EBC 2030

CATALAN BIOECONOMY STRATEGY

Generalitat de Catalunya

Generalitat de Catalunya
Departament d'Acció Climàtica, Alimentació i Agenda Rural

CTFC

IRTA

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Text:

DACC
Jaume Sió
Ignasi Rodríguez
Clara Solé

CTFC
Roser Maneja
Neus Puy
Antoni Trasobares

IRTA
Francesc Prenafeta
Ralph Rosenbaum

External editors:
Christian Patermann
Marc Palahí

CONTENTS

FIGURES AND TABLES

EBC 2030

CATALAN BIOECONOMY STRATEGY

The Department of Climate Action, Food and Rural Affairs faces the great challenge of tackling the fight against climate change and leading the necessary green transformation to make Catalonia sustainable from an economic, social and environmental point of view. The situation generated by the pandemic has demonstrated the essential strategic nature of the food production sector, in addition to our need to reconnect with the territory, push for local initiatives in a determined way and capitalise on the circular economy. The circular bioeconomy is, therefore, a great opportunity for leading the transformation which will allow us to address the challenge posed by climate change, attain a just and sustainable food system, and progress toward territorial balance.

There is an urgent need for society as a whole to participate in the bioeconomy and for the bioeconomy to represent a firm and decisive strategic commitment of companies in terms of their viability and environmental responsibility. We must capitalise on our potential to generate economic activity through our country's own resources and push to develop rural and maritime areas by creating new business models which make it possible to advance toward the decarbonisation of the economy and the implementation of productive systems with a lower ecological footprint.

The 2030 Catalan Bioeconomy Strategy (EBC2030) must serve as the roadmap for this transition. It is a cross-cutting, forward-looking strategy that will make it possible to improve the sustainability and competitiveness of every sector involved, with special attention paid to the primary sector. It focuses on underdeveloped spheres and activities, and it uses knowledge generation as a motor for change. The creation of quality jobs and the pursuit of territorial balance and cohesion through the anchoring of the population to the rural environment are also fundamental pillars of the proposal. Only with an economically dynamic territory will we have a prosperous, just and balanced country.

The Strategy aims, in addition, to be an instrument for ensuring the sustainable provision of the ecosystem services supplied by our landscapes. This entails conservation, appreciation and potentiation of these landscapes through the implementation of competitive value chains in the territory which promote the preservation and improvement of agrarian soils and the creation and integrated management of resilient landscapes, adapted to climate change.

All these challenges will require new knowledge and systems that transform the food production, forestry and fishing sectors, and the rural community as a whole, in order to respond to these needs. For this reason, we must capitalise on and strengthen our system of research, innovation and knowledge transfer to develop and improve these sectors, while harnessing their transformative power through the generation of local technology.

The only way to achieve these goals, and to evolve as a society, is with collaboration and co-governance; thus, it is more necessary than ever to listen, speak and reach agreements to combine our efforts. EBC2030 responds to this spirit and has arisen from the collaboration of all the departments with jurisdiction in the issue and of a large number of implicated parties. We find ourselves presented with a unique opportunity that we must find a way to take advantage of, all together, to accelerate the economic transition to fulfil the UN Sustainable Development Goals and the European Green Deal and achieve a more sustainable, inclusive and resilient economic model.

Teresa Jordà i Roura
Minister of Climate Action, Food and Rural Affairs

Preface

Preface

The Government Plan for the 12th legislature included the commitment to drafting a strategy for the circular bioeconomy in Catalonia, with the aim of promoting the efficient use of all natural resources and applying innovation and technology to foster the integrated management of these resources and improve the territory's development.

In fulfilment of this commitment, through Government Agreement GOV/23/2020, the goals and content of the 2021-2030 Catalan Bioeconomy Strategy (hereinafter, EBC2030) were passed, and its launching was entrusted to the Department of Agriculture, Livestock, Fisheries and Food, in collaboration with the rest of the Catalan government departments involved.

The drafting of EBC2030 follows the guidelines of the European Strategy, passed in 2012 and updated in 2018, which considers it fundamental to put into action, in the near future, the local and regional strategies designed to maximise the use of the circular bioeconomy sector's potential to generate economic activity.

Taking these precedents into account, the goal of EBC2030 is to:

EBC2030 goal:
Promote the sustainable growth and development of the Catalan economy by fostering the production of biological resources and local and renewable processes.

To achieve this goal, the aforementioned Government Agreement establishes a series of **principles** which must be observed and have been fully incorporated into and supplemented in the document:

- Integrate and supplement the policies and strategies developed by the Catalan government in all bioeconomy-related areas.
- Guarantee food security and independence, foster all uses which may be incorporated into the food chain and avoid any new uses which may compromise this goal.
- Contribute to mitigating and adapting to climate change, and fulfil the commitments acquired in these areas.
- Guarantee circularity and sustainability, in all the actions promoted, and include these two principles in policy design.
- Guide the interventions proposed towards developing the less economically favoured areas of the territory.
- Support research and innovation geared toward identifying new uses and products.
- Ensure the participation of all parties involved in both the drafting and the implementation and follow-up of EBC2030.

In addition, EBC2030 also incorporates the following **principles** due to their relevance and cross-cutting nature:

- Contribute to stopping biodiversity loss, conserving our natural heritage, supporting ecosystem services and advancing toward adaptation and resilience to climate change.
- Promote the efficient use of natural resources, especially water and energy.
- Include the one health paradigm, which links the health of ecosystems to human wellbeing.
- Foster the consolidation and incorporation of women in the activities promoted and guarantee the presence of women in leadership roles.
- Reinforce the leadership of the Catalan food sector and its international outreach.
- Promote the link between the urban environment and the primary sector to establish the alliances needed to achieve a circular bioeconomy.

To achieve the goal of EBC2030 and in line with the previously mentioned principles, the aim of this strategy is to initiate the various actions which have the capacity to transform and make it possible to advance the circular bioeconomy in Catalonia. These actions will form part of triennial action plans, supplemented by the interventions of the various groups promoting the bioeconomy in Catalonia.

Thus, to achieve the aforementioned goal, and always following these principles, the following **criteria** have been considered in the drafting of EBC2030:

Activate and raise awareness on the territory and its resources, including a**gricultural and forest biomass, fishing and aquaculture** and **natural capital** (biodiversity and ecosystem services), through the implementation of competitive **value chains** in the territory to promote socially, economically and environmentally **resilient landscapes**, adapted to climate change.

Become an opportunity for the **primary sector** to develop in collaboration with **other productive and environmental sectors** associated with the environment. Support rural and coastal areas in Catalonia, augmenting the creation of regional value by implementing innovative circular bioeconomy solutions and creating attractive, sustainable jobs.

Promote the **technological transformation** of biomass –from forestry, farming, livestock and fishing– into **bioproducts, biomaterials and bioenergy** by making use of local renewable biomass, reducing waste generation in the supply chain and changing consumption habits (demand and use of bioproducts).

