



Co-creating a Vision and Roadmap for Circular Economy in the Food and Beverages Packaging Sector

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Abstract

This paper describes a collaborative process engaging key stakeholders to co-create a shared vision for 2035 and a roadmap for action to support a circular economy transition in the packaging of the food and beverages sector in Portugal. Although the need to engage stakeholders is widely acknowledged, few collaborative initiatives can be found in the literature for scoping and visioning of circular economy strategies. Three main stages are broadly proposed to conduct a participatory scoping and visioning process, including the conduction of exploratory interviews and a collaborative visioning workshop supported by desk-based research. Engaging agents from across the value chain and from critical knowledge fields allowed to create a common understanding of major challenges, opportunities, and key circular strategies to implement towards a desired vision of the future. Five main areas of action were identified: innovation and research, new business models; eco-design; marketing and communication; and regulation and incentives. This work allowed to draw useful lessons for the sector: (i) there is a great potential of circularity in the food and beverages packaging sector; (ii) the engaged stakeholders have the will to continue collaborating. Regarding the proposed process: (i) a process of this nature allows the co-creation of a shared vision and the definition of a roadmap to achieve it and (ii) engaging stakeholders from all the value chain in structured discussions and collaborative exercises may contribute to promote social learning and knowledge co-creation. Some limitations can be pointed out; an important one is the dependency on stakeholders' engagement, which could bring additional challenges when implementing a

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process of this nature. Although the process can be applied in different contexts and sectors, the obtained results are specific for this sector in the Portuguese context.

Keywords Circular economy · Food & beverages packaging · Co-creation · Stakeholder engagement · Roadmap for action

Introduction

Circular economy (CE) has been gaining attention in recent years both in research and policy arenas [1] with several authors conducting reviews on the topic [2–6], proposing new frameworks [7, 8] and indicators [9, 10], and trying to understand how to pass from theory to implementation [11]. Ensuring sustainable consumption and production patterns is one of the seventeen Sustainable Development Goals established in 2015 by the UN. The 12th goal aims to foster resource and energy efficiency while allowing access to basic services, green and decent jobs, and quality of life for everyone [12]. At the European policy level, several initiatives have emerged to accelerate the transition towards circularity. The European Commission recently adopted the CE Package [13] and a New Action Plan for CE as one of the main building blocks of the European Green Deal [14]. These policies have also been steering CE initiatives and studies at the national level, with examples from countries such as Scotland [15], UK [16], Netherlands [17], Austria [18], or Finland [19].

In the Portuguese context, the National Action Plan for Circular Economy [20] was adopted in 2017, where agroindustry and consumer goods were identified as key sectors to leverage the desired transition. However, no concrete milestones are identified during the lifetime of the plan.

Despite all these efforts and recent initiatives, there is still a long way to go. According to the Ellen MacArthur Foundation – EMF [21], the economy is seemingly locked into a system in which production, regulations, and the way people behave favour a linear production and consumption model. To induce a shift to circular models, it is essential to decrease resource use, degradation, and pollution along the whole product/service lifecycle, involving different stakeholders, such as policymakers, researchers, business, consumers, retailers, among others [12].

Packaging and food and beverages sectors fall within the fast-moving consumer goods, one of the most important target areas for accelerating a CE transition. Their importance relies mainly on the large volumes of packaging resulting from a high frequency of distributed purchases massively and at a large scale. While most of these goods have low prices and a short lifetime, they represent a high material throughput volume.

Food has been gaining high attention in different arenas, namely due to the impacts of food waste. About a third of the world's food is never eaten, which means a waste of land and resources, with associated greenhouse gas emissions [22]. In developed countries, losses occur mainly at the retail and consumer stages of supply chains [23], where packaging plays an important role. According to [24], 207 million tons of packaging are bought globally, with a value of USD 384 billion each year [21]. In the beverages sector, the packaging is necessary to deliver the product to consumers [7], where most one-way packaging is discarded after use, entering the waste stream very quickly. On average, a citizen from the OECD consumes 800 kg per year of food and beverages and 120 kg of packaging [21]. In 2017, packaging waste in Europe was the highest ever—173 kg per inhabitant [14]. About 23 million tons per year of plastic packages are produced in Europe, with some sources pointing to 92 million tons expected in 2050, including single-use food packaging [25]. In 2016, 39.9% of the European plastics demand was used for packaging [26]. Since these products have relatively low prices,

the incentives for the recovery of packaging materials are weak. Additionally, their higher dispersion and short life period also increase the complexity of designing CE strategies [21].

The acknowledgement of the packaging and food and beverages sectors' role in support of circularity transitions is emerging in CE debates (e.g. [7, 19]). For instance, some initiatives have addressed different reuse models in both traditional and online retail: (a) refill at home; (b) refill on the go; (c) return from home; and (d) return on the go [27]. Other examples include valuing by-products from wine production, waste reduction in the distribution sector, or developing new business models [28]. The policy relevance of both sectors is also demonstrated in the new EU Circular Economy Action Plan [14] and, in a national context, such as in the Portuguese Circular Action Plan [29]. Packaging plays a crucial role in the conservation of food and beverages [30], which represents an additional challenge when developing circular solutions. This points to the need for integrated analyses of both sectors.

The literature also shows a gap in a reference framework for scoping relevant issues and outlining future pathways for circularity strategies. The design of such a transition requires a systemic approach and cooperation among actors operating in the supply chain, from producers to final consumers [12, 24, 27]. The engagement of stakeholders then becomes a critical element of the process of developing successful CE strategies. However, few collaborative initiatives can be found in the literature for scoping and visioning of CE strategies. Whicher et al. [15] developed an action plan for CE in Scotland through a co-development process with interviews, workshops, and peer review with key stakeholders. They have concluded that the collaborative approach allowed a transparent and inclusive process to develop a shared action plan towards CE. In another example, Mendonza [31] developed a framework integrating backcasting and eco-design for the CE to ensure that businesses could implement CE requirements more effectively, testing it in a pilot workshop. Besides agents from the value chain, other sources of knowledge may be brought into the process, such as innovation and new business models, highlighted as one of the trigger points for this transformation. Jesus et al. [3] reviewed the role of eco-innovation in the transition to a CE, concluding that CE is dependent on generalised and vast eco-innovation that should be strong in technology at the service level and involving service innovations and new business models. According to [32], sustainable business models can serve as a vehicle to coordinate technological and social innovation with systems-level sustainability.

Within this context, a study supported by the entity responsible for managing the flows of packages wastes in Portugal, Sociedade Ponto Verde (SPV), was conducted to address the gaps mentioned above. This paper aims to answer the question: how to scope the potential for a CE in packaging food and beverages while co-creating a roadmap for action in a participatory way? To address this question, a collaborative process was developed, engaging key stakeholders in Portugal to (i) identify the most promising opportunities and the main challenges; (ii) develop a shared vision for the future for the Food & Beverages Packaging sector; and (iii) outline a set of measures and policy instruments to achieve the vision and future actions. The paper explores the potential of engaging different stakeholders from the production, to consumption and waste management stages, including the management of material flows, in defining a shared vision portraying how to develop the pathway towards the desired future. We argue that a collaborative approach, combining different participatory methods, allows a more comprehensive integration of perceptions and values, which will positively affect the implementation of circular strategies contributing to the transition.

