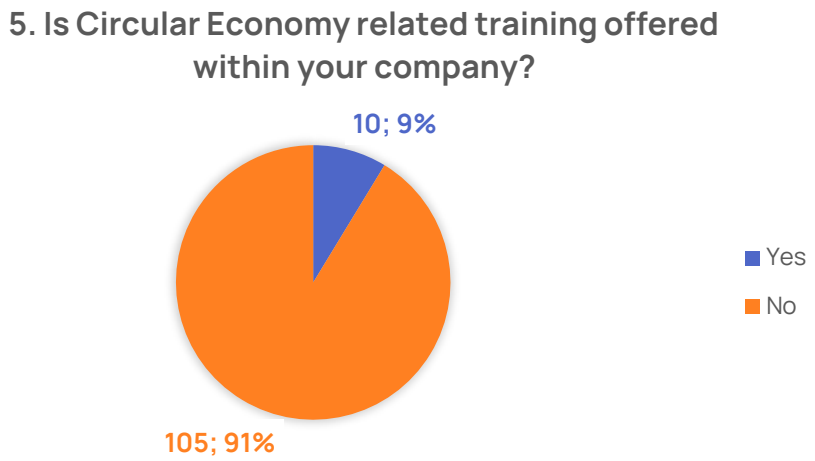

Figure 57. Pie chart (frequency and relative frequency) of Question 5 (Part B)

5.2.2.6 Engagement with suppliers towards Circular Economy

Table 19. "On a scale from 1 to 5, to what extent do you engage with suppliers to increase sourcing based on circular economy principles, with 1 being not engaged at all and 5 being highly engaged?" results

Scale	Frequency	Percent	Cumulative Percent
1	81	70.43%	70.43%
2	19	16.52%	86.96%
3	13	11.30%	98.26%
4	2	1.74%	100.00%
5	0	0.00%	
Total	115	100.00%	

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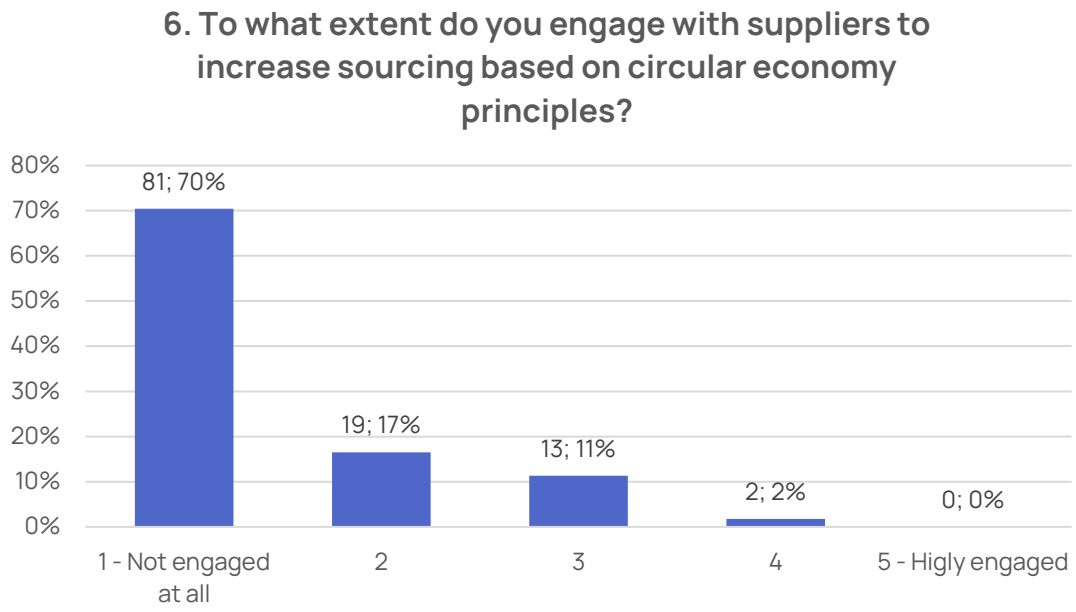

Figure 58. Bar chart (frequency and relative frequency) of Question 6 (Part B)

5.2.2.7 Customers' pressure towards a Circular Economy transformation

Scale	Frequency	Percent	Cumulative Percent
1	68	59.13%	59.13%
2	19	16.52%	75.65%
3	20	17.39%	93.04%
4	8	6.96%	100.00%
5	0	0.00%	
Total	115	100.00%	

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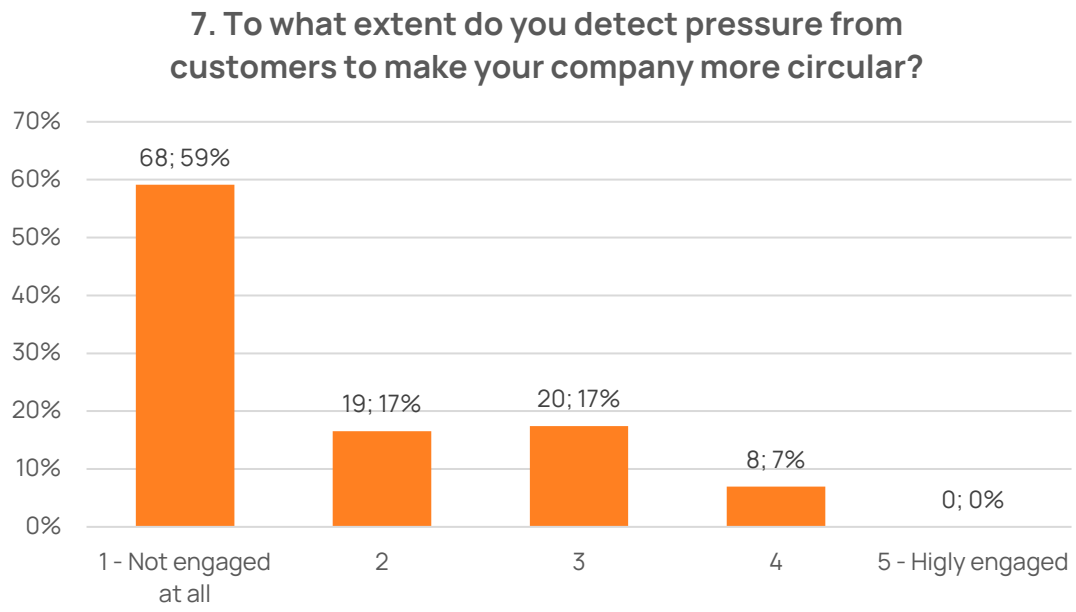

Figure 59. Bar chart (frequency and relative frequency) of Question 7 (Part B)

5.3 Recommendations for the Agri-Food Sector in Bulgaria

The role of the state is to develop policies and ensure the framework, conditions, and confidence of the companies. It is the companies themselves that need to rework the entire supply chain to achieve circularity and efficiency. In order to meet EU's resource efficiency targets by 2030, the transition to a circular economy model should become a state priority. It is not enough only to increase energy efficiency or reduce emissions. It is necessary to extend the concept of reduction in waste and recycling and to bring consumer awareness, to increase the products lifecycle, and to change the relationship between the economic growth and waste production.

The state should promote investment in innovation in circular economy and facilitate the mobilization of more private funding in resource efficiency. Innovations that contribute to reduction in environmental pollution, implementation of environmental products whose production absorbs fewer resources and more efficiently manages resources. Innovations also contribute to

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growth acceleration, and increase in employment, while at the same time create opportunities to overcome the dependence of the economic growth on resource absorption and pollution. Public-private partnerships are also an effective way to attract private investment in resource efficiency.

Setting specific parameters to achieve in the medium-term goals will offer more clarity, security and guarantees for the farms and for the business. Moreover, it would allow for more transparency and certainty for business investors. Setting specific objectives, related to reduction in the share of waste landfilled e.g., by 20% by 2025, or 50%, recycling of plastic waste and gradual replacement of plastic with organic packaging are all steps that can lead to multiple business opportunities and initiatives, including creation of new jobs.

When it comes to SMEs and farms, government policy could be very supportive and engaging. So far, it has mainly come down to the energy efficiency. To achieve a genuine environmental transformation of production models, companies need to be stimulated and co-financed in initiatives related to technological renewal, need to acquire new resource-saving technologies with which waste is minimized, and to deploy waste-free technologies.

In order to be successful, Bulgaria's government authorities and business community need to take several consecutive and dedicated steps:

1. Develop long-term goals and objectives related to CE. They should be more comprehensive and go beyond what has been developed now under the National Waste Management Plan (2014-2020).
2. Launch and promote the idea that the products have a longer lifespan, are suitable for reuse, repair, or recycling. In that direction, the promotion of good practices will mobilize business and will contribute to a faster change in the production models. Adoption of specific targets for development of recycled materials can also mobilize producers.
3. Increase liability requirements for manufacturers to transition to a circular economy.