Seek **innovative solutions** in the area of bioeconomy through the convergence between the disciplines which constitute the principal motors of the current scientific and technical revolution: biotechnology and digitalisation.

Implement productive systems with **low environmental impact** in terms of **emissions** (greenhouse gases, unmanaged excess nutrients, phytosanitary and zoosanitary products, among others) and resource **consumption**.

Advance toward a **healthy and sustainable food production system**, with competitive value chains, in the current context of climate change, which contribute to decarbonising the economy and achieving the Sustainable Development Goals (hereinafter, SDGs) and the Paris Agreement.

Spread and reinforce **knowledge and awareness** of the circular bioeconomy to bring about economic, social and environmental change.

Frame of reference

EBC2030 in the post-Covid-19 and European Green Deal context

There is more and more evidence that our current globalised model of economic management, centred on the classic approach of GDP growth, is beginning to show clear limitations when it comes to addressing the main global challenges before us. The current context of climate change, population growth and overcrowding in urban areas, and the more-than-foreseeable limitations on clean water, food, natural resources and energy, demonstrate this fact.

In recent years, there have occurred a number of adverse events linked to climate change and the phenomenon of globalisation (extreme weather events, large forest fires, invasive species, pests and diseases), which happen ever more frequently and may cause serious problems for natural ecosystems, crops and infrastructures, even leading to the loss of human life.

Post-COVID-19

The Covid-19 pandemic, closely linked to the effects of this globalisation and to human-induced disruptions in biodiversity, has confronted us with an unprecedented scenario, forcing us to tackle a health, social and economic challenge on top of the already delicate environmental situation associated with the climate emergency.

In this new and highly complex scenario, **having a strong primary sector, with an advanced degree of autonomy and social, economic and environmental sustainability, is vital.**

Now is the time to intensify our efforts to face and anticipate the future by **capitalising on the territory and promoting the active management of activities linked to the primary sector, promoting existing value chains and implementing new ones, making sustainability and competitiveness compatible through the circular bioeconomy.**

Thus, the global crisis generated by the impact of Covid-19 must make it possible to highlight the value of the country's primary sector and the sustainable management of the territory. It calls on us to reconsider the current **economic model** and advance in the transition from a linear economic model, based on resources derived from raw materials and fossil fuel energy, toward a **circular bioeconomy**. model. In this context, the primary sector becomes the cornerstone of this circular bioeconomy and one of the essential pillars for the mitigation of climate change. Thus, it is essential to guarantee social and economic stability as well, by, among other means, activating rural and coastal areas, creating jobs and diversifying farm, forest and fishing income.

European Green Deal

In fact, one of these great challenges is the European Green Deal, which aims to transform Europe into the first carbon-neutral continent by 2050. In pursuit of this goal, the European Commission has launched two major initiatives: the Biodiversity Strategy[1] and the Farm-to-Fork Strategy[2].

The aim of the first strategy is to halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2050 through their protection, recovery and restoration. The second strategy aims to advance toward fairer, healthier and more sustainable systems, and it establishes a series of goals: to reduce pesticide use by 50% and fertiliser use by 20% in the agricultural systems of Europe. It also aims to reduce the use of antimicrobials (mainly the antibiotics used in cattle raising and aquaculture) by 50%. The strategy states that organic farming is an environmentally sustainable practice which must be pursued; therefore, it calls to raise the current percentage of organic farming throughout Europe, from 8% to 25% by 2030. Thus, the strategy emphasises the importance of informed consumer decisions and the need to increase the efficiency of the food chain through measures such as labelling sustainable food or supporting the fight against food waste.

1 https://ec.europa.eu/environment/strategy/biodiversity-strategy-2030_en
2 https://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm

These two Green Deal strategies will have to be coordinated in conjunction with the implementation of the European Bioeconomy Strategy updated in 2018, which quite clearly establishes that there is no **circular bioeconomy without conserving biodiversity and natural capital** in general. In the same way, the European Forest Strategy must also fit well within this framework.

At this time, the European Green Deal has become the central frame of reference in relation to the European economic recovery plan designed to tackle the effects of the crisis caused by Covid-19. However, it is important not to lose sight of the fact that the principal emergency faced by humanity today is still, without a doubt, the climate crisis.

Cross-cutting instruments for fostering and supporting the circular bioeconomy

Here follows a list of the cross-cutting instruments for fostering and supporting the circular bioeconomy in the international, European, statewide and Catalan spheres which have been taken into account in the drafting of the 2030 Catalan Bioeconomy Strategy (EBC2030).

Given that the Bioeconomy Strategy does not have legal content, when other plans and strategies incorporate aspects of mandatory fulfilment, they will prevail over what EBC2030 proposes.

International Plans and Strategies

UNITED NATIONS AGENDA 2030

- 2030 Agenda for Sustainable Development (United Nations)

European Commission

- European Bioeconomy Strategy (European Commission)
- Common Agricultural Policy (European Commission)
- Common Fisheries Policy (European Commission)
- Circular Economy Action Plan (European Commission)
- RIS3 –Catalan Research and Innovation for Smart Specialisation Strategy (European Commission)

GREEN DEAL

- Farm-to-Fork Strategy in the framework of the Green Deal (European Commission)

Horizon 2020

- Horizon 2020 – Framework Programme for Research and Innovation (European Commission)
- Horizon Europe – Framework Programme for Research and Innovation (EC) 2021-2027

BBI JU

- BBI: Bio-based Industries – Public-Private Partnership between the EU and the Bio-based Industries Consortium

Plans and Strategies of Other States

bioeconomy+

- Finnish Bioeconomy Strategy (Ministry of Economic Affairs and Employment)

Baden-Württemberg

- The Baden-Württemberg government's sustainable bioeconomy strategy (Ministry of Rural Affairs and Environmental Protection and Ministry of the Environment, Climate Protection and the Energy Sector)

UNE STRATÉGIE BIOÉCONOMIE POUR LA FRANCE

- A bioeconomy strategy for France (Ministry of Agriculture and Food)