The paper will proceed as follows. The “[Methods](#)” section describes the methods to conduct a collaborative process to increase the circularity in the packaging of the food and beverages sector. The “[Results and Discussion](#)” section presents and discusses the main results of the study. The “[Conclusions](#)” section concludes with leading lessons and future developments.

Methods

Three main stages are broadly proposed to conduct a participatory scoping and visioning process supporting CE strategies. First, a diagnosis of the current situation for identifying opportunities and challenges and selecting key sectors for CE promotion. Second, developing a collaborative process to co-create a shared vision of the future that is conducive to a CE model for the selected key sector. Third, the production of a roadmap with concrete measures and actions to implement in the future to achieve the co-created vision. In all three stages, the engagement of critical agents is potentiated through participatory methods, as depicted in Fig. 1. The description of methods and tools deployed in each stage of the proposed approach is detailed in the following sections, illustrated with the packaging of food and beverages case study developed in Portugal.

Scoping Stage

The process started with a literature review and data collection to establish the current state of the art in international CE practices, as well as in the implementation of circular initiatives in Portugal. Relevant circular economy examples were identified from the *eco.nomia* database¹, a Portuguese circular economy portal. After that, the different cases were selected and organized according to their activity sector. A relatively lower number of case studies in the food and beverages packaging sector corroborated the initial assertion that this was a sector worth of further investigation.

In parallel, the material and waste flows of the Portuguese economy were characterised and a set of indicators was established to analyse the circularity potential of different economic activity sectors. This included a comparison of the waste production and the consumed energy across different sectors with their role on the economy measured through the gross value added (GVA). The standout strategies implemented by different sectors for promoting CE included by-products and waste valorisation, product life cycle extension, eco-design, and adoption of new business models. These scoping tasks confirmed the relevance of selecting the food and beverage packaging sector for testing the proposed approach, given its importance in the national context and in consumers' day-to-day life, encompassing a promising circularity potential.

The collaborative process was initiated in the scoping stage, beginning with a stakeholder analysis and the institutional context definition. A detailed stakeholder identification was performed, which resulted in a preliminary list validated and complemented by SPV, which also supported the research team by providing participants' contact data.

Semi-structured exploratory interviews were conducted with sixteen key actors previously identified from the selected sector's value chain, including representatives from food and beverages producers, packaging producers, distribution, and consumers (Table 1).

Several questions guided the interviews, aiming to capture stakeholders' perceptions, identify opportunities, barriers, and potential pathways for an increase in this sector's circularity in Portugal, as presented in Table 2.

Visioning Stage

In the interviews, participants revealed their individual, short-term vision for the sector. Subsequently, a collaborative workshop was organised to co-create a shared long-term vision,

¹ <https://eco.nomia.pt>

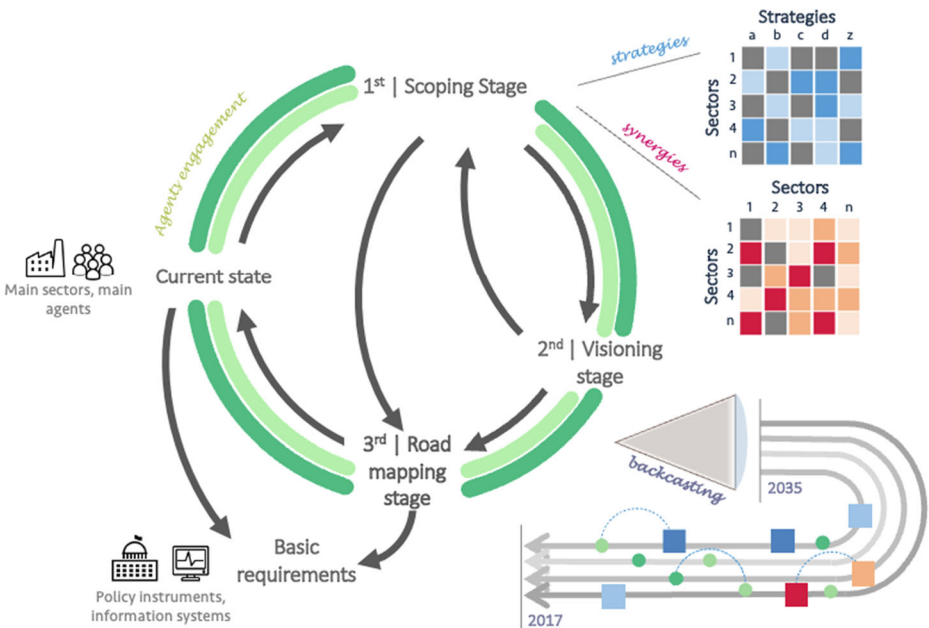


Fig. 1 Stages of the collaborative process for scoping, visioning, and co-creating a CE roadmap

engaging twenty-nine participants from the fields of packaging and food and beverages in Portugal, covering the value chain. Additionally, based on the interviewees’ suggestions, experts from the fields of regulation and incentives, research and innovation, new business models, eco-design, and communication and marketing were also engaged, as presented in Table 1.

The process integrated visioning and backcasting exercises, inspired by the *world café* method, a method for stakeholder engagement that promotes the co-production of

Table 1 Number of stakeholders engaged in the collaborative process, per point of the value chain

	Public administration	Research	Business	Civil society /associations	Number of participants
Interviews—Scoping and Visioning stage					
Food and beverages production	x		x	x	9
Packaging production			x		2
Distribution			x	x	4
Consumers				x	1
Waste management flows					0*
Workshop—Scoping, visioning, and road-mapping stages					
Food and beverages production			x	x	3
Packaging production				x	3
Distribution				x	1
Consumers				x	2
Waste management flows	x		x		10
Others	x	x	x	x	10

*Perceptions from the waste management flows group were captured through the meetings with SPV team

knowledge through collaborative learning [33, 34]. The process aimed to generate and share ideas, stimulate innovative thinking and explore action possibilities around concrete issues and questions. Visions of collective and desirable futures may mobilise understandings of the common good and concrete actions, and they often embody everyday life assumptions [35–37]. Collaborative workshops potentiate space and time for reflection, a process to exchange experiences and for co-creation of knowledge, which are fundamental factors when dealing with new and complex issues [38, 39].

The outcomes obtained from the interviews allowed to prepare and support the collaborative workshop. During half a day, participants worked on exercises organised following the script presented in Table 3. Three collaborative exercises allowed the construction of a shared Vision for 2035, the definition of opportunities and challenges, and the generation of specific ideas to achieve the sector's desired vision. Both results from interviews and workshop also informed the first stage of scoping.

Road-Mapping Stage

The final stage of the workshop allowed to define a set of measures and policy instruments for the achievement of the co-created vision and to support the implementation of the roadmap of future actions. These actions can cause a positive change in the current state by allowing closing different cycles in the value chain throughout the different phases: food and beverages and packaging production; distribution, transportation and logistics; consumption and management of material flows. The identified measures were grouped in five priority areas, identified by the project team, and some of them integrated the cross-cutting measures. Basic requirements to support the actions were also identified.