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4. Promote economic incentives for projects related to technological innovation of processes, new products and materials, leading to the "greening" of the industrial production. There is also the need for more incentives for projects that favor use of fewer resources and allow for a longer life span of the products and easier repair and recycling.
5. Promote investments in key resources and natural capital such as: water, renewable energy, biodiversity and ecosystem services, sustainable agriculture, forests, waste, and recycling. These investments can become areas of future economic growth and unable access to international markets.

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6 Comparison of the current status quo between Greece and Bulgaria

6.1 General Information: difference in respondents' profile

Between the two countries, Greece has a sample of 205 companies, whereas Bulgaria had 115 companies. In Greece, the respondents appeared to be slightly younger in age (between 25 and 54 years old) compared to Bulgaria (where the respondents were aged between 35-64 years old), However, in both countries:

- both genders were sufficiently represented.
- holding either a College/University degree or a Master's/PhD degree.
- half of the respondents were freelancers or owners of the company, and half of them were employees.

The companies were mainly located in the broader area of the municipality of Thessaloniki in Greece (which is understandable given the population in the area in comparison to the other municipalites) and in Blagoevgrad in Bulgaria

In Greece, half of the companies were either starting companies or they had an operating history of up to 10 years, while in Bulgaria the percentage falls at 59%. In both countries of the border area, the companies were from all the fields of operations and most of the companies were small sized with less than 10 employees, and also most of them had an annual revenue lower than 500.000€.

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6.2 Circular Economy and Environmental Impact comparisons in the CB region

6.2.1.1 Type of waste

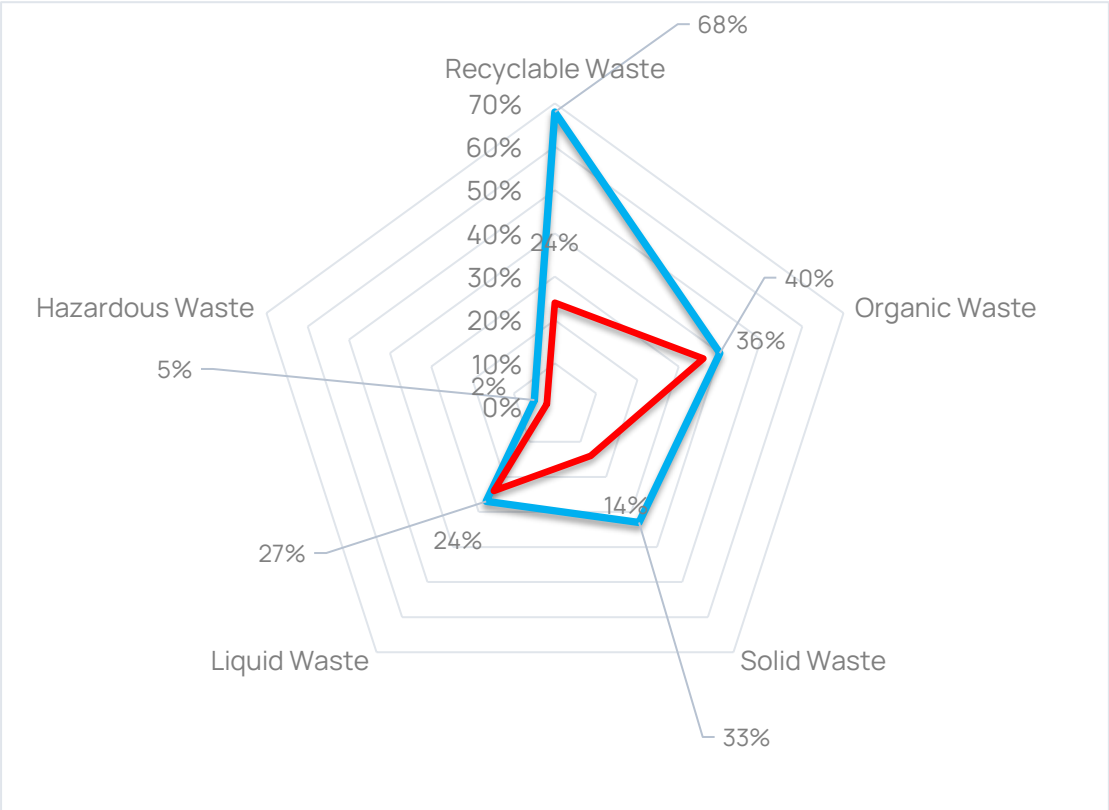

Figure 60. Radar chart (frequency and relative frequency) of Question 1 (Part B): a comparison between Greece (blue) and Bulgaria (red)

In both countries, there seems to be a statistically significant association between waste and the type of company. In Bulgaria, this association is as follows: for recyclable waste $x^2(26, N = 115) = 39.981$, $p = 0.039$, for organic waste $x^2(26, N = 115) = 74.77$, $p < 0.01$, for liquid waste $x^2(26, N = 115) = 44.74$, $p = 0.013$, and for solid waste $x^2(25, N = 115) = 69.108$, $p < 0.01$. Similarly, in Greece, the results per type of waste were for recyclable waste $x^2(4, N = 205) = 17.5$, $p < 0.01$, for organic waste $x^2(4, N = 205) = 68.8$, $p < 0.01$, for liquid waste $x^2(4, N = 205) = 11.1$, $p = 0.05$, and for solid waste $x^2(4, N = 205) = 12.2$, $p < 0.01$.

Some difference between the two countries are that, while Greece appears to have a significant amount of recyclable waste, Bulgaria's rate in this type of waste is

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much smaller (24% versus 68% in Greece), while organic waste takes the lead. However, this may just be that companies In Bulgaria did not consider the recyclable waste's contribution to their waste as important to mention. In overall, recyclable, organic and liquid waste may be the types of wastes CE should be tuckering in the following years.

In Table 20, the waste profile in relation to the field of operation between the two countries is shown. Some important differences between the two countries are:

1) Organic waste is very low for Greek packing , trading and logistics companies in comparison to Bulgarian companies
2) The same applies for liquid waste in Greek logistics, trading and service providing companies.
3) Hazardous waste in production is at 10% for Greece and 0% for Bulgaria.
4) In Bulgarian trading and service providing companies, over 5% have hazardous waste, while the same percentage is 0% for Greek companies.

Due to the relativity of the answers, these differences can be explained by the different understanding of waste between the two countries. The profile of the respondents however is different, so training in waste and what one can do to minimize it could potentially help the sector in both countries.

Table 20. Relative frequency of the companies within each operating field that have the particular type of waste between Greece and Bulgaria

		Type of waste				
Field of operation	**Country**	**Recyclable***	**Organic***	**Liquid***	**Solid***	**Hazardous**
Production	Greece	50%	71%	37%	18%	10%
	Bulgaria	41.6%	96.1%	50.6%	14.3%	0%
Packing	Greece	85%	15%	31%	39%	0%
	Bulgaria	85.7%	78.6%	89.3%	46.4%	3.6%

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Processing	Greece	63%	53%	37%	44%	7%
	Bulgaria	76%	68%	76%	52%	4%
Logistics	Greece	83%	4%	17%	26%	9%
	Bulgaria	70%	40%	80%	60%	15%
Trading	Greece	72%	11%	11%	39%	0%
	Bulgaria	78%	63.4%	63.4%	56.1%	7.3%
Service Providing	Greece	81%	15%	17%	44%	0%
	Bulgaria	66.7%	40%	53.3%	66.7%	6.7%

6.2.1.2 Circular Economy and strategic priorities

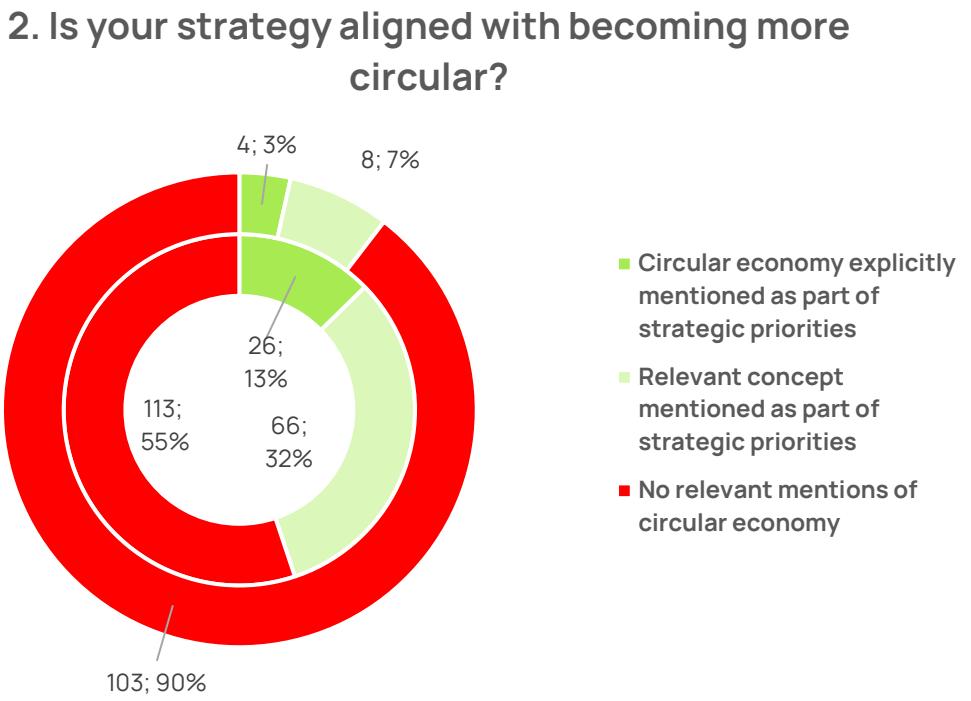

Figure 61. Pie chart (frequency and relative frequency) of Question 2i (Part B): Greece (inner circle) and Bulgaria (outer circle)