Bayerisches Staatsministeriung

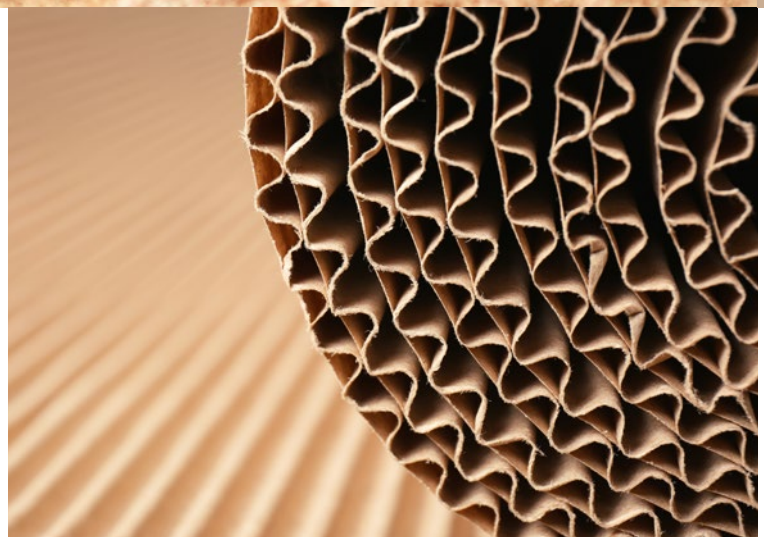
- Bavarian Bioeconomy Strategy

Spanish Plans and Strategies

- The Spanish Bioeconomy Strategy. Horizon 2030. (Ministry of Economy and Competitiveness)
- The Spanish Circular Economy Strategy (Ministry for the Ecological Transition and Democratic Challenge)
- The Andalusian Circular Bioeconomy Strategy (Government of Andalusia)
- 2030 Extremadura 2030. Strategy for a green and circular bioeconomy (Government of Extremadura)

Catalan Plans and Strategies

- 2021-2026 Strategic Food Plan of Catalonia (Strategic Food Plan for Catalonia 2021-2026)
- 2030 Catalan Strategic Plan for Food Production Research, Innovation and Transfer (Department of Agriculture, Livestock, Fisheries and Food)
- 2030 Maritime Strategy of Catalonia (Department of Agriculture, Livestock, Fisheries and Food)
- Strategy for Promoting Farm and Forest Biomass Energy Use (Catalan Energy Institute)
- 2020-2025 Forest Agenda (Department of Agriculture, Livestock, Fisheries and Food)
- Catalan Rural Development Programme (Department of Agriculture, Livestock, Fisheries and Food)
- *Aprofita els Aliments* (Department of Agriculture, Livestock, Fisheries and Food)
- Intervention Programme for Areas Vulnerable to Nitrate Pollution from Agricultural Sources (Department of Agriculture, Livestock, Fisheries and Food)
- The General Programme of Prevention and Management of Waste and Resources of Catalonia 2020 (PRECAT20) (Catalan Waste Agency)
- Catalan Strategy for Adapting to Climate Change (ESCACC) (The Catalan Office for Climate Change)
- National Agreement for the Energy Transition of Catalonia (Catalan Energy Institute)
- Catalan Energy and Climate Change Plan (Catalan Energy Institute)
- RIS3CAT (Ministry of the Vice-presidency, Digital Policies and Territory)
- Strategy for Promoting Green and Circular Economy of the Government of Catalonia. (Department of Territory and Sustainability)
- The 2030 Agenda: Transform Catalonia, Improve the World (Advisory Council for Sustainable Development)
- 2030 Catalan Strategy for Natural Heritage and Biodiversity (Department of Territory and Sustainability)
- National Agreement for a Knowledge-based Society (PN@SC) (Ministry of Buisiness and Employment)



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The circular bioeconomy: 21st-century vision

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The circular bioeconomy:
21st-century vision

There are currently multiple definitions of bioeconomy. The European Bioeconomy Strategy (2018) defines it as **sustainable and circular**. More specifically, the bioeconomy covers all sectors and systems based on biological resources (flora, fauna, microorganisms and derived biomass, including co-products and organic wastes) and their functions and principles. This definition includes: terrestrial and marine ecosystems and the ecosystem services they provide; all primary production sectors which use and produce biological resources (agriculture, livestock, forestry, fishing and aquaculture), and all economic and industrial sectors which use biological resources and processes to produce, principally, food, animal feed, bioproducts, energy and services. Following its basic principles, sustainability and circularity, the circular bioeconomy will be required to drive the renewal of industries and the modernisation of primary production systems and, at the same time, ensure the conservation of biodiversity, territorial balance and the protection of the social and economic value of the environment.

In other words, the circular bioeconomy employs **renewable biological resources** for the **production of goods and services** in all economic sectors[3]. At the same time, the circular bioeconomy aims to reduce our dependency on fossil fuels and mineral products, incorporate ecosystem and biodiversity services into the economy, promote economic development, and create new jobs in accordance with the principles established by the SDGs.

In the writing of EBC2030, the following definition of bioeconomy has been used:

> "The bioeconomy is a circular and sustainable economic model based on the use of local renewable resources to produce goods and services in all economic sectors."

3 Hetemäki, L., Hanewinkel, M., Muys, B., Ollikainen, M., Palahí, M. and Trasobares, A., 2017. Leading the way to a European circular bioeconomy strategy. From Science to Policy 5. European Forest Institute.

The circular bioeconomy, therefore, covers a wide variety of bio-products and industrial sectors (construction, packaging materials, agricultural fertilisers, food ingredients, textiles, green chemistry, energy, pharmaceuticals and nutraceuticals), as well as services associated with ecosystems. Its characteristic holistic vision gives it great potential to yield social, economic and environmental benefits, which are summarised below:

1 Inclusive economic growth and job creation

The distribution, ownership and characteristics of biological resources (from agriculture, livestock, fishing and forestry) represents a better opportunity for inclusive sustainable development and job creation than the one currently offered by non-renewable resources, especially in rural areas.

2 Climate-friendly urban and industrial development models

Cities are responsible for more than 80% of economic production worldwide, consume nearly two thirds of the world's energy, and generate more than 70% of all greenhouse gas emissions (World Bank[4]). A circular bioeconomy model can help cities become more sustainable, inclusive, safe and resilient, especially in the current context of climate change.

Building blocks made from cellulose, hemicellulose, lignin and other biomass-based construction products are already available today and are increasingly being used to make materials for different sectors and products. The correct separation and recovery of the OFMSW[5]/sewage sludges generated in the city is also worth mentioning, as is the use of waste biomass in the rural sphere to produce biomethane (later used in public transportation or injected into the natural gas network) and organic fertilisers (compost).

It is important to highlight the growing integration of the rural and urban spheres in current urban planning, where concepts like urban and peri-urban agriculture, the production of locally grown, in-season foods and, ultimately, the raising of citizen awareness on sustainability are fundamental questions for reducing atmospheric emissions.

3 Biological capital and environmental sustainability

The existence of a linear economy based on fossil-fuel energy and mineral extraction threatens the planet's biodiversity by contributing to global warming, producing toxic wastes, and causing other negative social and environmental effects. Investing in the conservation of biodiversity and halting its loss and degradation should be a priority in a sustainable circular bioeconomy, with the goal of a positive coupling between economy and ecology, both in natural and in farm- and forest-related systems.