Table 2 Exploratory interviews script

Topic	Questions to explore
Circular economy	Awareness of the sector for new Circular Economy models? Changes in business strategies to provide more services or to adequate the supply to more circular contexts? Examples of how the sector has incorporated a circular economy?
Circular economy strategies	Stage of the value chain where it is easier to implement circular economy strategies in this sector? Main barriers to the implementation of circular models in the sector? Main opportunities in the implementation of circular models by the sector?
Production	Who are the main producers, and which are their concerns on circular economy issues? Are products designed for lasting long? Are products designed for disassembly? Are recycled materials incorporated in the production? How? Examples? Amount and type of raw materials used? Type of packaging used? Energy consumption and source?
Waste	Type and amount of waste produced? Valuation of by-products and produced waste?
Transportation	How is transportation made?
Synergies	Existing synergies along the value chain and sectors, and potential future synergies?
Consumer	The role of the consumer in a circular economy? Specific strategies to the consumer?
Vision for the future	Short and long-term vision for a circular economy in the sector?

Results and Discussion

Scoping Stage—Identification and Analysis of Stakeholders' Perceptions

Awareness of Circular Economy

The interviews revealed that the main actors from the packaging of food and beverages have been starting to show awareness of new models that need to be integrated if we want to put in place a transition towards CE. In the exploratory interviews, different stakeholders were able to point out circular actions and, in some cases, circular strategies in their business. Actors from *food production* are very committed to strategies that avoid waste. Some good examples arose, such as the development of a fruit puree line, dehydrated fruit products, and the valorisation of by-products sent to the juice industry.

Despite the evident efforts for waste reduction in the food production sector, CE awareness is perceived differently. Actors from the canned and dairy products did not show high awareness regarding circular issues, probably due to their conservative vision. However, they were able to point out an increase in awareness when compared to ten years ago. The *beverages producers* also mentioned a commitment with circular aspects; for example, a representative from the bottled mineral water sector stated that “the sector has been investing in the reduction of packages weight (...) in the last years mineral water bottles have suffered a 40% reduction in their weight” (interviewee from a bottled mineral water association).

The *packaging sector* has been focusing on reducing packages' weight and improving the design and logistics to allow better storage and transportation. For example, in plastic packages, it was stated that “our business model removes the transport of empty packages from the market. All the production line is placed close to the filling line. This means reducing about 30% to 40% of environmental impacts (interviewee from a plastic packages company). The segment of glass packages considers itself very circular; it was mentioned that “this sector is by itself circular (...) glass is totally circular in terms of materials” (interviewee from a glass packaging association).

The service of renting boxes for *transportation* of products with large volumes was referred to as being the most promising to promote an increase in transportation efficiency (e.g. about 60% cost reduction in packaging for fruit and vegetable transportation).

The most referred actions from different businesses were renewable energy (e.g. solar PV installation) to reduce energy costs. The *distribution* sector is mostly concerned with implementing measures to avoid food waste and packaging reduction, with increasing investment in last years to reduce food waste and promote consumer awareness through several campaigns and development of new products and services.

Perceived Opportunities and Challenges

When asked about the most important benefits of a transition to a CE, most interviewees identified positive effects, such as environmental improvements, cost reduction, and less waste. The associated costs of specific measures, lack of regulation and incentives, consumers' convenience, marketing department misalignment, and lack of communication within the value chain and within sectors were some examples of the challenges mentioned during the interviews. The identified opportunities and benefits were more generic when compared to challenges, which were more specific. This may indicate that participants already experience more obstacles/challenges in practice.

Table 3 Collaborative workshop script

Tasks	Steps and outputs
<p><i>1st task</i></p> <p>Circularity in the packaging of the food and beverages sector, which vision for 2035?</p>	<p>1.1. Participants are distributed in five different groups along the value chain:</p> <ul style="list-style-type: none"> • Food and beverages production • Packages production • Transport, distribution, and logistics • Food & Beverages consumption • Material flows management <p>1.2. Each group appoints a rapporteur that is responsible for presenting the intermediate outcomes and for synthesising the group discussions</p> <p>1.3. Each group develops a desired future vision for its theme</p> <p>1.4. Rapporteurs present each group's vision to all participants, and a first draft version of a shared vision is integrated. The research team collected the five visions and the integrated version and produced a version sent for all the participants for final validation and additional suggestions. Through this process, we guarantee that all participants identify with the co-created vision.</p>
<p><i>2nd task</i></p> <p>Which opportunities and challenges associated with the created vision?</p>	<p>2.1. Participants work in the five groups described in 1.1. All groups identify opportunities and challenges associated with the created vision and find out which synergies already exist and/or may be established with other value chain sectors and with others.</p> <p>2.2. Participants exchange groups for validating and complement the obtained outcomes. The rapporteur stays in the original group and explains key results from the first round of discussions.</p>
<p><i>3rd task</i></p> <p>Generating ideas and concrete actions</p>	<p>The third exercise aims to generate concrete ideas to achieve the created vision. Different groups are defined according to the following topics (defined based on the outcomes of the interviews):</p> <ul style="list-style-type: none"> • Research and innovation • communication and marketing • New business models • Regulation and incentives • Eco-design <p>A brainstorming exercise is conducted in order to identify a higher number of ideas. After that, participants in each group select the three more important ones (according to their perception) to discuss in detail and to present to all. It is expected that these ideas are defined to be put in practice in a specific year/time towards the vision in 2035.</p>
<p><i>4th task</i></p> <p>Workshop evaluation and individual perceptions</p>	<p>At the end of the collaborative workshop, all participants are asked to vote in the most suitable circular strategies for each sector, according to their perceptions (from very suitable to relatively suitable to less suitable). An evaluation survey is also distributed to collect stakeholders' feedback on the format and content of the collaborative process.</p>

During the collaborative workshop, participants discussed again these topics in the group activities conducted in the second task (Table 3). Table 4 summarises the opportunities and challenges identified by the five workshop groups. The workshop results are aligned with the interviews' responses; however, the group discussions allowed us to develop further and specify those opportunities and challenges.

Table 4 Opportunities and challenges identified in the collaborative workshop by the five working groups

	Food and beverage production	Food and beverage packages	Distribution, transport, and logistics	Food and beverage consumption	Material flows management
Opportunities	<ul style="list-style-type: none"> • Nutrients market; • Advanced biotechnology; • Local production • New channels for online distribution; • Optimisation of resources management. 	<ul style="list-style-type: none"> • Reduction and optimisation of packages; • Recovery of recycled; • Better image of the sector. 	<ul style="list-style-type: none"> • New business models; • Adaptation of the existent models; • Sharing information and knowledge; • Sharing resources; • Development of new technologies. 	<ul style="list-style-type: none"> • Transparency in the impacts of the production process to the consumer; • Promotion of conscientious choices; • Communication and education (shared responsibility). 	<ul style="list-style-type: none"> • Development of materials and production; • Technological development for waste treatment; • Innovation; • New models of waste collection.
Challenges	<ul style="list-style-type: none"> • Environmental impacts reflected in prices; • Investments and financial models; • Legal constraints; • Processes agility in short production cycles; • Spatial distribution. 	<ul style="list-style-type: none"> • Awareness; • Quality in packaging and transport; • Increase the perceived value of recycling; • Preserving the primary function of packaging and food safety. 	<ul style="list-style-type: none"> • Awareness; • Quality in packaging and transport; • Increase the perceived value of recycling; • Preserving the primary function of packaging and food safety; • Space for storage. 	<ul style="list-style-type: none"> • Awareness • Fair impact of the actual costs of waste management; • Behaviour change in the consumption and after-consumption phase; • Consumer convenience. 	<ul style="list-style-type: none"> • Adaption of systems in preparation for reuse and recyclability; • Change in habits and attitudes; • Introduction of more competition; • Packaging and Marketing; • Legal bottlenecks in waste collection systems.