At the strategic level, the Circular Economy profile of the companies appears to be weak in both countries, given that most of the companies do not have their

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strategy aligned with Circular Economy and they do not include any of the Circular Economy concepts and practices among their strategic priorities. In Bulgaria, only one out of 10 companies mentions either CE or a relevant concept in their strategic priorities, while in Greece 13 % mention CE specifically, and 32% mention a relevant concept. As a result, Greek agrifood companies appear to have more CE focused strategy.

In general, bigger companies, in terms of the number of employees and revenues, appear to set CE-related strategic priorities more often compared to small business in both cases. In Greece, the pressure put by customers towards the CE transformation of the companies seems to be a motivation for the strategic enhancement of their Circular Economy content., while companies that do include CE priorities as part of their strategic plans are more often engaged with suppliers towards increasing sourcing based on CE principles. However, in Bulgaria, the companies which stated that they feel higher pressure from their customers "to be more Circular" and/or present higher levels of CE-related engagement with their suppliers are, do not necessarily have a more significant impact to whether a company aligns its strategy to become more circular.

6.2.1.3 Circular Economy measures

In general, the implementation level of Circular Economy measures is low among companies in both countries. The generic CE measures are the most popular ones, exhibiting an average implementation rate of approximately 20% for Greece and 16% for Bulgaria, while around 35% of the companies in Greece and 30% in Bulgaria are interested in such measures. It is worth mentioning that approximately more than half of the respondents (54%) in Bulgaria think that such measures are not applicable to their business, which could also bring light as to why CE has not yet been adopted by many companies. The recycling of waste is the most widely implemented measure among the generic CE good practices in Greece, with the same measure scoring much lower in Bulgaria, where the utilization of reused and recycled inputs is the most popular measure.

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The energy-related CE measures have an implementation rate of 12% and 14% on average in Greece and Bulgaria respectively. Energy consumption monitoring is the energy-related CE solution of choice in Greece (second in Bulgaria), while in Bulgaria the use of renewable energy resources other than biofuels or energy recovery (e.g., solar or wind power) is the most popular measure among the respective energy-related CE good practices, since 24% of the companies currently implement this measure. The average percentage of companies that implement each measure within the water-related CE group of measures is very low in both sides of the CB region (just over 5%), while 67% of the Bulgarian companies believe such measure are not even applicable for their companies.

6.2.1.4 Environmental impact assessment

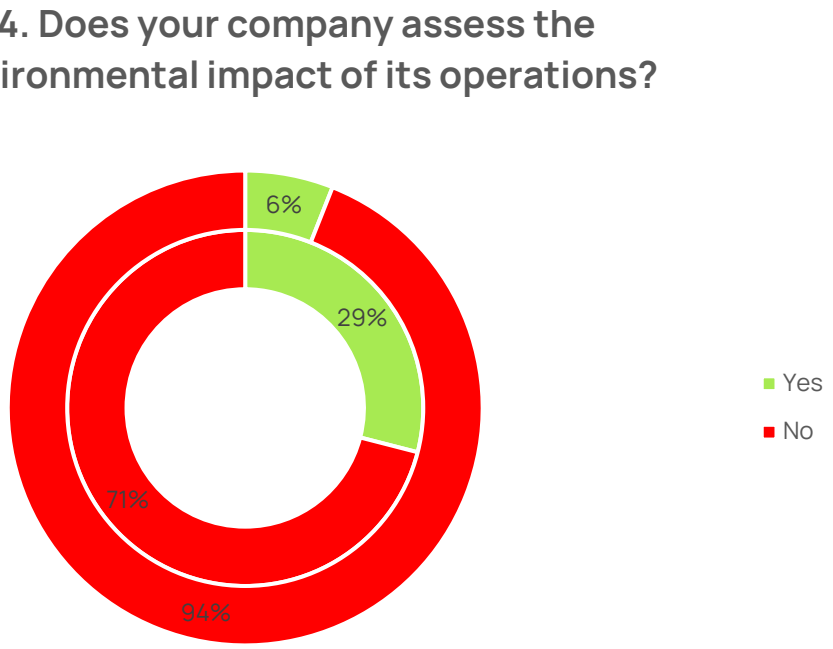

Figure 62. Pie chart (frequency and relative frequency) of Question 2i (Part B): Greece (inner circle) and Bulgaria (outer circle)

In terms of the assessment of their environmental impact, approximately one out of three companies in Greece employ some kind of procedures to assess this impact, e.g., via life cycle analysis, environmental footprint, etc. In Bulgaria, the

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same percentage is much smaller (6%). This means that most of the companies in the CB region do not assess their environmental impact, and this may be caused due to lack of information and/or unavailability of easy-to-access tools. The assessment of the environmental impact is positively related to the size(i.e., number of employees) of a company in both countries. Companies that include CE-related priorities to their strategic plans, and also companies that feel their customers' pressure to become more CE friendly, as well as companies with a high level of engagement with their suppliers in terms of CE-related issues, appear to have a higher probability of implementing some kind of assessment as regards their environmental impact.

6.2.1.5 Circular Economy training

As regards the training on Circular Economy issues, in Bulgaria one in ten companies provide that option, while only one out of four companies offer this opportunity to its personnel in Greece. This training is either provided by an external organization, or it is internally performed, and it may either be mandatory or not. In most of the cases, when training is available, all levels of employees have access to the associated sessions. The following figures provide more analytical insight as to the characteristics of the provided training in both countries. The main difference in the profile of training in the countries is that in Greece there are case that training is available to some levels of employees while in Bulgaria it's either available to all employees or a few specific employees.

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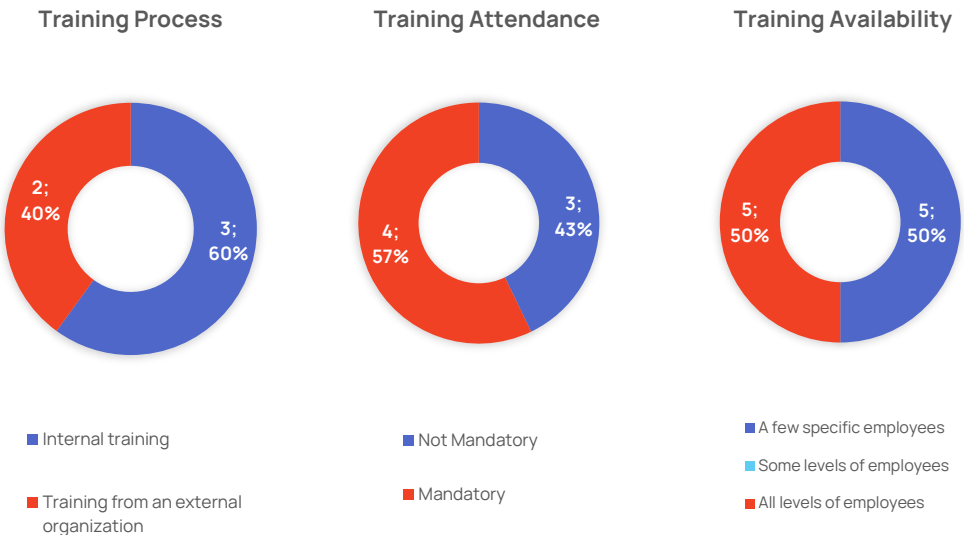

Figure 63. Pie chart (frequency and relative frequency) of Question 5i, Question 5ii, and Question 5iii (Part B) in Bulgaria