4 Renewable energy and sustainable use of nutrients

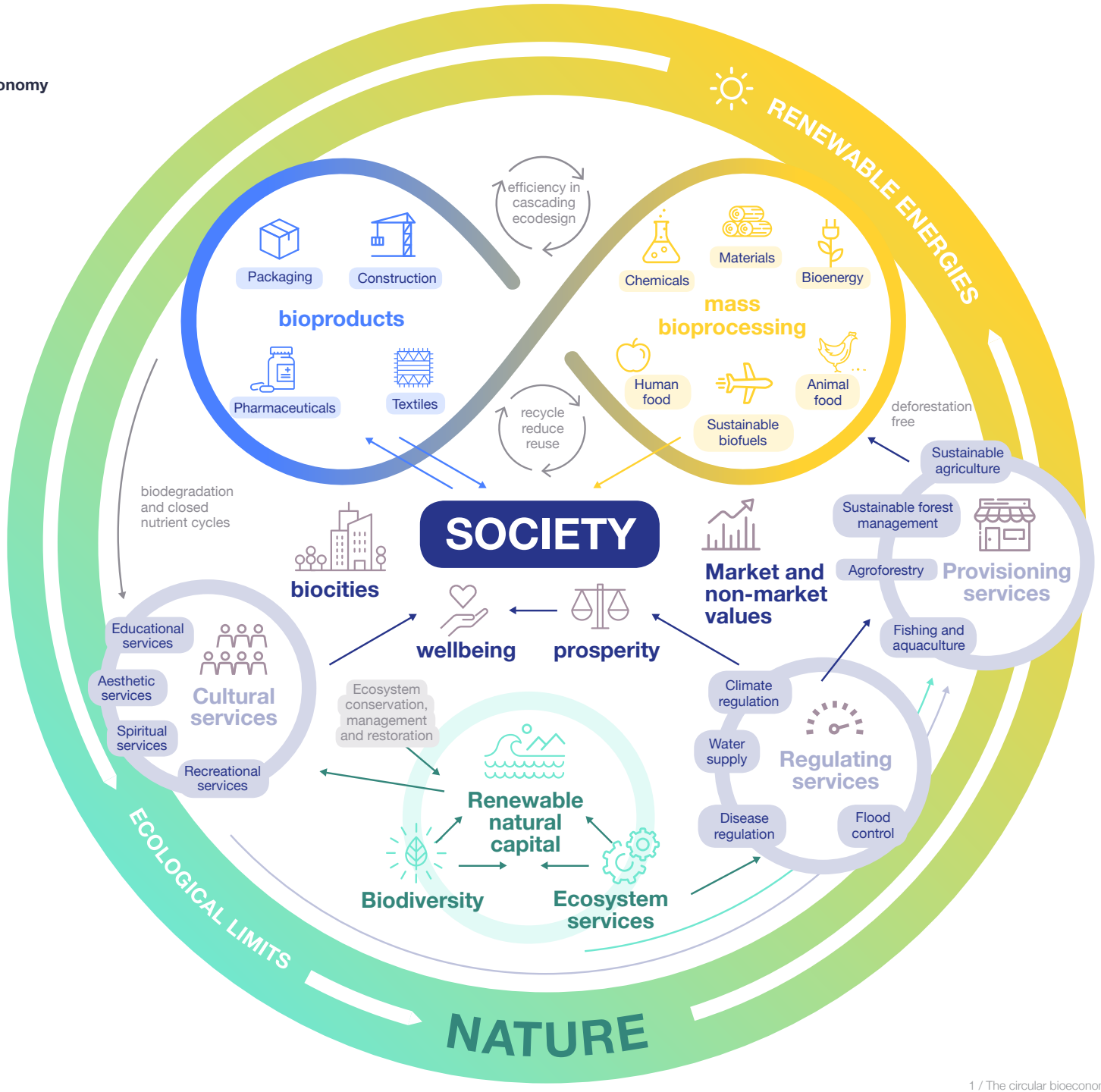
The circular bioeconomy ought to ensure synergies with sustainable renewable energy production based on forest biomass, non-food agriculture and organic wastes. It should move in the direction of closing nutrient cycles. It is crucial to recover nutrients from organic wastes (particularly phosphorus and nitrogen) and prevent their loss, whether through infiltration into aquatic systems or, in the case of nitrogen, through volatilisation of ammonia and emission of nitrous oxides into the atmosphere.

The negative impacts derived from biological production, the excessive application of fertilisers, and emissions of chemical farm products into the soil, water and atmosphere must be minimised. In this sense, the circular bioeconomy must ensure the sustainable management of nutrient cycles, through a more efficient use of fertilisers and the recycling of by-products and organic wastes, and contribute to replenishing organic matter in the soil (for example, by improving the soil's quality with organic fertilisation, while allowing it to serve as a carbon sink to mitigate the effects of climate change). Thus, regenerative agricultural practices help lower atmospheric CO_2 while raising the soil's productivity (fertility) and resistance to erosion and drought (these techniques include sowing the fields all year round with a diversified alternation and balanced rotation of the crops, or with cover crops and agricultural and forestry practices which combine extensive crops with timber and grazing).

4 https://www.worldbank.org/en/home

5 OFMSW: Organic fraction of municipal solid waste. Mainly composed of small volumes of selectively collectable, biodegradable food and plant waste. SOURCE: Catalan Waste Agency.

Figure 1
Flows in the circular bioeconomy of wellbeing.
Source: EFI



1.1

Towards a new paradigm: the circular bioeconomy

On 14 February 2017, the Government of Catalonia began designing the Plan for the Implementation of the 2030 Agenda and created the Interdepartmental Commission in charge of designing this Plan[6]. One of its main results was to demonstrate that to achieve the SDGs and effectuate measures of adapting to and mitigating climate change, it will be essential to evolve towards a circular bioeconomy model[7].

The circular economy, as defined by the Ellen MacArthur Foundation (**Figure 2**), is "*restorative and regenerative by design and aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles*".

While the circular economy aims to design products for a cycle of disassembly and reuse/recycling, and to minimise waste, the circular bioeconomy offers the possibility of replacing fossil-fuel- or mineral-based materials with renewable and biodegradable solutions. Furthermore, the circular bioeconomy can also grant new uses to materials of biological origin, in particular a longer life, greater strength and less or zero toxicity, that circularity alone, however, cannot offer. Thus, it makes sense to follow the principles of the circular economy and bioeconomy[8] and to support the utilisation of the broad concept of circular bioeconomy.