In boldface are the challenges common to packaging production, distribution, transport and logistics, and food and beverage consumption

The main opportunities identified by the different groups are related to innovation, new business models, awareness and design. On the other hand, the recognised challenges are also related to innovation and regulation and incentives, logistics, and consumer behaviour. In boldface (Table 4), we highlight the challenges common to packaging production, distribution, transport and logistics, and food and beverage consumption.

The challenge of innovation exists because of a lack of financial and time resources. This challenge can be overcome with the development of new business models. For this, an appropriate legal framework with specific incentives should be created, aligned with consumers' awareness.

Addressing Circular Economy in the Packaging of Food and Beverages

The interviews revealed that the perceived most important measures to promote CE are “regulation and incentives” (44%), followed by “new business models” (20%), “marketing and communication” (14%), “eco-design” (14%), and “research and innovation” (8%), as presented in Table 5. Different measures were identified and then grouped in these five categories, then explored in the group exercises during the visioning workshop.

These results may indicate a strong need for top-down regulatory measures that will then be followed by bottom-up initiatives. However, when addressing such a complex topic that calls for a transition with disruptive approaches, the role of new business models is essential and was also understood as crucial by these stakeholders.

Perception on Synergies

Synergies are mentioned as one of the main ways to achieve circularity [5]; however, through the interviews, it became obvious that there is still a lot of work to conduct in this matter. Fifty-six percent of the interviewees revealed that synergies are inexistent, while 19% pointed that there is potential to establish them; however, 25% perceived that it is impossible to create synergies, mainly because of the traditional nature of the sectors and their competitive vision.

Table 5 Identified measures to promote circularity in food and beverages packaging

Measures to promote circularity	Attributed importance in % of responses	Examples of the specific measures
Regulation and incentives	44%	Regulation on the % of recycled material used in packaging Regulation on the volume of packaging per volume of product Taxes and penalties
New business models	20%	PAYT system One-way packaging tank Recover tank
Marketing and communication	14%	New strategies for recovery systems Consumers' awareness Producers' awareness
Eco-design	14%	Communication within the companies Design out of waste
Research and innovation	8%	Removal of recycling inhibitors Funding for research and innovation

Fifty-five percent of the synergies that already exist are established between companies within the same sector, 27% between companies within the same group and only 18% among different sectors. The majority of the synergies occur through by-products to animal feeding (Fig. 2).

These results show the importance of creating an environment conducive to collaboration instead of competition, highlighting to different businesses the gains that can be achieved with a collaborative model.

Where to Act in the Value Chain and the Role of Consumers

Answers to the question of “in which point of the value chain CE initiatives would be more effective?” show that all value chain stages were considered important. This means that we need integrated and also holistic strategies. One of the interviewees from the plastic packaging production segment highlighted that there are still opportunities to reduce plastic bottles’ weight; however, it is crucial that the transport and distribution actors are aligned with this trend. The techniques and handling processes of light or less resistant packages need to evolve. This observation points to the need to involve all nodes of the value chain in developing CE strategies, as advocated by different stakeholders [40].

Consumers were identified as one of the most crucial actor groups in the chain to apply specific measures (Fig. 3). Consumers have the potential to decide differently, and there is a shared responsibility in the Portuguese current legal framework that most consumers are not aware of: the responsibility to dispose packages into the recycle bin to be recycled. According to the interview results, there is still a lack of information and consumers’ education, which brings the need to develop tailored strategies for specific consumer groups. When analysing these issues, it is essential to look into the consumers’ convenience, one of the most critical marketing drivers when developing products and sales strategies.

The sector of the food industry that consists of establishments that prepare and serve food and beverages, called as HORECA channel (Hotels/Restaurants/Catering), was pointed as crucial due to its role as a direct link to consumers and the decisions they make regarding the forwarding of organic waste and packages. For this reason, special attention should be given to this sector in articulation with consumer strategies.

According to the EU CE Action Plan [13], the choices of millions of consumers could be responsible for potentiating or locking CE. These choices are conditioned by the information that is available to consumers, the range of prices, and the legal framework.

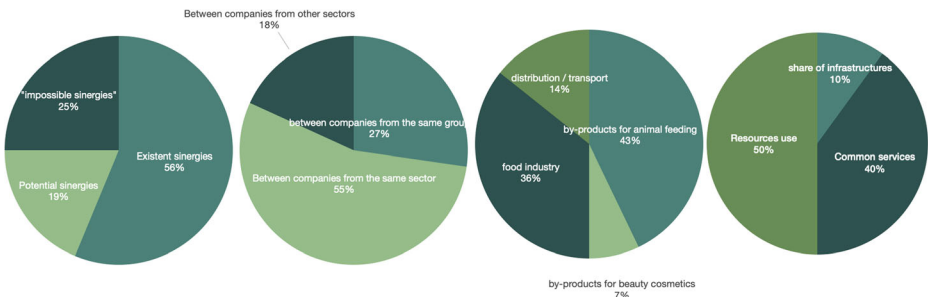


Fig. 2 Types of existing synergies according to the interviewed stakeholders (the existence of synergies; where the synergies occur; what type of synergies between different sectors and within the same sector)

Visioning Stage—Creating a Circular Economy Vision for the Packing of Food and Beverages

Shared Vision of the Future

According to [36], imagined futures turned into visions may guide public or corporate policy, which calls for the importance of creating these visions through a collaborative process. During the individual interviews, we asked participants to share their short and long-term visions for their organisations regarding the transition to a circular economy (Table 2). One of the primary outcomes was high difficulty in defining long term visions/strategies. All the answers were concentrated on specific single actions for the next years (e.g. “waste reduction”; “package weight reduction”; “by-product valorisation”; “transportation reduction”).

This motivated the development of a collaborative workshop to co-create a shared vision of the future, gathering stakeholders from this value chain and fostering their interaction, sharing of experiences and co-creation of knowledge. Following the script presented in Table 3, participants at the visioning workshop were asked to build a Vision for 2035. Five groups were organised according to the position in the value chain: “food and beverages production”, “food and beverages packaging production”, “transportation, distribution, and logistics”, “food and beverages consumption”, and “material flows management”. Each group was instructed to focus on the perspective of each specific stage of the value chain. After the workshop, a final version of the vision was developed for the whole value chain by integrating the statements developed by each group. This integrated vision statement was validated by participants after the workshop (Box 1).

Box 1 Vision for 2035 for the food and beverages packaging sector

“In 2035, the packaging of food and beverages sector is a leader in adopting circular strategies and practices in Portugal.