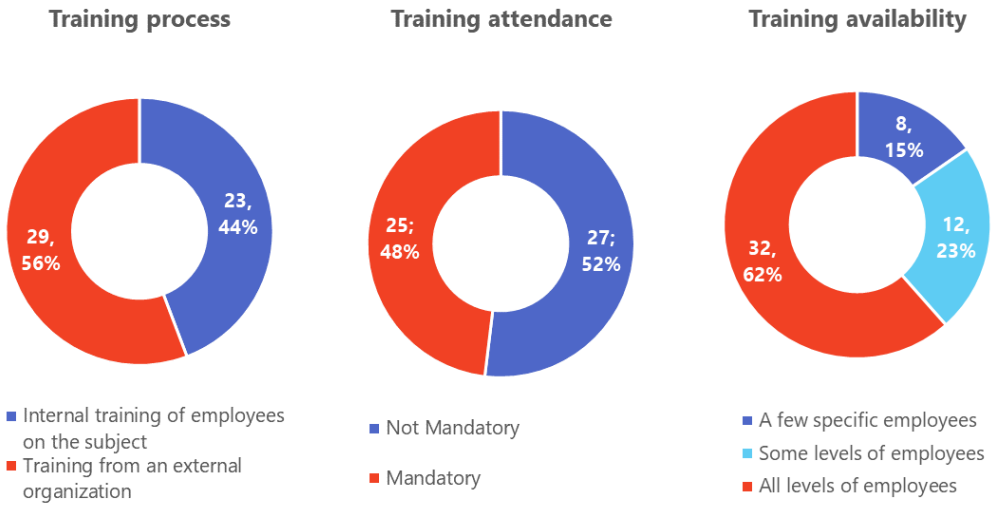

Figure 64. Pie chart (frequency and relative frequency) of Question 5i, Question 5ii, and Question 5iii (Part B) in Greece

As regards the impact of varied factors on the training availability for a company, training in CE issues appears to be positively related to the size and the revenues of a company, to the level of inclusion of CE-related priorities in its strategic planning.

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6.2.1.6 Engagement with suppliers towards Circular Economy and Customers' pressure towards a Circular Economy transformation

The engagement of the companies with their suppliers to increase sourcing based on Circular Economy principles as well as the coustomer's pressure towars a CE transformation is – in general – low to moderate in Greece, while the results are even lower for Bulgaria, with no companies marking these two metrics at 5/5. The results signify that in both sides of the borders, there is work needed to be done with engaging suppliers into sourcing more in a more CE friendly manner, while consumers do not seem to put pressure to the companies, showing a need for a systemic change in the way of thinking in all stakeholders of the supply chain.

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7 Conclusions

This study focused on Circular Economy in the Agri-food Sector in Greece and Bulgaria. The aim was to:

a. Define CE and its purposes in the EU.
b. Capture the uses and environmental impact of CE practices.
c. Record best practices in Greece and Europe that could be applied to companies of the Agri-food Sector in the CB region.
d. Analyze the Status-Quo of such companies regarding CE and the Environment in general.

The goal was to be able to provide CE solutions applicable to the CB area.

As mentioned in the Introduction section of this report, CE has been gaining in importance in Europe, with the EU setting specific relevant goals, and governments, academia and corporations studying, applying and trying to quantify its results to the environment and the economy. At the same time, the Agri-Food sector has always and still is an important aspect of the European economy, with the EU establishing the CAP in order to preserve the natural capital, ensure the sector's sustainability and support the stakeholders.

In the following section, the environmental impact in agrifood companies was discussed, and the relevant farm to fork strategy's implications. The ecological indicators can be a valuable tool to that matter, while the environmental impact of the sector proves to be a significant challenge that needs to be faced. The third section of this study focused on CE applications of the Agri-food sector, in the CB region and Europe, with good practices paradigms being introduced in order to provide a better understanding of CE applications that are already being adopted, as well as what could be adopted. In the fourth section, the survey and its design are first presented in order to provide information on the methodology of the questionnaires, their development and data management. Afterwards, the

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statistical analysis and the analysis of the results depict the current situation in Greece regarding CE and the environment.

The latter can provide us information on the peculiarities and the CE-related gaps in the sector. Some key-findings are:

- Recyclable, organic and liquid waste are found in these companies. However, the type of industry could potentially differentiate the main sources of waste.
- CE appears to not be part of the strategic plan of the companies. This also pointed out a lack of understanding of what CE practices are.
- CE measures' implementation is currently low. In Greece, recycling of waste and energy consumption monitoring were the leading methods in the generic and energy category, while water-related measures had a very low implementation rate in general. In Bulgaria, the use of biofertilizers,, the use of renewable energy resources are the leaders in the first two categories respectively, while again, water measures score very low in application.
- There is interest in implementing several CE practices in the future in both side of the CB region.
- In Bulgaria, many companies believe that many measures are not even applicable to them.
- Most companies do not evaluate their environmental impact. This measurement appears to correspond to the size and revenue of the company, i.e., the bigger size/higher revenue the company has, the higher likability there is for them to evaluate this metric. The respondents who included CE-related priorities to their strategic plan and/or felt the customers pressure to be more circular also more likely to assess their environmental impact.
- Training for the personnel on CE is minimal in both sides of the border, although lower for Bulgaria, with the results showing a corresponding

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driving force for the provided training to that of the environmental impact assessment.

In conclusion, **education** of the stakeholders of what CE is and how it could potentially help a company to not only be more environmentally friendly, but how it can also provide added value to their product. As shown from the results on the good practices of the sector, there are examples of companies that have successfully incorporated CE principles. Energy generation and soil enhancers from organic waste, animal-feed and fertilizers from by-products, animal feed additives from discarded plants and zero-waste policies are some examples of success in the raw material production and processing of agri-food products. During the marketing and distribution stage i.e., where the product is transported to the market and the final consumer, food waste can be minimized by offering it to weaker social groups, while other forms of biowaste can be gathered to be utilized for energy production or other solutions.

At the same time, other forms of waste also need to be dealt with. In Greece, the high percentages of companies with recyclable waste, as well as the lower ones of solid waste that is not recycled, may indicate a need to better design the products in order to ensure packaging is sustainable and optimal, and, wherever possible, biodegradable. Liquid waste is also an important source of waste in both countries, as water shortage and irrigation issues are often present in Greece, thus minimizing it could prevent clean water usage and groundwater pollution. Finally, hazardous waste, although not prevalent, should in any case be avoided, and CE applications could potentially aid, as by-products from waste could replace dangerous materials.

Both countries are in the development stage and the process is slow and inefficient. Among the main obstacles are insufficient awareness about the CE from the farm owners and food plants owners, managers and entrepreneurs; fear of the new, the unknown, and desire to stay on a safe side; insufficient resources for technological innovation and implementation of new, environmentally friendly

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and resource-saving technologies; insufficient motivation; lack of qualified employees. The existing infrastructure and the present business models and technologies, together with the established behavior, keep the economy "attached" to the linear model. The local financial systems often fail to provide investment in innovative and more complex business models, which deters many traditional investors.

In order to intensify the environmental transformation, there should be on a binational level, clear and systematic macroeconomic policies such as development and deployment of innovative, environmentally friendly technologies, change in the logic of the eco-fiscal policy, have more efficient financing of the environmental transition through the introduction of new instruments in the public-private partnership.

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Annex 1: Questionnaire (English)

I. General information

1. What is your gender?

1. Woman
2. Man

2. In which of the following age groups do you belong?

1. 18-24
2. 25-34
3. 35-44
4. 45-54
5. 55-64
6. >65

3. What is the highest degree or level of education you have completed?

1. Elementary
2. High School
3. Lyceum
4. Trade/technical/vocational training
5. College/University
6. Master's Degree or higher

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4. Where is your company located?

*list of selected areas in Greek and Bulgarian part.

5. What is your current position in the company?

1. Freelancer
2. Owner
3. Administrative personnel
4. Technical staff
5. Laborer

6. Years of operation of your company:

1. 0-3
2. 3-5
3. 5-10
4. 10-20
5. 20+

7. In which field of the Agri-food industry does your company operate in?

1. Production
2. Packing
3. Processing
4. Logistics
5. Trading
6. Service providing

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8. How many employees are currently employed in your company?