6 The Plan was established in the CADS report "The 2030 Agenda: Transform Catalonia, Improve the World", which analyses the first 16 Sustainable Development Goals (SDGs). The action of the DARP is manifested in several of the 16 goals (More information at: http://cads.gencat.cat/ca/informes/informes-per-anys/2016/lagenda-2030-transformar-catalunya-millorar-el-mon-/

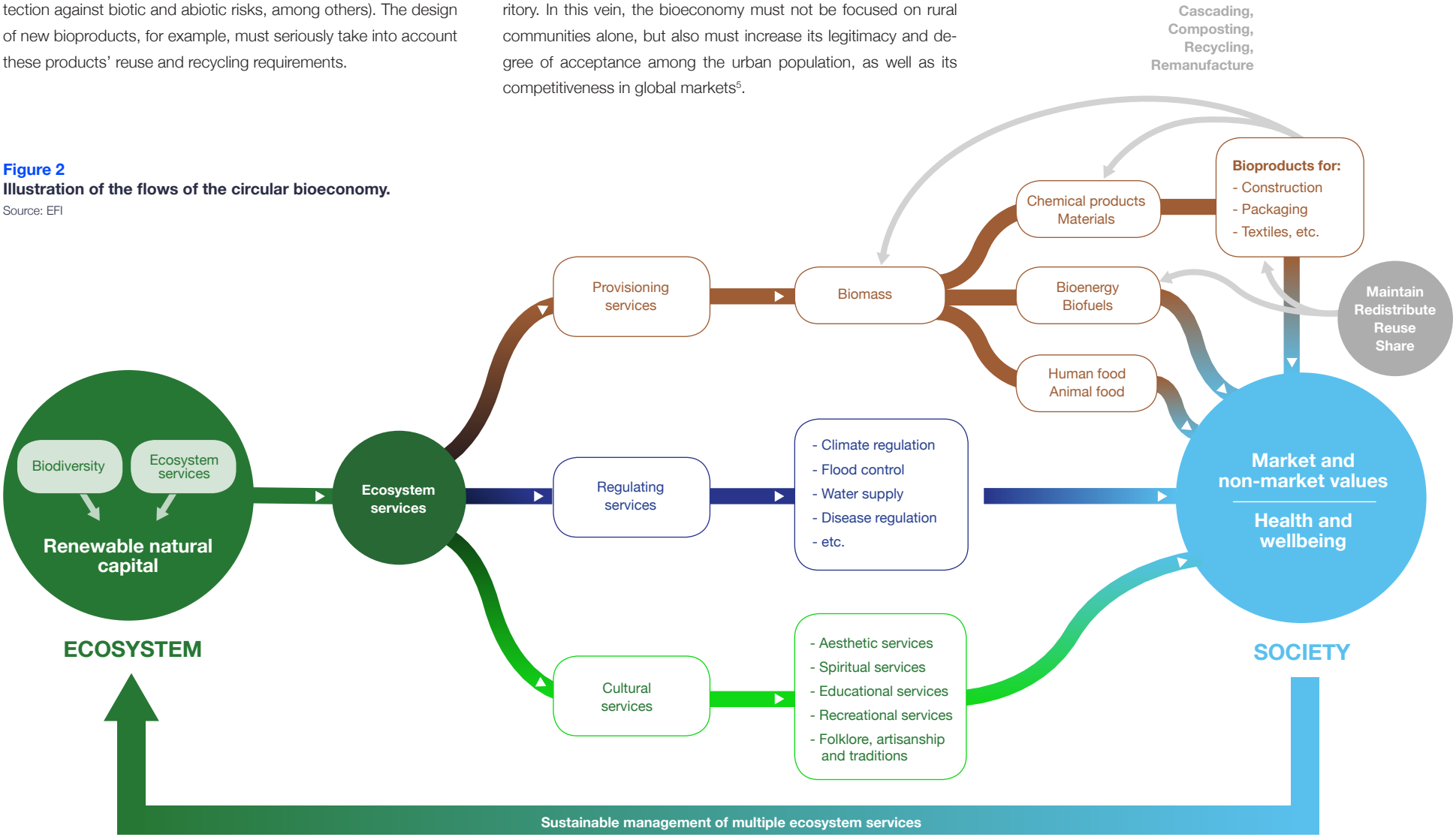
7 Hetemäki, L., Hanewinkel, M., Muys, B., Ollikainen, M., Palahí, M. and Trasobares, A., 2017. Leading the way to a European circular bioeconomy strategy. From Science to Policy 5. European Forest Institute

8 Antikainen, R. *et al.,* 2017. Renewal of forest based manufacturing towards a sustainable circular bioeconomy. Reports of the Finnish Environment Institute 13/2017. https://helda.helsinki.fi/handle/10138/186080

Nonetheless, it bears noting that neither bioeconomy nor circular economy imply sustainability by themselves, but rather that they must be made sustainable. To do so, the production of bioproducts must not compete with food production or adversely affect other ecosystem services (biodiversity, mitigation of climate change, protection against biotic and abiotic risks, among others). The design of new bioproducts, for example, must seriously take into account these products' reuse and recycling requirements.

Furthermore, the bioeconomy and circular economy must be implemented in accordance with a business model which ensures socioeconomic and environmental sustainability and prevents the concentration of business into few hands, in addition to ensuring that these businesses are spread and diversified across the territory. In this vein, the bioeconomy must not be focused on rural communities alone, but also must increase its legitimacy and degree of acceptance among the urban population, as well as its competitiveness in global markets[5].

Figure 2
Illustration of the flows of the circular bioeconomy.
Source: EFI



1.2

Circular bioeconomy and agroforestry ecosystem services

In the case of Catalonia, where the forested area comprises close to 64% of the territory, **forests play a key role in driving the circular bioeconomy** by incorporating the value of natural resources and their ecosystem services into economic development. The contribution of forests to the circular bioeconomy is summarised below:

1. They are the greatest source of terrestrial biological resources which do not compete with food production.

2. They are the region's largest green infrastructure, provide a wide range of ecosystem services and play an important – though currently underestimated – role in the economy.

3. Significant synergies between ecosystem services can be created by managing the forest; for example, reducing the risk of forest fires, supplying high-value molecules (e.g. cellulose) and materials, and controlling erosion and/or regulating seasonal water bodies.

Meanwhile, **food production in Catalonia also shows significant potential**, thanks to the great diversity of crops and typologies of livestock farms and the industrial sector which depends on them. Currently, food production contributes to the bioeconomy linked to the farming sector, given that:

1. It carries great economic weight and represents a cornerstone of territorial balance, both demographically and culturally as well as in terms of landscape.

2. It will be increasingly necessary, both in quantity and quality, which is why it is fundamental to design models for sustainable businesses adapted to local conditions.

3. It generates significant environmental impacts which, with productive practices related to the bioeconomy, can be mitigated or even reversed.

4. There is a high degree of inefficiency, which means there is significant potential to increase the use and/or recovery of resources and/or wastes.

5. It is highly synergic with other productive sectors, which can also benefit from productive methods based on the bioeconomy (for example, bioenergy or fertilisers generated from organic wastes).

Although current bioeconomy policy places a great deal of importance on activities associated with wood and food production, there are a wide variety of societal needs related to diverse economic activities based on forest and agricultural ecosystem services, including ecotourism, recreational value, non-wood forest products (primarily mushrooms, medicinal plants and herbs) and organic farming. Thus, it is important for the definition of bioeconomy to also include all economic and social activities related to the use of ecosystem goods and services.