The food and beverages production processes are based on industrial symbioses, are transparent and use all the by-products.

Food and beverage packages have a high percentage of recycled material, guaranteeing great quality standards and improved recyclability. Packages are designed applying eco-design techniques, maximising the use of effectiveness and the materials lifetime.

In transport, distribution, and logistics, there are synergies among agents (transport and resources sharing) with eco-efficiency gains in the entire value chain, potentiated by innovation in the distribution and consumption systems.

Consumers are effectively informed and aware of choosing more circular products and services, assuming a conscious use of products and disposing of the waste they produce in a suitable way.

In material flows management, there are adequate waste collection services, and there is the aim to maximise the added value of recycled materials. No waste is deposited in landfills, giving place to the reuse, recycling and organic and energy recovery”.

It was a general agreement that the vision is ambitious and needs commitment and collaboration of all agents to be achieved.

Having in mind the Vision for 2035 and the identified opportunities and challenges, different working groups were formed to generate concrete ideas in the areas of research and innovation; new business models; eco-design; marketing and communication; and regulation and incentives (as a result of the areas defined through the outcomes of the exploratory interviews). The emerging ideas were then transformed into concrete actions to be included in a roadmap.

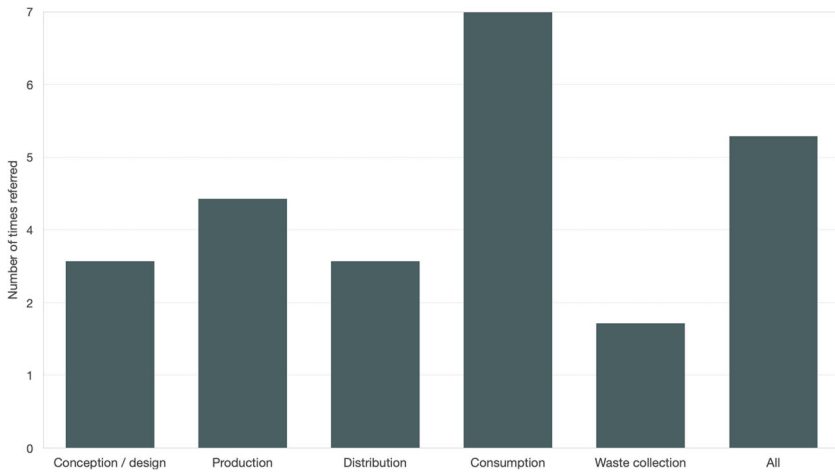


Fig. 3 Where to act in the value chain? Most important stages to implement circular strategies, according to the interviewed stakeholders

Road Mapping Stage—Co-creating a Roadmap for Action

Outlining the Action Plan

A Roadmap for Action to achieve the vision for 2035 (Fig. 4) was developed based on the outcomes from the collaborative process. In each thematic area, the proposed actions are linked to priority value chain points, where effectiveness was perceived to be higher. The action plan also integrates more holistic activities crosscutting the value chain (represented by the different icons). No silver bullet will be available for increasing the CE of this sector; instead, it will be a matter of *silver buckshot*—a combination of many actions and policies across the value chain through the integration of several fields of knowledge. Notwithstanding, some are more suitable for leveraging circularity in this sector in the coming years. This roadmap supports the development of actions and a way forward to CE implementation in this sector, as detailed below for each thematic area.

Research and Innovation CE requires a high level of complexity which brings the need to integrate different sectors and areas of research and, for the novelty it represents, causing changes at different levels. In that sense, research and innovation emerge as essential at all levels. The investment in R&D should be a priority for production, waste treatment, and the intermediate processes that involve several agents. New synergies and ways of collaboration should be promoted to increase industrial symbioses, which are often identified as one of the main CE strategies. This was referred to by stakeholders in our study as a current limitation since very few examples of synergies are in place. R&D may expand the implementation of such strategies by mapping food production in Portugal and the potential use of food by-products in other activities. In the packaging sector, greater attention should be given to reduce the use of raw materials, increase their recyclability, and find new ways of reusing and increasing their lifetime. In the distribution, transportation, and logistics areas that are key for connecting demand and supply, new solutions should be found. Despite the cross-cutting

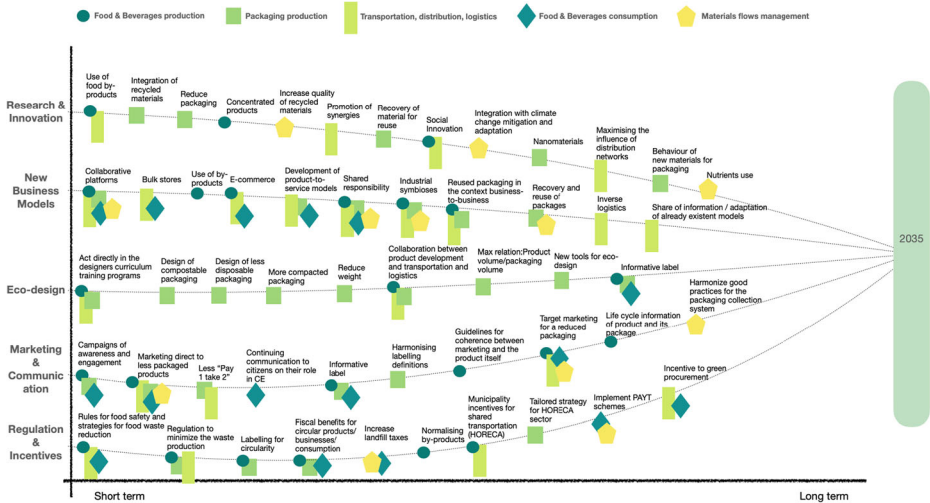


Fig. 4. Roadmap for action towards circular economy transition in food and beverages packaging sector

importance of R&D, it is also evident that tailored lines of research should be pursued in different sectors.

New Business Models New business models are needed to accommodate CE's principles, presenting more efficient solutions, consuming fewer natural resources, and manufacturing fewer products. The development of this action area should be accomplished throughout the value chain, from food and beverages and packaging production to distribution, to transportation and logistics, and ultimately to materials flows management. As mentioned above, industrial symbioses are a fundamental strategy that may be considered in new business models, potentiating more cooperation between sectors, for example, through collaborative platforms and new models in the supply chain and transportation. The new business models may consider medium-term new lifestyles, digital economy and e-commerce, blockchain, the green internet, and the 4th industrial revolution. In the short-term, it is possible to find new models that reward the transition from selling products to offering services, recovery of materials that are currently sent for disposal, and new business models in the integrated management system of packaging waste. These would avoid the increase in energy consumption and transportation/mobility needs. The developed roadmap for action shows that new business models are among the five areas where specific actions influence and could be a priority in different sectors across the value chain. Moreover, the development of new business models may be accompanied by a shared vision and working in parallel with other knowledge areas to avoid potential “perverse” effects, as an increase of greenhouse gas emissions resulting from the increased mobility demand of goods (e.g. e-commerce).