1. 0-10
2. 11-49
3. 50-100
4. 101-250

9. What is the annual revenue of your business?

1. <500.000€
2. 500.000€-2.000.000€
3. 2.000.000€-10.000.000€
4. >10.000.000€
5. Don't know/no opinion

II. D.3.2 Circular Economy & Environmental Impact

1. Which of the following types of waste does your company have?
    - □ Recyclable waste
    - □ Organic waste (biodegradable materials from either a plant or an animal)
    - □ Liquid waste (e.g. wastewater, dirty water, grease or oil, sludges, waste detergents)
    - □ Solid waste (e.g. Glass and Ceramics, plastic, paper, metals and tins that are not being recycled)

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- □ Hazardous waste (e.g. flammable, corrosive, toxic and reactive materials, dangerous or potentially harmful to human health or the environment)

2. Is your strategy aligned with becoming more circular?
   a) No relevant mentions of circular economy
   b) Relevant concept (e.g. materials circulation, new business models that follow the principles of circular economy, not just resource efficiency) mentioned as part of strategic priorities
   c) Circular economy explicitly mentioned as part of strategic priorities

3. Which of the following CE measures are you implementing or interested/aiming to implement?

	We are currently implementing such measures	We are interested in implementing such measures	Not Applicable
Generic			
Recycle of waste (either of packaging or other sources of waste)	□	□	□
Repurpose of waste (i.e.	□	□	□

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	We are currently implementing such measures	We are interested in implementing such measures	Not Applicable
use of waste to produce another product)			
Reused and Recycled Inputs	□	□	□
Use of Regenerative Inputs (p.roduced in ways to have a positive impact to nature)	□	□	□
Use of Upcycled Inputs (from by-products that would have otherwise	□	□	□

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	We are currently implementing such measures	We are interested in implementing such measures	Not Applicable
been wasted)			
Design of a Waste Management Plan	□	□	□
Circular Product Design (i.e., the product is designed along CE principles)	□	□	□
Use of Biofertilizers (for production)	□	□	□
ENERGY			
Energy Recovery from waste	□	□	□

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	We are currently implementing such measures	We are interested in implementing such measures	Not Applicable
Use of Biofuels	□	□	□
Use of Renewable Energy Resources other than biofuels or energy recovery (e.g. solar or wind power)	□	□	□
Energy Consumption Monitoring	□	□	□
Emissions Monitoring	□	□	□
WATER			
Use of water from rainwater harvesting	□	□	□

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	We are currently implementing such measures	We are interested in implementing such measures	Not Applicable
Cascading use of water (i.e.. direct use of untreated wastewater, in a manner that is safe for the environment and human health)	□	□	□
Use of internally recirculated water	□	□	□
Use of seawater or non-potable water from freshwater areas that are not classified as	□	□	□

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	We are currently implementing such measures	We are interested in implementing such measures	Not Applicable
water-stressed			

4. Does your company assess the environmental impact of its operations (e.g. via life cycle analysis, environmental footprint?

   Yes □

   No □

5. Is circular economy related training offered within your company?

   Yes □

   No □

If yes, please, circle the correct answers:

i. Training Process:
   a) Training from an external organization
   b) Internal training of employees on the subject

ii. Attendance:
   a) Mandatory
   b) Not Mandatory

iii. Training is available:
   a) to all levels of employees
   b) to some levels of employees
   c) to a few specific employees

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6. On a scale from 1 to 5, to what extent do you engage with suppliers to increase sourcing based on circular economy principles, with 1 being not engaged at all and 5 being highly engaged?

   Not at all 1 2 3 4 5 Very Much

7. On a scale from 1 to 5, to what extent do you detect pressure from customers to make your company more circular, with 1 being no pressure and 5 being very pressured?

   Not at all 1 2 3 4 5 Very Much

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Annex 2: Questionnaire (Greek)

I. ΓΕΝΙΚΕΣ ΕΡΩΤΗΣΕΙΣ

1. Ποιο είναι το φύλο σας:

1. Άρρεν

2. Θήλυ

2. Σε ποια ηλικιακή ομάδα ανήκετε;

1. 18-24

2. 25-34

3. 35-44

4. 45-54

5. 55-64

6. >65

3. Ποιο είναι το υψηλότερο πτυχίο ή το επίπεδο εκπαίδευσης που έχετε ολοκληρώσει;

1. Δημοτικό

2. Γυμνάσιο

3. Λύκειο

5. Εμπορική/τεχνική/επαγγελματική κατάρτιση

6. Κολλέγιο/Πανεπιστήμιο

7. Μεταπτυχιακό ή ανώτερο πτυχίο

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4. Σε ποια περιοχή δραστηριοποιείται η επιχείρησή σας;

(*Scroll down list for Greek Part)

1. Θεσσαλονίκη

2. Σέρρες

3. Δράμα

4. Καβάλα

5. Ξάνθη

6. Ροδόπη

7. Έβρος

5. Ποια είναι η τρέχουσα θέση σας στην εταιρεία;

1. Ελεύθερος Επαγγελματίας

2. Ιδιοκτήτης

3. Διοικητικό προσωπικό

4. Τεχνικό προσωπικό

5. Εργάτης

6. Πόσα χρόνια λειτουργεί η εταιρεία σας:

1. 0-3

2. 3-5

3. 5-10

4. 10-20

5. 20+

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7. Σε ποιον τομέα της αγροδιατροφικής βιομηχανίας δραστηριοποιείται η εταιρεία σας;

1. Παραγωγή

2. Συσκευασία

3. Μεταποίηση

4. Εφοδιαστική Αλυσίδα

5. Εμπορία

6. Παροχή υπηρεσιών

8. Πόσους εργαζόμενους απασχολεί αυτή τη στιγμή η εταιρεία σας;

1. 0-10

2. 11-49

3. 50-100

4. 101-250

9. Ποιος είναι ο ετήσιος κύκλος εργασιών της επιχείρησής σας;

1. < 500.000€

2. 500.000€-2.000.000€

3. 2.000.000€-10.000.000€

4. >10.000.000€

5. Δεν ξέρω/δεν έχω γνώμη

II. Π.3.2 Μελέτη Κυκλικής Οικονομίας στο Αγροδιατροφικό τομέα

1. Ποιους από τους ακόλουθους τύπους αποβλήτων έχει η εταιρεία σας;

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□ Ανακυκλώσιμα απόβλητα

□ Οργανικά απόβλητα (βιοαποδομήσιμα υλικά είτε από φυτό είτε από ζώο)

□ Υγρά απόβλητα (π.χ. λύματα, βρώμικο νερό, γράσο ή λάδι, ιλύς, απορρυπαντικά αποβλήτων)

□ Στερεά απόβλητα (π.χ. γυαλί και κεραμικά, πλαστικό, χαρτί, μέταλλα και κονσέρβες που δεν ανακυκλώνονται)

□ Επικίνδυνα απόβλητα (π.χ. εύφλεκτα, διαβρωτικά, τοξικά και αντιδραστικά υλικά, επιβλαβή ή δυνητικά επιβλαβή για την ανθρώπινη υγεία ή το περιβάλλον)

2. Ευθυγραμμίζεται η στρατηγική σας με το να γίνετε πιο κυκλικοί;
   d) Δεν υπάρχει καμία σχετική αναφορά στην κυκλική οικονομία
   e) Αναφορά σε σχετικές έννοιες (π.χ. κυκλοφορία υλικών, νέα επιχειρηματικά μοντέλα που ακολουθούν τις αρχές της κυκλικής οικονομίας και όχι μόνο της αποδοτικότητας των πόρων) ως μέρος των στρατηγικών προτεραιοτήτων
   f) Η κυκλική οικονομία αναφέρεται ρητά ως μέρος των στρατηγικών προτεραιοτήτων

3. Ποιο από τα ακόλουθα μέτρα Κυκλικής Οικονομίας εφαρμόζετε ή ενδιαφέρεστε/στοχεύετε να εφαρμόσετε;

	Εφαρμόζουμε ήδη τέτοια μέτρα	Ενδιαφερόμαστε για την εφαρμογή τέτοιων μέτρων	Δεν είναι εφαρμόσιμο
ΓΕΝΙΚΑ			

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Ανακύκλωση αποβλήτων (είτε από συσκευασίες είτε από άλλες πηγές αποβλήτων)	□	□	□
Επαναχρησιμοποίηση αποβλήτων (δηλαδή χρήση αποβλήτων για την παραγωγή άλλου προϊόντος)	□	□	□
Επαναχρησιμοποίησιμες και ανακυκλώσιμες εισροές	□	□	□
Χρήση αναγεννητικών εισροών (που παράγονται με τρόπους που έχουν θετικό αντίκτυπο στη φύση)	□	□	□
Χρήση εισροών αναβαθμιστικής ανακύκλωσης (από υποπροϊόντα που διαφορετικά θα είχαν σπαταληθεί)	□	□	□
Σχεδιασμός Σχεδίου Διαχείρισης Αποβλήτων	□	□	□
Κυκλικός σχεδιασμός προϊόντων (δηλ. το προϊόν σχεδιάζεται κατά μήκος των αρχών CE)	□	□	□

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Χρήση βιολιπασμάτων (για παραγωγή)	□	□	□
ΕΝΕΡΓΕΙΑ			
Ανάκτηση ενέργειας από απόβλητα	□	□	□
Χρήση Βιοκαυσίμων	□	□	□
Χρήση Ανανεώσιμων Πηγών Ενέργειας εκτός των βιοκαυσίμων ή ανάκτηση ενέργειας (π.χ. ηλιακή ή αιολική ενέργεια)	□	□	□
Παρακολούθηση ενεργειακής κατανάλωσης	□	□	□
Παρακολούθηση εκπομπών	□	□	□
ΝΕΡΟ			
Χρήση νερού από τη συγκομιδή όμβριων υδάτων	□	□	□
Διαδοχική χρήση νερού (δηλαδή άμεση χρήση μη επεξεργασμένων λυμάτων, κατά τρόπο ασφαλή για το περιβάλλον και την ανθρώπινη υγεία)	□	□	□