The development of a circular bioeconomy based on the sustainable management of forests and agricultural, livestock and maritime systems[9] means developing underused ecosystem services and developing solutions whereby all the implicated parties win.

9 EBC2030 does not address activities related to the Catalan maritime space, as they are already included in the 2030 Maritime Strategy of Catalonia which considers this space's economic sectors, leisure, culture and research as well as its economic, social and environmental sustainability.

In this vein, it is possible to identify, at least, four non-exclusive spheres upon which to develop a strategy for fostering the bioeconomy:

1. Promote a circular **bioeconomy in agriculture and forestry** through the use of unexploited biomass potential, which could meanwhile produce a positive effect on other aspects of sustainability, such as fire resilience, employment and rural economies.

2. Consider the relationship between **biomass production/use and biodiversity conservation**. There is significant potential to more effectively align the production of forest biomass with the conservation of biodiversity through the competent planning, on a landscape level, of logging and extraction activities. On a broader level, the combined landscape management between forests, fields and pastures, **agrosilvopastoral mosaics**, has proven to be one of the most effective strategies for promoting biodiversity and preventing large forest fires, providing **landscapes which are more resilient** to the effects of climate change. In this sense, to make the circular bioeconomy sustainable, it will be necessary to redress potential conflicts between ecosystem services with decision-making mechanisms which combine scientific knowledge, social preferences and sustainable forest management.

3. Develop **technologies** to facilitate the use and/or **recovery** of resources and wastes from the food chain, turning biomass into industrial food compounds, feeds, chemical products, fertilisers, fuels and energy, among others.

4. Develop the significant, and frequently underestimated, potential of a circular bioeconomy based on **non-wood forest products** and short value chains or on **local and organic agricultural products**. In this vein, cultural and recreational services, frequently aligned with biodiversity and the demands of urban society, represent an opportunity to develop a local territorial identity through the creation of a brand and through processes of social innovation (nature and farm tourism, for example).

Ecosystem services can serve to improve communication with and raise awareness in urban society in terms of the contribution of forests and agricultural landscapes to human wellbeing and health. Thus, **public perception of the circular bioeconomy plays a key role** in its social acceptance and in consumer attitudes toward the products and services derived from it, with the aim of incorporating a systemic vision of the entire value chain and its economic, social and environmental impact.

As established in the definition of the United Nations Sustainable Development Goals (SDGs), the idea of an economy based only on growth for growth's sake (the GVA or GDP concept), without explicitly including natural, human and social capital and current limitations on the sustainable use of natural resources, can no longer be considered a sustainable future approach[10]. Other approaches must be analysed, such as the Genuine Progress Indicator (GPI)[11], which represents the net contribution of the economy (production and consumption) to wellbeing. If the GPI were combined with monetary estimates of the positive contribution of natural capital and ecosystem services[12], it would be possible to obtain a more accurate measurement of the circular bioeconomy's contribution to the Catalan economy and society's welfare[10].

10 Costanza, R. *et al.* (2016): Modelling and measuring sustainable wellbeing in connection with the UN Sustainable Development Goals. Ecological Economics, vol. 130, 350-355.

11 Talberth, D.J., Cobb, C., Slattery, N., 2007. The Genuine Progress Indicator 2006: A Tool for Sustainable Development. Redefining Progress, Oakland, California.

12 Sutton, P. C., Costanza, R., 2002. Global estimates of market and non-market values derived from nighttime satellite imagery, land use, and ecosystem service valuation. Ecol. Econ. 41, 509–527.

1.3

Circular bioeconomy and innovation

The circular bioeconomy will be one of the main motors of innovation in the coming years, as it could lead to a systemic change in the way resources are produced, used and recycled or transformed at the end of their life cycles and create new opportunities in the ways products and energy are supplied. Therefore, the circular bioeconomy not only creates opportunities for addressing current social and environmental problems in a context of climate crisis, but also has the clear potential to establish a new model of economy, one that allows for the creation of attractive and environmentally-friendly jobs in rural, coastal, urban and industrial areas.

Thus, the circular bioeconomy is highly synergic with the two great scientific and technical revolutions of the present time. On the one hand, the bioeconomy is supported by processes from biotechnology and bioengineering, two fields going through great advances spurred by the development of molecular biology and the omic sciences (genomics, metabolomics, synthetic biology, etc.); and, on the other, by the digital revolution which has made it possible to gather and analyse massive amounts of data of all kinds and automatically, through sensors, communication networks, artificial intelligence, etc. These new capabilities could contribute to implementing more far-reaching, efficient, sustainable and transparent models of bioeconomy.

In this sense, EBC2030 aims to contribute to offering opportunities and potentialities for innovation in environmental, economic and social areas:

1. Environmental:
The circular bioeconomy contributes to protecting against the effects of climate change, ecosystem preservation, biodiversity conservation and the sustainable use of renewable resources.

2. Economy:
The circular bioeconomy can offer new opportunities for the economy and help protect jobs, generate investment and promote innovative raw material and energy supply chains, while it may simultaneously require specialised services of high added value (expertise in biotechnology and digitalisation). Meanwhile, the circular bioeconomy has the potential to create added value in the territory, a fundamental factor for preventing depopulation..

3. Social:
The circular bioeconomy has the power to bring about the social transformation of the citizenry, moving in the direction of a more conscious and responsible model of development, biologically-based and circular, that improves citizen wellbeing.