Eco-design The area of product design and conception is another field that will have a vast influence on the transition to a CE. Up to 80% of products, environmental impacts are determined at the design stage [14]. The closure of the different cycles will depend on actions that are implemented upstream of the value chain, at the origin of the products and the options found for their foundation and packaging/transport, which will depend mainly on the solutions developed by the offices and schools of design. Packaging options that incorporate new

materials and recycled materials and that are lighter should be developed. Special attention should be given to the over-packaging of products, and the use of mono-materials in the production of packaging, in order to enable greater and more efficient recycling. In the same line, eliminating disposable packaging should be a choice, allowing for more uses, increasing its useful life. For the results to be enhanced, collaboration between schools and design departments with logistics and distribution departments must be fostered. As a result, more efficient solutions can be identified. Incorporating these themes into the syllabus of design courses will have a positive effect on this transition and new generations of designers.

Marketing and Communication Marketing and communication will be essential, as they allow a message to be conveyed effectively to all society groups. Marketing and communication strategies aimed at reducing consumption and changing lifestyles will be one of the biggest challenges for a CE transition in the packaging of food and beverages. It is, therefore, necessary that the marketing departments are aligned with the other areas of the same business so that there is coherence between the product that is developed and how the message is presented and communicated. Tailored campaigns for different audiences at each stage of the value chain should be promoted, focusing on the diversity of societal actors, aiming to make consumers more aware, not forgetting that new consumers that will emerge in the next decade will think and live differently. Large distribution can be seen as a channel for promoting communication and awareness, working together with other areas to foster the principles of circularity in society.

Therefore, this area should be developed with the consumer, including the development of information campaigns and labelling systems that signal lower negative impacts and higher performance of products. The HORECA sector should not be overlooked. It is itself a consumer and has a strong connection to the final consumer and finds new solutions within companies and associations of food and beverage and packaging producers and distribution channels.

Regulation and Incentives For most social actors, it will be crucial that new and improved regulations and incentives are implemented so that different organisations can initiate the process and follow the frontrunners. It is expected that this transition starts with a definition of the institutional framework for identifying incentives to be implemented and mapping their impacts. The need to increase the Landfill Tax, the implementation of new Pay-As-You-Throw (PAYT) schemes in municipalities and the creation of tax benefits (e.g. reductions, exemptions) directed to more circular companies and products emerged as essential measures in the roadmap. On the other hand, this stresses the importance of finding specific regulations and incentives for the HORECA sector due to its dimension in Portugal and its strong connection to the final consumer, grouping several sectors of producers, distributors, suppliers, and consumers. Regulations and incentives should be put in practice in close articulation with the development of the other action areas.

From Plan to Implementation

According to [12], transformation to a CE relies on engaging consumers through awareness-raising and education on sustainable consumption and lifestyles, providing adequate information through standards and labels. Some of the roadmap actions are related to awareness and engagement and shared responsibility, highlighting the importance of processes where

consumers and stakeholders are brought together to share perceptions and experiences towards a shared vision of the future.

Important guidelines to pay attention to when implementing the roadmap are outlined:

- i. Since the first stage of this work, the importance of “consumers’ convenience” was evident. This is present in the majority of current product development and marketing campaigns. That is a crucial aspect to have in mind when promoting a CE transition;
- ii. The central role of marketing departments that most of the time “impose” products to consumers at the risk of boycotting some sustainability strategies;
- iii. The need for food and beverages preservation, to avoid food waste, and the need to find a balance between the need to reduce packaging and to ensure product conservation;
- iv. The pivotal role of the HORECA sector, for the impacts that it generates through the selection of products offered to final consumers, for the transportation that promotes (e.g. large number of different brands transported and distributed within cities every day); and for the role in adequate disposal of organic waste and packages.

The effectiveness of the roadmap implementation also depends on the available information for monitoring. There is a recognised need to develop specific indicators to assess CE performance since circularity strategies are at an early stage of development [41, 42]. Some initiatives have been putting in place suggestions in this regard, such as the dashboard of indicators that were created to be used with BS8001:2017 from the British Standard [43]. Moraga et al. [44] highlighted that most of the existing CE indicators do not focus on functions (such as product sharing), revealing the complexity of this analysis since it depends on consumer behaviour.

The proposed roadmap was discussed with SPV. Some of the actions that are dependent on this organisation are now in place; most of them related to awareness and communication. SPV has launched a new iconography for recycling, aiming to better inform consumers on separation and recycle rules [45]. The Pack4Recycling [46] tool was developed to support the conception of new packages to design out of waste. A monthly newsletter on Circular Economy news was also created to inform and communicate at a larger scale. These follow-up initiatives are aligned with the results obtained in the process, which is a good sign of the importance of co-creating a shared vision and a roadmap for action.

Process Evaluation

Workshop Evaluation by Participants

At the end of the workshop, participants were asked to fill an evaluation survey on the workshop’s structure, content, and outcomes. Figure 5 presents the results, showing that overall, the visioning workshop was well evaluated. The majority of the provided answers were between agree and totally agree (Fig. 5). Based on these results, it is possible to say that the visioning workshop accomplished the proposed goals and effectively allowed the co-creation of a shared vision for the future and support the co-creation of the roadmap.

In addition to the closed questions, participants were asked to mention the main positive and negative aspects of the workshop. The main positive aspects included “*a relaxed moment that allowed the intervention of all participants*”; “*a time for collective reflection*”; “*very positive confrontation of ideas in a multidisciplinary context*”; “*share of experiences*”; “*higher perception on different perspectives*”; “*co-development of a vision in a structured way*”. The

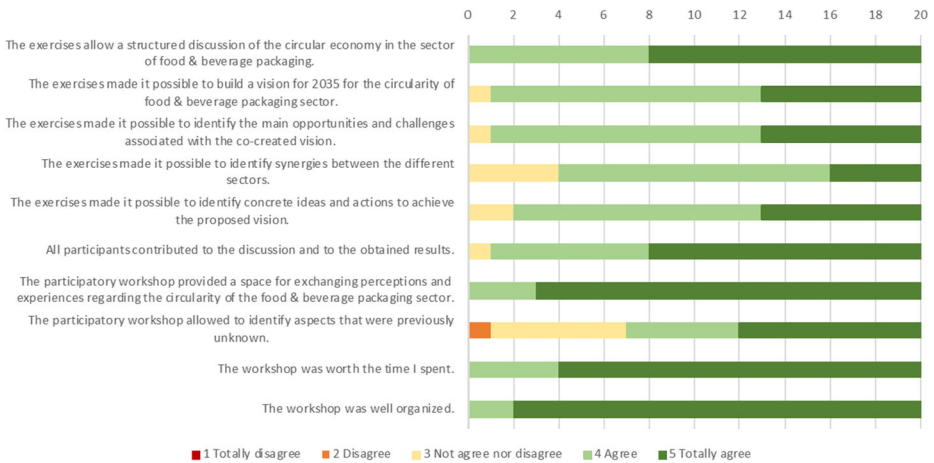


Fig. 5 Workshop evaluation by participants (evaluation survey answers between 1—totally disagree, and 5—totally agree)

negative aspects were mainly regarding the “*lack of time for more discussion*” and “*the outputs were very broad*”.