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Χρήση εσωτερικά ανακυκλωμένων υδάτων	□	□	□
Χρήση θαλασσινού νερού ή μη πόσιμου νερού από περιοχές γλυκού νερού που δεν ταξινομούνται ως στεγανές	□	□	□

4. Η εταιρεία σας αξιολογεί τις περιβαλλοντικές επιπτώσεις των δραστηριοτήτων της (π.χ. μέσω ανάλυσης κύκλου ζωής, περιβαλλοντικού αποτυπώματος);

Ναι □

Όχι □

5. Προσφέρεται εκπαίδευση που σχετίζεται με την κυκλική οικονομία στην εταιρεία σας;

Ναι □

Όχι □

Εάν ναι, παρακαλώ επιλέξτε τις σωστές απαντήσεις:

iv. Εκπαιδευτική Διαδικασία:
   c) Εκπαίδευση από εξωτερικό συνεργάτη
   d) Εσωτερική κατάρτιση των εργαζομένων στο θέμα

v. Παρουσία/Παρακολούθηση:
   c) Υποχρεωτική
   d) Δεν είναι υποχρεωτικό

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vi. Η εκπαίδευση είναι διαθέσιμη:

d) σε όλα τα επίπεδα των εργαζομένων

e) σε ορισμένα επίπεδα εργαζομένων

f) σε συγκεκριμένους υπαλλήλους

6. Σε μια κλίμακα από το 1 έως το 5, σε ποιο βαθμό επικοινωνείτε με τους προμηθευτές την ανάγκη για αύξηση του αριθμού των προμηθειών που παράγονται με βάση τις αρχές της κυκλικής οικονομίας, με το 1 να μην το επικοινωνείτε καθόλου και το 5 να το επικοινωνείτε πολύ ;

Καθόλου 1 2 3 4 5 Πολύ

7. Σε μια κλίμακα από το 1 έως το 5, σε ποιο βαθμό εντοπίζετε πίεση από τους πελάτες για να κάνετε την εταιρεία σας πιο κυκλική, με το 1 να μην εντοπίζετε καθόλου πίεση και το 5 να πιέζεστε πολύ;

Καθόλου 1 2 3 4 5 Πολύ

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Annex 3: Data processing and hypotheses testing results

I. Data processing for cluster analysis

A two-step process was applied, as follows: the "Not interested in implementing such measures" and the "Not Applicable" values were merged into a new value labeled "0", whereas the "We are interested in implementing such measures" and the "We are currently implementing such measures" values were recoded into a new value labeled "1". Within each of the three groups of measures, the number of values labeled with "1" were summed up (per subject/company), so that the maximum score per subject/company for the general CE measures was 8, i.e., a company that currently implements or it is willing to implement all the 8 measures of the general CE measures group, for the energy-related measures the maximum score was 5, and for the water-related measures the maximum score for a company was 4.

The total sum of "1" values was used to characterize the subject's (company) behaviour against each type of measures. Specifically, for the general CE measures, the following coding was applied: a score ≥ 5 characterizes a company of a "high" implementation level for this type of measures, a 3 ≤ score ≤ 4 characterizes a company of a "moderate" implementation level for this type of measures, and a 0 ≤ score ≤ 2 characterizes a company of a "low" implementation level for this type of measures.

For the energy-related and water-related CE measures, the following coding was applied: a score ≥ 3 characterizes a company of a "high" implementation level for this type of measures, a score equal to 2 characterizes a company of a "moderate" implementation level for this type of measures, and a 0 ≤ score ≤ 1 characterizes a company of a "low" implementation level for this type of measures.

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II. Type of waste

Table 21. Contingency table for the association between the field of operation of a company and recyclable waste

Crosstab

			recyclable		
			no	yes	Total
Field of operations	Production	Count	31a	31b	62
		% within Field of operations	50.0%	50.0%	100.0%
	Packing	Count	2a	11a	13
		% within Field of operations	15.4%	84.6%	100.0%
	Processing	Count	15a	26a	41
		% within Field of operations	36.6%	63.4%	100.0%
	Logistics	Count	4a	19a	23
		% within Field of operations	17.4%	82.6%	100.0%
	Trading	Count	5a	13a	18
		% within Field of operations	27.8%	72.2%	100.0%
	Service providing	Count	9a	39b	48
		% within Field of operations	18.8%	81.3%	100.0%
Total		Count	66	139	205
		% within Field of operations	32.2%	67.8%	100.0%

Each subscript letter denotes a subset of recyclable categories whose column proportions do not differ significantly from each other at the .05 level.

Table 22. Contingency table for the association between the field of operation of a company and organic waste

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Crosstab

			organic		Total
			no	yes	
Field of operations	Production	Count	18a	44b	62
		% within Field of operations	29.0%	71.0%	100.0%
	Packing	Count	11a	2a	13
		% within Field of operations	84.6%	15.4%	100.0%
	Processing	Count	15a	26b	41
		% within Field of operations	36.6%	63.4%	100.0%
	Logistics	Count	22a	1b	23
		% within Field of operations	95.7%	4.3%	100.0%
	Trading	Count	16a	2b	18
		% within Field of operations	88.9%	11.1%	100.0%
	Service providing	Count	41a	7b	48
		% within Field of operations	85.4%	14.6%	100.0%
Total		Count	123	82	205
		% within Field of operations	60.0%	40.0%	100.0%

Each subscript letter denotes a subset of organic categories whose column proportions do not differ significantly from each other at the .05 level.

Table 23. Contingency table for the association between the field of operation of a company and liquid waste

Crosstab

			liquid		Total
			no	yes	
Field of operations	Production	Count	39a	23b	62
		% within Field of operations	62.9%	37.1%	100.0%
	Packing	Count	9a	4a	13
		% within Field of operations	69.2%	30.8%	100.0%
	Processing	Count	26a	15a	41
		% within Field of operations	63.4%	36.6%	100.0%
	Logistics	Count	19a	4a	23
		% within Field of operations	82.6%	17.4%	100.0%
	Trading	Count	16a	2a	18
		% within Field of operations	88.9%	11.1%	100.0%
	Service providing	Count	40a	8a	48
		% within Field of operations	83.3%	16.7%	100.0%
Total		Count	149	56	205
		% within Field of operations	72.7%	27.3%	100.0%

Each subscript letter denotes a subset of liquid categories whose column proportions do not differ significantly from each other at the .05 level.

Table 24. Contingency table for the association between the field of operation of a company and solid waste

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Crosstab

			solid		
			no	yes	Total
Field of operations	Production	Count	51a	11b	62
		% within Field of operations	82.3%	17.7%	100.0%
	Packing	Count	8a	5a	13
		% within Field of operations	61.5%	38.5%	100.0%
	Processing	Count	23a	18a	41
		% within Field of operations	56.1%	43.9%	100.0%
	Logistics	Count	17a	6a	23
		% within Field of operations	73.9%	26.1%	100.0%
	Trading	Count	11a	7a	18
		% within Field of operations	61.1%	38.9%	100.0%
	Service providing	Count	27a	21a	48
		% within Field of operations	56.3%	43.8%	100.0%
Total		Count	137	68	205
		% within Field of operations	66.8%	33.2%	100.0%

Each subscript letter denotes a subset of solid categories whose column proportions do not differ significantly from each other at the .05 level.

III. Circular Economy strategy

Table 25. Contingency table for the association between the Circular Economy strategic priorities and the number of employees of a company

Crosstab

			Circular Economy strategy			
			No relevant mentions of circular economy	Relevant concept mentioned as part of strategic	Circular economy explicitly mentioned as part of strategic priorities	Total
Number of employees	0-10	Count	66a	44a	14a	124
		% within Number of employees	53.2%	35.5%	11.3%	100.0%
	11-49	Count	41a	17a	6a	64
		% within Number of employees	64.1%	26.6%	9.4%	100.0%
	>50	Count	6a	5a, b	6b	17
		% within Number of employees	35.3%	29.4%	35.3%	100.0%
Total		Count	113	66	26	205
		% within Number of employees	55.1%	32.2%	12.7%	100.0%

Each subscript letter denotes a subset of Circular Economy strategy categories whose column proportions do not differ significantly from each other at the .05 level.

Table 26. Contingency table for the association between the Circular Economy strategic priorities and the annual revenue of a company

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Crosstab

			Circular Economy strategy			
			No relevant mentions of circular economy	Relevant concept mentioned as part of strategic	Circular economy explicitly mentioned as part of strategic priorities	Total
Annual revenue	<500.000€	Count	66a	40a, b	6b	112
		% within Annual revenue	58.9%	35.7%	5.4%	100.0%
	500.000€-2.000.000€	Count	18a	13a	5a	36
		% within Annual revenue	50.0%	36.1%	13.9%	100.0%
	>2.000.000€	Count	14a	9a, b	7b	30
		% within Annual revenue	46.7%	30.0%	23.3%	100.0%
Total		Count	98	62	18	178
		% within Annual revenue	55.1%	34.8%	10.1%	100.0%

Each subscript letter denotes a subset of Circular Economy strategy categories whose column proportions do not differ significantly from each other at the .05 level.