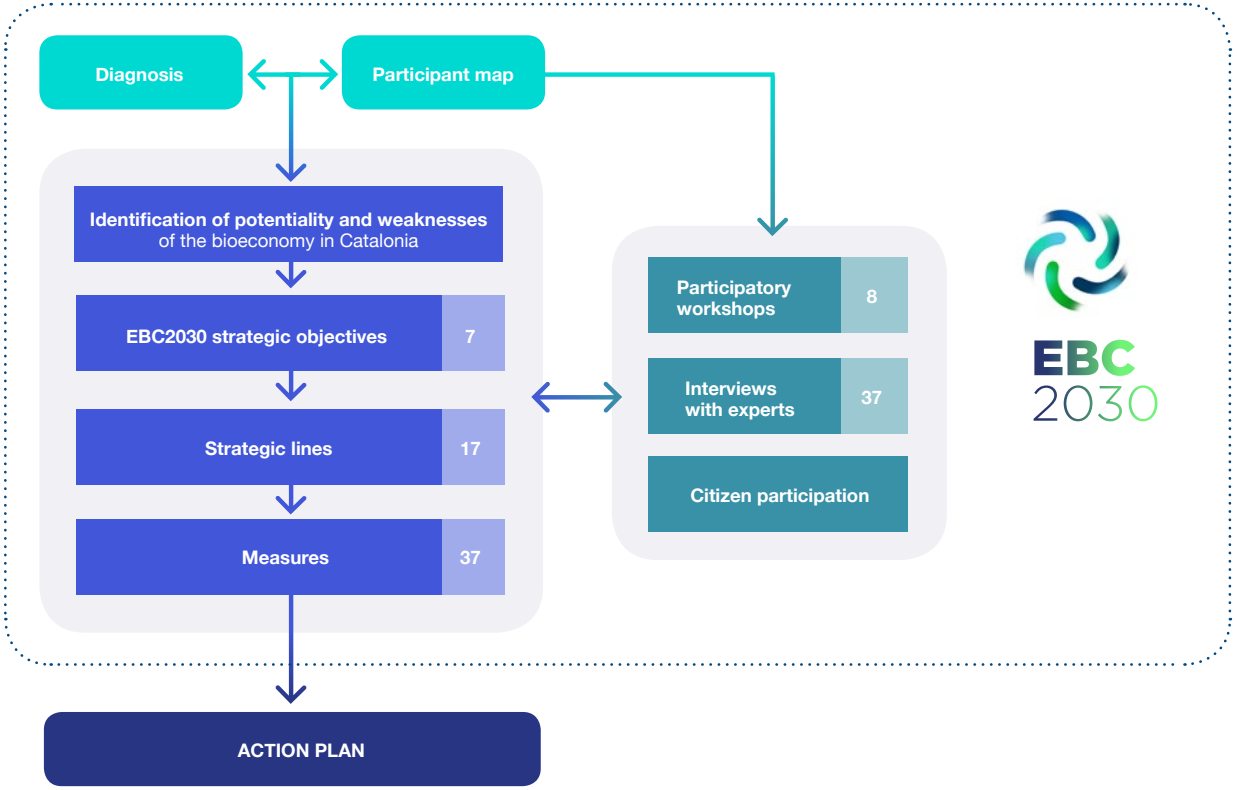
2 /

EBC2030
design process

2 / EBC2030 **design process**

The process of designing EBC2030 is shown in **Figure 3**.

Figure 3
Process of designing and validating EBC2030.




Roser Maneja - CTFC
Neus Puy
Bianca Tilliger | inèdit
Xavier | inèdit
Leandro Barquin
Jaume Sio
Antoni Traso...
Josep Ramon Sainz de...
Jaume Sió
Sergi Penedès
Oriol Gomis UPC
Carles M. Gasol | inèdit
Xavier
Joan Boix
Jesus Fernandez
Miquel Torralba
MONTSE GARDONA
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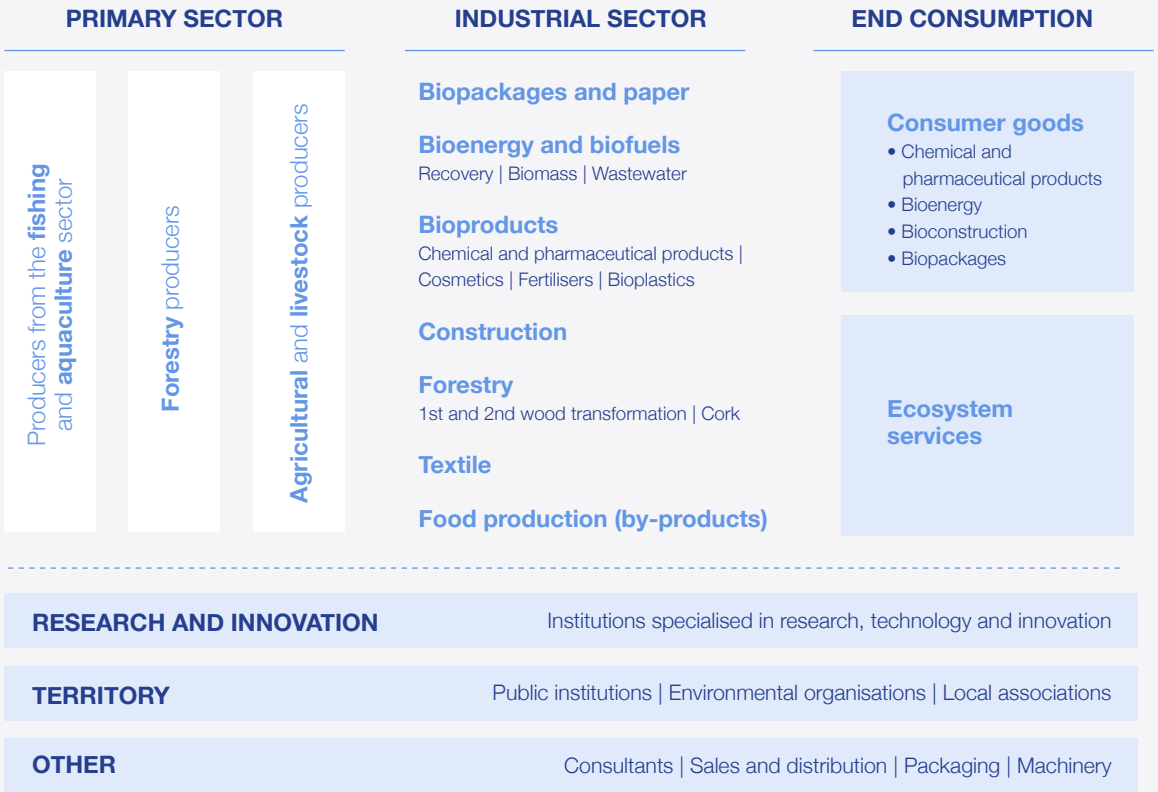
Moises
Jordi Bartolomé UAB
Guillem Segarra
Francesc Reguant
Carles Martí
Jordi
Pep Puig i Boix
Sergio Ponsa (BET...
eduard
Alberto Alcañiz - J...
Josep Pascual
Martí Boada
Meritxell Rota
Oscar Tovar
Gisela Bosch - AEC...
Carlos Llop
Seguridad
Participantes
48
Chat
Compartir pantalla
Reanudar/detener grabación
Reacciones

To effectuate the **participatory processes of EBC2030** and according to the diagnosis, the first step was to identify the interest groups (**Figure 4**) and draw a map of actors throughout the chain and from the different sectors, where 388 agents were identified, 254 of which were prioritised.