The survey allowed participants to express their views on novel elements brought by the collaborative process, as compared to the traditional view on the potential of CE in the food and beverages packaging sector. The answers suggested that the collaborative workshop promoted learning. Examples of the referenced new elements are as follows: “*understanding the ideas of other activities*”; “*understanding that the majority of the participants identify regulation and incentives as essential*”; “*packaging restrictions*”; “*the workshop allowed me to understand that the system is more complex and integrated than I thought*”; “*ideas towards the vision in 2035*”.

The workshop evaluation allowed to understand the effective importance of engaging stakeholders from all the value chain in structured discussions and collaborative exercises, which could promote social learning and knowledge co-creation. To understand the effects of the process and the roadmap measures, it is essential to monitor and continuously evaluate follow-up outcomes.

Process Evaluation by the Research Team

Ultimately, the importance of a process of this nature relies on the integration of different views and sub-sectors from the value chain towards a common circular vision of the future and the discussion on how to achieve it. The proposed roadmap is tailored for this sector in the Portuguese context, but it can nevertheless be extrapolated to some extent to other realities. It resulted from the combination and integration of different knowledge sources, including desktop research, stakeholders’ views, and the social learning process. In that sense, this vision and roadmap differ from one built solely through literature since it integrates multiple perspectives and the learning reached during the process. This process allowed to draw the following lessons:

There is an excellent potential for circularity in the food and beverages packaging sector. The engaged stakeholders demonstrated awareness regarding CE and the importance of adopting circular strategies in this sector. Besides the current challenges, an ambitious vision

for 2035 was co-created and specific actions identified in different areas. An extensive set of opportunities, both in interviews and collaborative workshops, was recognised, showing room to implement circular strategies and moving towards a transition to a circular economy in the food and beverages packaging sector. The role of consumption/consumers throughout the value chain was identified as crucial in transforming this potential in concrete circular actions.

The engaged stakeholders have the will to continue collaborating. This work has shown the capacity of a collaborative process to engage multiple stakeholders across the value chain. Although the number of stakeholders involved could have been higher, according to the stakeholder analysis, the process allowed the participation of representatives from all the value chain, with competences to implement some of the roadmap measures. Processes of this nature have the risk of low participation due to their high demand for stakeholders' time. In this case, despite being an exploratory exercise, participants acknowledged the importance of the process, the sharing of ideas, and the confrontation of viewpoints in a multidisciplinary context (according to their evaluation answers). These stakeholders have shown availability and will to continue participating and collaborating in the future. The collaborative approach that was followed has indicated a vast availability from stakeholders to be and stay involved in this process, which means that it is fundamental to create conditions to allow collaboration continuity.

A process of this nature allows the co-creation of a shared vision and the definition of a pathway to achieve it. Engaging stakeholders through the combination of exploratory interviews with a collaborative workshop allowed to capture their perceptions and set the ground to co-create a shared vision of the future for a circular economy in the food and beverages packaging sector. The interviews revealed a great difficulty from stakeholders in the definition of long-term visions; this aspect was overcome in the collaborative workshop, where participants were able to define a vision for 2035. This shows the importance of combining these two participatory moments: first capturing individual perceptions and then focusing on group discussions and learnings. The long-term shared vision allowed to think backwards and define concrete actions to be implemented to achieve the envisaged future. The sense of ownership and the contribution to the outcomes and to the solution may foster a more straightforward implementation of the roadmap by the different stakeholders.

Engaging stakeholders from all the value chain in structured discussions and collaborative exercises may contribute to promote social learning and knowledge co-creation. Four main elements support this statement: (i) the positive aspects highlighted by stakeholders in the evaluation survey, which included, among others, the workshop promoting a time for collective reflection, with a positive confrontation of ideas allowing participants to have a higher perception of different perspectives; (ii) the stakeholders' recognition that the participatory workshop allowed the identification of new elements; (iii) the co-creation of a vision for 2035 in the workshop, which participants were not able to formulate in the individual interviews; and (iv) the complementarity between exploratory interviews and collaborative workshop revealed for example in the identified opportunities and challenges.

Conclusions

This work shed light on how the packaging of food and beverages can pave the way towards more circular strategies and how to engage the key agents in a collaborative process to co-design a vision and a roadmap for action to engage agents in the pursuit of circular goals. CE is a disruptive model that needs structural changes in society and in people's mental models.

The collaborative process that combined exploratory interviews with a visioning workshop was able to structure a set of opportunities and challenges in implementing circular strategies in the food and beverage packaging sector. This work through the integration of results allowed the identification of a set of actions to be developed by 2035 to achieve the constructed vision. Contributions were organised in a Roadmap for Action to support the way forward based on five priority areas: innovation and research, new business models; eco-design; marketing and communication; and regulation and incentives.

Workshop participants were asked to evaluate the workshop. Their feedback was very positive, highlighting the importance of a process of this nature where different stakeholders can interact, reflect and exchange experiences and knowledge.

Although the positive balance of this process, the results are specific to this sector and to the Portuguese context, being important to highlight that co-creation processes are deeply dependent on stakeholders' involvement, which can represent one of the main limitations of such a process. In that sense, this work's primary constraint is associated with its dependency on participation and the capacity to guarantee the engagement of diverse stakeholder groups along the value chain. Although we invited a broad group of representatives from different stages of the food and beverages packaging sector's value chain, the turnout could have been higher. Notwithstanding, this is always dependent on different reasons, such as agenda constraints and motivation. The fact that it is a time-consuming process with associated costs could also be seen as a limitation. Additionally, if these prospective and aspirational exercises are not mandated by a specific decision-making process or linked to an institutional process could attract less participation.

With this study, a first step was made to start a more extensive discussion on this topic within this sector and to identify opportunities for action in the short, medium, and long term. Based on the perceptions of this group of stakeholders, the potential of circularity in the packaging of food and beverages sector exists, which calls for new initiatives and incentives to promote the transition to circular models. Additionally, in the near future, it is suggested the creation of an information system and a set of regulations and financial incentives to develop the institutional and social framework fostering the implementation of circular strategies for packaging of food and beverages, as well as procedures to allow a continuous monitoring and evaluation of measures effectiveness.

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Declarations

Conflict of Interest The authors declare no competing interests.