Table 27. Contingency table for the association between the Circular Economy strategic priorities of a company and the CE-related pressure put by its customers

Crosstab

			Circular Economy strategy			
			No relevant mentions of circular economy	Relevant concept mentioned as part of strategic	Circular economy explicitly mentioned as part of strategic priorities	Total
Pressure from customers for CE	high	Count	25a, b	8b	10a	43
		% within Pressure from customers for CE	58.1%	18.6%	23.3%	100.0%
	low	Count	66a	30a	3b	99
		% within Pressure from customers for CE	66.7%	30.3%	3.0%	100.0%
	moderate	Count	22a	28b	13b	63
		% within Pressure from customers for CE	34.9%	44.4%	20.6%	100.0%
Total		Count	113	66	26	205
		% within Pressure from customers for CE	55.1%	32.2%	12.7%	100.0%

Each subscript letter denotes a subset of Circular Economy strategy categories whose column proportions do not differ significantly from each other at the .05 level.

Table 28. Contingency table for the association between the Circular Economy strategic priorities of a company and the level of engagement with its suppliers towards sourcing based on CE principals

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Crosstab

			Circular Economy strategy			
			No relevant mentions of circular economy	Relevant concept mentioned as part of strategic	Circular economy explicitly mentioned as part of strategic priorities	Total
Engagement with suppliers towards CE	high	Count	20a	16a	13b	49
		% within Engagement with suppliers towards CE	40.8%	32.7%	26.5%	100.0%
	low	Count	69a	22b	4b	95
		% within Engagement with suppliers towards CE	72.6%	23.2%	4.2%	100.0%
	moderate	Count	24a	28b	9a, b	61
		% within Engagement with suppliers towards CE	39.3%	45.9%	14.8%	100.0%
Total		Count	113	66	26	205
		% within Engagement with suppliers towards CE	55.1%	32.2%	12.7%	100.0%

Each subscript letter denotes a subset of Circular Economy strategy categories whose column proportions do not differ significantly from each other at the .05 level.

IV. Environmental impact assessment

Table 29. Contingency table for the association between the environmental impact assessment of a company and its annual revenue

Crosstab

			Environmental impact assessment		
			no	yes	Total
Annual revenue	<500.000€	Count	88a	24b	112
		% within Annual revenue	78.6%	21.4%	100.0%
	500.000€-2.000.000€	Count	27a	9a	36
		% within Annual revenue	75.0%	25.0%	100.0%
	>2.000.000€	Count	13a	17b	30
		% within Annual revenue	43.3%	56.7%	100.0%
Total		Count	128	50	178
		% within Annual revenue	71.9%	28.1%	100.0%

Each subscript letter denotes a subset of Environmental impact assessment categories whose column proportions do not differ significantly from each other at the .05 level.

Table 30. Contingency table for the association between the environmental impact assessment of a company and its engagement with suppliers towards sourcing based on CE principles

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Crosstab

			Environmental impact assessment		
			no	yes	Total
Engagement with suppliers towards CE	high	Count	25a	24b	49
		% within Engagement with suppliers towards CE	51.0%	49.0%	100.0%
	low	Count	81a	14b	95
		% within Engagement with suppliers towards CE	85.3%	14.7%	100.0%
	moderate	Count	39a	22a	61
		% within Engagement with suppliers towards CE	63.9%	36.1%	100.0%
Total		Count	145	60	205
		% within Engagement with suppliers towards CE	70.7%	29.3%	100.0%

Each subscript letter denotes a subset of Environmental impact assessment categories whose column proportions do not differ significantly from each other at the .05 level.

Table 31. Contingency table for the association between the environmental impact assessment of a company and the pressure put by its customers towards its CE transformation

Crosstab

			Environmental impact assessment		
			no	yes	Total
Pressure from customers for CE	high	Count	23a	20b	43
		% within Pressure from customers for CE	53.5%	46.5%	100.0%
	low	Count	81a	18b	99
		% within Pressure from customers for CE	81.8%	18.2%	100.0%
	moderate	Count	41a	22a	63
		% within Pressure from customers for CE	65.1%	34.9%	100.0%
Total		Count	145	60	205
		% within Pressure from customers for CE	70.7%	29.3%	100.0%

Each subscript letter denotes a subset of Environmental impact assessment categories whose column proportions do not differ significantly from each other at the .05 level.

Table 32. Contingency table for the association between the environmental impact assessment of a company and its CE strategic priorities level

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Crosstab

			Environmental impact assessment		
			no	yes	Total
Circular Economy strategy	No relevant mentions of circular economy	Count	102a	11b	113
		% within Circular Economy strategy	90.3%	9.7%	100.0%
	Relevant concept mentioned as part of strategic	Count	36a	30b	66
		% within Circular Economy strategy	54.5%	45.5%	100.0%
	Circular economy explicitly mentioned as part of strategic priorities	Count	7a	19b	26
		% within Circular Economy strategy	26.9%	73.1%	100.0%
Total		Count	145	60	205
		% within Circular Economy strategy	70.7%	29.3%	100.0%

Each subscript letter denotes a subset of Environmental impact assessment categories whose column proportions do not differ significantly from each other at the .05 level.

V. Training on Circular Economy

Table 33. Contingency table for the association between training on Circular Economy and the field of operation of a company

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Crosstab

			Training		Total
			no	yes	
Field of operations	Production	Count	55a	7b	62
		% within Field of operations	88.7%	11.3%	100.0%
	Packing	Count	9a	4a	13
		% within Field of operations	69.2%	30.8%	100.0%
	Processing	Count	26a	15a	41
		% within Field of operations	63.4%	36.6%	100.0%
	Logistics	Count	19a	4a	23
		% within Field of operations	82.6%	17.4%	100.0%
	Trading	Count	9a	9b	18
		% within Field of operations	50.0%	50.0%	100.0%
	Service providing	Count	35a	13a	48
		% within Field of operations	72.9%	27.1%	100.0%
Total		Count	153	52	205
		% within Field of operations	74.6%	25.4%	100.0%

Each subscript letter denotes a subset of Training categories whose column proportions do not differ significantly from each other at the .05 level.

Table 34. Contingency table for the association between training on Circular Economy and the annual revenue of a company

Crosstab

			Training		Total
			no	yes	
Annual revenue	<500.000€	Count	90a	22b	112
		% within Annual revenue	80.4%	19.6%	100.0%
	500.000€-2.000.000€	Count	28a	8a	36
		% within Annual revenue	77.8%	22.2%	100.0%
	>2.000.000€	Count	15a	15b	30
		% within Annual revenue	50.0%	50.0%	100.0%
Total		Count	133	45	178
		% within Annual revenue	74.7%	25.3%	100.0%

Each subscript letter denotes a subset of Training categories whose column proportions do not differ significantly from each other at the .05 level.

Table 35. Contingency table for the association between training on Circular Economy for a company and its engagement with suppliers towards sourcing based on CE principles

This Project is co-funded by the European Development Fund (ERDF) and by national funds of the countries participating in the Interreg V-A "Greece – Bulgaria 2014-2020" Cooperation Programme

Crosstab

			Training		
			no	yes	Total
Engagement with suppliers towards CE	high	Count	27a	22b	49
		% within Engagement with suppliers towards CE	55.1%	44.9%	100.0%
	low	Count	88a	7b	95
		% within Engagement with suppliers towards CE	92.6%	7.4%	100.0%
	moderate	Count	38a	23b	61
		% within Engagement with suppliers towards CE	62.3%	37.7%	100.0%
Total		Count	153	52	205
		% within Engagement with suppliers towards CE	74.6%	25.4%	100.0%

Each subscript letter denotes a subset of Training categories whose column proportions do not differ significantly from each other at the .05 level.

Table 36. Contingency table for the association between training on Circular Economy for a company and the pressure put by the customers of a company towards becoming more Circular

Crosstab

			Training		
			no	yes	Total
Pressure from customers for CE	high	Count	27a	16b	43
		% within Pressure from customers for CE	62.8%	37.2%	100.0%
	low	Count	88a	11b	99
		% within Pressure from customers for CE	88.9%	11.1%	100.0%
	moderate	Count	38a	25b	63
		% within Pressure from customers for CE	60.3%	39.7%	100.0%
Total		Count	153	52	205
		% within Pressure from customers for CE	74.6%	25.4%	100.0%

Each subscript letter denotes a subset of Training categories whose column proportions do not differ significantly from each other at the .05 level.

Table 37. Contingency table for the association between training on Circular Economy for a company and its CE strategic priorities level

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Crosstab

			Training		
			no	yes	Total
Circular Economy strategy	No relevant mentions of circular economy	Count	93a	20b	113
		% within Circular Economy strategy	82.3%	17.7%	100.0%
	Relevant concept mentioned as part of strategic	Count	50a	16a	66
		% within Circular Economy strategy	75.8%	24.2%	100.0%
	Circular economy explicitly mentioned as part of strategic priorities	Count	10a	16b	26
		% within Circular Economy strategy	38.5%	61.5%	100.0%
Total		Count	153	52	205
		% within Circular Economy strategy	74.6%	25.4%	100.0%

Each subscript letter denotes a subset of Training categories whose column proportions do not differ significantly from each other at the .05 level.

VII. Engagement with suppliers towards sourcing based on CE principles

Table 38. Contingency table for the association between the number of employees of a company and its engagement with suppliers towards sourcing based on CE principles

Crosstab

			Engagement with suppliers towards CE			
			high	low	moderate	Total
Number of employees	0-10	Count	29a	64a	31a	124
		% within Number of employees	23.4%	51.6%	25.0%	100.0%
	11-49	Count	15a	29a	20a	64
		% within Number of employees	23.4%	45.3%	31.3%	100.0%
	>50	Count	5a, b	2b	10a	17
		% within Number of employees	29.4%	11.8%	58.8%	100.0%
Total		Count	49	95	61	205
		% within Number of employees	23.9%	46.3%	29.8%	100.0%

Each subscript letter denotes a subset of Engagement with suppliers towards CE categories whose column proportions do not differ significantly from each other at the .05 level.

Table 39. Contingency table for the association between the annual revenue of a company and its engagement with suppliers towards sourcing based on CE principles

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Crosstab

			Engagement with suppliers towards CE			Total
			high	low	moderate	
Annual revenue	<500.000€	Count	24a, b	62b	26a	112
		% within Annual revenue	21.4%	55.4%	23.2%	100.0%
	500.000€-2.000.000€	Count	6a	15a	15a	36
		% within Annual revenue	16.7%	41.7%	41.7%	100.0%
	>2.000.000€	Count	10a	7b	13a	30
		% within Annual revenue	33.3%	23.3%	43.3%	100.0%
Total		Count	40	84	54	178
		% within Annual revenue	22.5%	47.2%	30.3%	100.0%

Each subscript letter denotes a subset of Engagement with suppliers towards CE categories whose column proportions do not differ significantly from each other at the .05 level.

VIII. Customers' pressure for CE transformation

Table 40. Contingency table for the association between the number of operating years of a company and the pressure put by the customers on the company towards becoming more Circular

Crosstab

			Pressure from customers for CE			Total
			high	low	moderate	
Number of operational years	0-3	Count	8a	10a	3a	21
		% within Number of operational years	38.1%	47.6%	14.3%	100.0%
	3-5	Count	3a	19a	4a	26
		% within Number of operational years	11.5%	73.1%	15.4%	100.0%
	5-10	Count	11a, b	19b	26a	56
		% within Number of operational years	19.6%	33.9%	46.4%	100.0%
	10-20	Count	13a	26a	20a	59
		% within Number of operational years	22.0%	44.1%	33.9%	100.0%
	>20	Count	7a	25a	9a	41
		% within Number of operational years	17.1%	61.0%	22.0%	100.0%
Total		Count	42	99	62	203
		% within Number of operational years	20.7%	48.8%	30.5%	100.0%

Each subscript letter denotes a subset of Pressure from customers for CE categories whose column proportions do not differ significantly from each other at the .05 level.

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Table 41. Contingency table for the association between the number of employees of a company and the pressure put by the customers on the company towards becoming more Circular

Crosstab

			Pressure from customers for CE			Total
			high	low	moderate	
Number of employees	0-10	Count	27a, b	67b	30a	124
		% within Number of employees	21.8%	54.0%	24.2%	100.0%
	11-49	Count	13a	30a	21a	64
		% within Number of employees	20.3%	46.9%	32.8%	100.0%
	>50	Count	3a, b	2b	12a	17
		% within Number of employees	17.6%	11.8%	70.6%	100.0%
Total		Count	43	99	63	205
		% within Number of employees	21.0%	48.3%	30.7%	100.0%

Each subscript letter denotes a subset of Pressure from customers for CE categories whose column proportions do not differ significantly from each other at the .05 level.

Table 42. Contingency table for the association between the annual revenue of a company and the pressure put by the customers on a company towards becoming more Circular

Crosstab

			Pressure from customers for CE			Total
			high	low	moderate	
Annual revenue	<500.000€	Count	22a, b	65b	25a	112
		% within Annual revenue	19.6%	58.0%	22.3%	100.0%
	500.000€-2.000.000€	Count	10a	15a	11a	36
		% within Annual revenue	27.8%	41.7%	30.6%	100.0%
	>2.000.000€	Count	6a, b	7b	17a	30
		% within Annual revenue	20.0%	23.3%	56.7%	100.0%
Total		Count	38	87	53	178
		% within Annual revenue	21.3%	48.9%	29.8%	100.0%

Each subscript letter denotes a subset of Pressure from customers for CE categories whose column proportions do not differ significantly from each other at the .05 level.

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IX. K-Modes: Selection of the optimal number of clusters

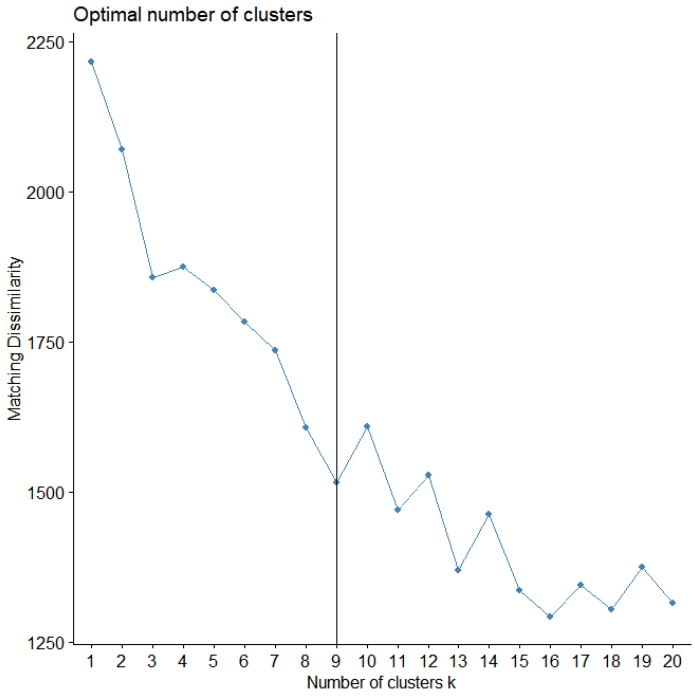

Figure 65. Elbow method for the selection of the optimal number of clusters for the implementation of the K-Modes clustering algorithm based on the matching dissimilarity

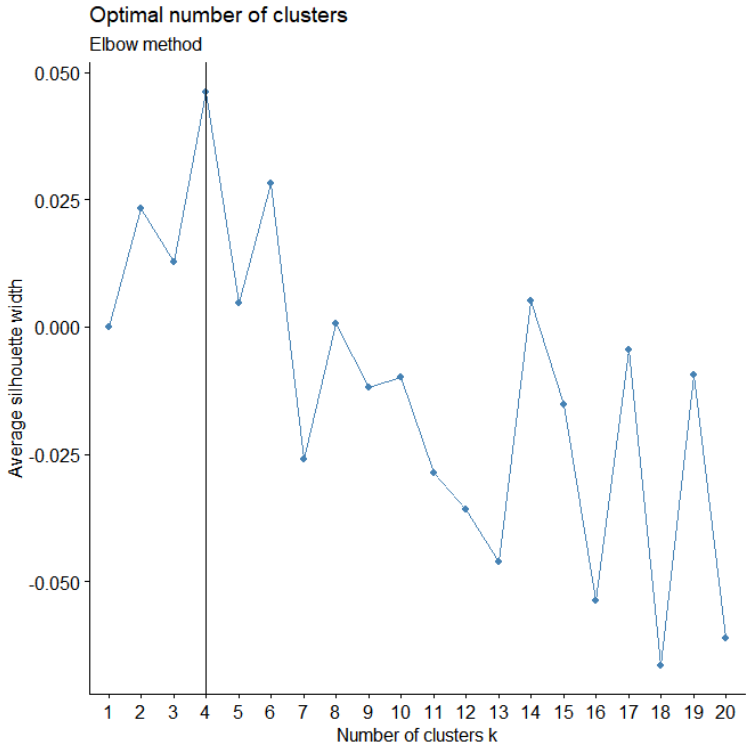

Figure 66. Average silhouette width criterion for the selection of the optimal number of clusters for the implementation of the K-Modes clustering algorithm

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