References

1. Geissdoerfer M, Savaget P, Bocken N, Hultink E (2017) The circular economy – a new sustainability paradigm? *J Clean Prod* 143:757–768
2. Winans K, Kendall A, Deng H (2017) The history and current applications of the circular economy concept. *Renew Sust Energy Rev* 68:825–833
3. Jesus A, Antunes P, Santos R, Mendonça S (2017) Eco-innovation in the transition to a circular economy: an analytical literature review. *J Clean Prod* 172:2999–3018
4. Pietzshch N, Ribeiro J, Medeiros J (2017) Benefits, challenges and critical factors of success for zero waste: a systematic literature review. *Waste Manag* 67:324–353
5. Herczeg G, Akkerman R, Hauschild M (2018) Supply chain collaboration in industrial symbiosis networks. *J Clean Prod* 171:1058–1067
6. Klein N, Ramos TB, Deutz P (2020) Circular Economy Practices and Strategies in Public Sector Organizations: An Integrative Review. *Sustainability*. 12(10):4181. <https://doi.org/10.3390/su12104181>
7. Niero M, Hauschild M (2017) Closing the loop for packaging: finding to operationalise circular economy strategies. The 24th CIRP Conference on Life Cycle Engineering. *Procedia CIRP* 61:685–690
8. Tecchio P, McAlister C, Mathieux F, Ardente F (2017) In search of standards to support circularity in product policies: a systematic approach. *J Clean Prod* 168:1533–1546
9. Di Maio F, Rem P, Baldé K, Polder M (2017) Measuring resource efficiency and circular economy: a market value approach. *Resour. Conserv. Recycl* 122:163–171
10. Huysman S, Schaepeemeester J, Ragaert K, Dewulf J, Meester S (2017) Performance indicators for a circular economy: a case study on post-industrial plastic waste. *Resour., Conserv. and Recycling* 120:46–54
11. Kalmykova Y, Sadagopan M, Rosado L (2018) Circular economy – from review of theories and practices to development of implementation tools. *Resour Conserv Recycl* 135:190–201
12. UN (2015) Global Sustainable Development Report, 2015 edition. United Nations - Department of Economic and Social Affairs.
13. EC (2015) Closing the loop - an EU action plan for the Circular Economy (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. No. COM(2015) 614 final). European Commission, Directorate-General for the Environment.
14. EC (2020) Changing how we produce and consume: new circular economy action plan. For a cleaner and more competitive Europe. Available at: https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf
15. Whicher A, Harris C, Beverly K, Swiatek P (2018) Design for circular economy: Developing an action plan for Scotland. *J Clean Prod* 172:3237–3248
16. WRAP (2010) Re-defining plastics: from design to disposal. Waste and Resources Action Programme. Available at: <http://www.wrap.org.uk/>.
17. HCH (2018) Holland circular hotspot - sharing innovation. Holland Circular Hotspot (HCH) Available at: www.netherlandscircularthotspot.nl
18. Eygen E, Laner D, Fellner J (2017) Circular economy of plastic packaging: Current practice and perspectives in Austria. *Waste Manag* 72:55–64
19. Dahlbo H, Poliakova V, Myllari V, Sahimaa O, Anderson R (2017) Recycling potential of post-consumer plastic packaging waste in Finland. *Waste Manag* 71:52–61
20. DR (2017) Plano de Ação para a Economia Circular em Portugal. *Diário da República*, 1ª Série, nº. 236. 11 de Dezembro de 2017. Resolução do Conselho de Ministro n.º190-A/2017. Portuguese Ministers Council Resolution – Action Plan for Circular Economy in Portugal.
21. EMF (2013) Towards the Circular Economy: opportunities for the consumer goods sector (No. Vol. 2). Ellen MacArthur Foundation (EMF).
22. Foley, J.; Wilkinson, K.; Frischmann, Chad; Bayuk, K.; Allard, R.; Gouveia, J.P.; Mehra, M.; Toensmeier, E.; Forest, Chris E.; Gentry D (2020) The drawdown review - climate solutions for a new decade. Available at: <https://www.drawdown.org/>

23. Hawken P, Wilkinson K, Frischmann C, Allard R, Bayuk K, Gouveia JP, Mehra M, Toensmeier E, Chissel C et al (2017) Drawdown: the most comprehensive plan ever proposed to reverse global warming. Penguin
24. EMF (2017) The new plastics economy: rethinking the future of plastics & catalysing action. Ellen MacArthur Foundation (EMF)
25. Plastics Europe (2015) Plastics—the Facts 2015.
26. Plastics Europe (2017) Plastics – the Facts 2016. An analysis of European plastics production, demand and waste data. Available at: www.plasticseurope.org/en/resources/market-data
27. EMF (2018). New Plastics Economy. Ellen MacArthur Foundation. Available at: <https://newplasticseconomy.org/>
28. Eco.nomia portal in <https://eco.nomia.pt>
29. Portuguese Republic (2017) – Action plan for circular economy in Portugal: 2017-2020: leading the transition. Environment, Economy, Agricultural, Forest and Rural development, Science, Technology and higher education ministries.
30. Licciardello F (2017) Packaging, blessing in disguise. Review on its diverse contribution to food sustainability. *Trends Food Sci Technol* 65:32–39
31. Mendonza (2017) Integrating backcasting and Eco-design for the Circular Economy. The VECE Framework. *J Ind Ecol* 21(3):526–554
32. Bocken N, Short S, Rana P, Evans S (2014) A literature and practice review to develop sustainable business model archetypes. *J Clean Prod* 65:42–56
33. Brown J, Hurley T (2009) Conversational leadership: thinking together for a change. *The Systems Thinker* 20:2–7
34. Brown J, Isaacs D (2001) The WORLD CAFÉ : living knowledge through conversations that matter. *The Systems Thinker* 12:1–5
35. Quist J, Vergragt P (2006) Past and future of backcasting: the shift to stakeholder participation and a proposal for a methodological framework. *Futures* 38:1027–1045
36. Welch D, Keller M, Mandich G (2017) Imagined futures of everyday life in the circular economy. *Special Topic, Interactions*, 24, 2 (February 2017), 46-51
37. WCCF (ND). *The World Cafe: Shaping Our Futures Through Conversations That Matter*. The World Café Community Foundation Available at: <http://www.theworldcafe.com/>
38. Videira N, Lopes R, Antunes P, Santos R, Casanova J (2012) Mapping maritime sustainability issues with stakeholder groups. *Syst Res Behav Sci* 29(6):596–619
39. Lopes R, Videira N (2016) A collaborative approach for scoping ecosystem services with stakeholders: the case of Arrábida Natural Park. *Environ Manag* 58:323–342
40. EBSP (2017) European Bioeconomy Stakeholders Panel. European Bioeconomy Stakeholders Manifesto
41. Santagata R, Zucaro A, Viglia S, Ripa M, Tian X, Ulgiati S (2020) Assessing the sustainability of urban eco-systems through Emergy-based circular economy indicators. *Ecol Indic* 109:105859. <https://doi.org/10.1016/j.ecolind.2019.105859>
42. Kristensen HS, Mosgaard MA (2019) A review of micro level indicators for a circular economy – moving away from the three dimensions of sustainability? *J Clean Prod* 118531. <https://doi.org/10.1016/j.jclepro.2019.118531>
43. Pauliuk (2018) Critical appraisal of the circular economy standard BS 8001:2017 and a dashboard of quantitative system indicators for its implementation in organisations. *Resour Conserv Recycl* 129(2018): 81–92
44. Moraga G, Huysveld S, Fabrice M, Blengini GA, Alaerts L, Acker KV, Meester S, Dewulf J (2019) Circular economy indicators: what do they measure? *Resour Conserv Recycl* 146:452–461
45. SPV (2020a) Manual de Normas Iconografia de Reciclagem [Manual of Standards Recycling Iconography] available at: https://www.pontoverdelab.pt/wp-content/uploads/2020/05/MANUAL-DE-NORMAS_ICONOGRAFIA-RECICLAGEM.pdf
46. SPV (2020b) Ponto Verde Lab – O que é o Pack 4 recycling? [What it is the packing4recycling?] <https://www.pontoverdelab.pt/pack4recycling/pack4recycling/>