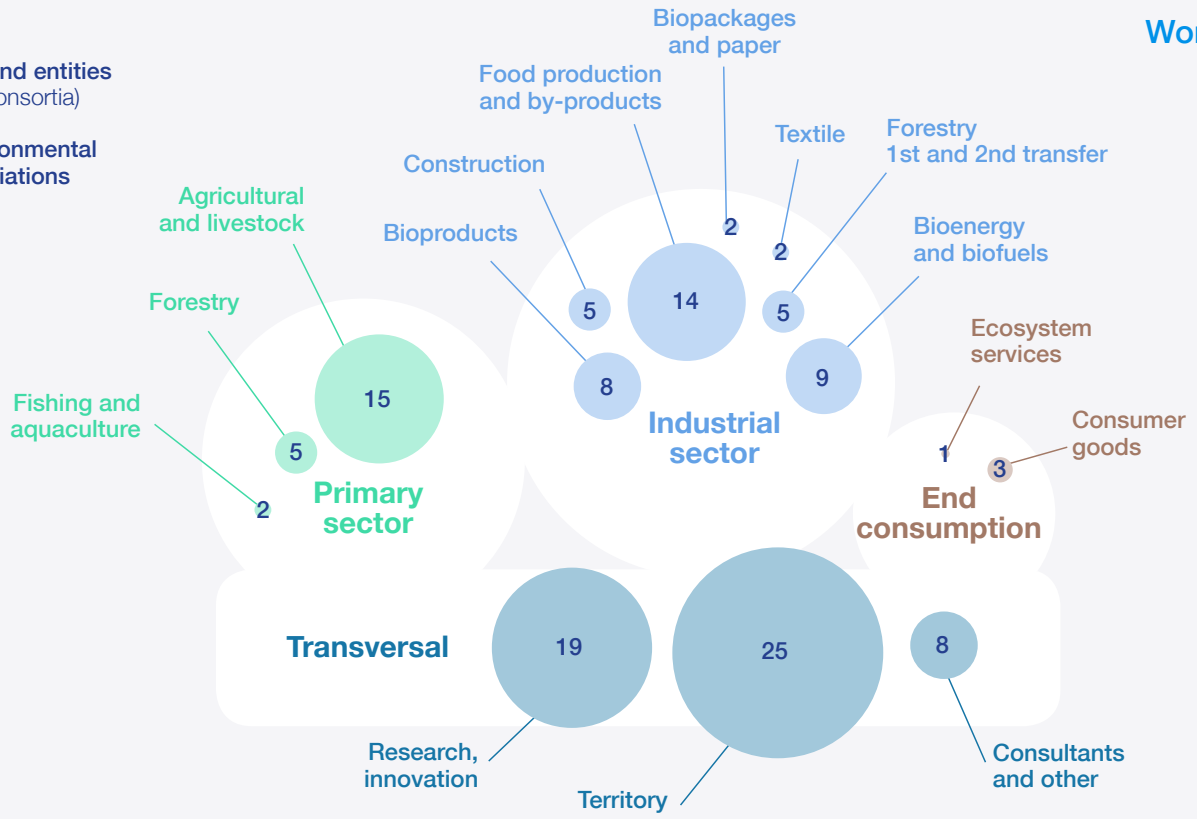
Figure 4
Interest groups for the participatory workshops of EBC2030.



Out of these, **a total of 123 agents participated** in the workshops from the primary sector, industrial sector, final consumers and related service providers (**Figure 5**).

Figure 5
Actors participating in EBC2030 co-creation and validation workshops.

- 68 private companies and entities (clusters, associations, consortia)
- 29 public entities, environmental groups and local associations
- 18 entities of research and innovation
- 8 other agents



The first co-creation workshops were held during the months of October and November 2020 and consisted of: 1 multi-sector workshop to identify barriers and opportunities; and 6 sector-specific workshops addressed the validation, identification and prioritisation of interventions and sector-specific challenges of the following value chains:

Sectoral workshops	Construction
	Bioenergy
	Byproducts from the food production sector
	Wastes from the food production sector
	Bioproducts
	Territory and citizenry

The result of these co-creation workshops was to identify the weaknesses, strengths and opportunities of the circular bioeconomy in Catalonia and to draft an initial proposal of strategic goals, strategic lines and measures, confirmed during the months of February and March 2021 in a final multi-sector EBC2030 confirmation workshop and a series of in-depth interviews with experts.

In the last multi-sector confirmation workshop, a total of 26 key sectoral actors participated. The in-depth interviews were given to a total of 37 experts from the Administration and companies and to international experts in bioeconomy (**Figure 6**). In parallel to the confirmation process, a citizen participation process was executed with the goal of informing the citizenry on the strategic goals and measures proposed in the document and receiving proposals which would make it possible to complete these goals and measures and adapt them to the needs expressed by the participants[13].

Figure 6
Participant involvement in development of EBC2030.

In total, **160 agents took part in the EBC2030 participation process**.

EBC2030 was drafted and confirmed by a working group with the different implicated sections of the driving department (DACC) itself and by a second working group with representatives of the different Catalan government departments with jurisdiction in the matter.

13 The detailed report from the participation process can be accessed through the following link: https://participa.gencat.cat/uploads/decidim/attachment/file/2596/informe_participacio_EBC2030.pdf

3 /

Diagnosis:
the circular bioeconomy in Catalonia

3.1

Importance of the circular bioeconomy in Catalonia

Quantifying the value of the circular bioeconomy requires a working definition that includes all sectors that produce natural raw materials as well as the sectors that transform these materials into bioproducts, biomaterials and bioenergy.

The numbers of the quantification of the circular bioeconomy in Catalonia for the year 2018 for the various sectors are shown in **Figure 7**. For the quantification, the data from IDESCAT has been used in accordance with the CCA3-2009[14] classification, applying the weighting scheme in the 2014 input-output framework of Catalonia[15].

14 www.idescat.cat/classificacions/?tc=5&v0=1&id=ccae-2009-ca&v2=2.

15 www.idescat.cat/estad/mioc.

Figure 7

The Catalan circular bioeconomy in figures for the year 2018 (millions EUR and jobs).

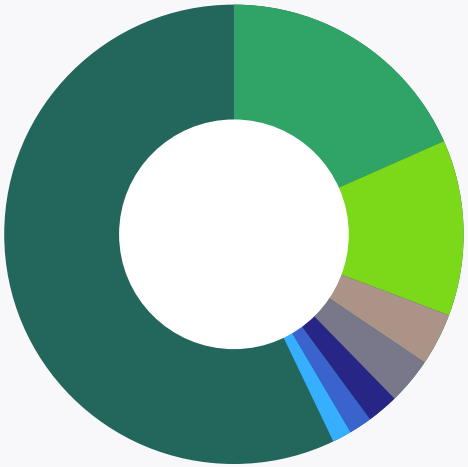
Source: Prepared by the authors using IDESCAT data.

	GVA		Production		Jobs	
	Mil EUR	vs GDP	Mil EUR	vs Total	unit	vs Total
Agriculture, livestock, forestry and fishing	2,062	0.9%	4,967	1.1%	62,469	1.7%
- Agriculture, livestock and hunting	1,843	0.8%	4,569	1.0%	56,564	1.5%
- Forestry and forest production	80	0.0%	110	0.0%	2,486	0.1%
- Fishing and aquaculture	138	0.1%	289	0.1%	3,419	0.1%
Food, beverage and tobacco industries	5,836	2.4%	28,352	6.4%	96,161	2.6%
Textile industry (natural fibres) and leather	245	0.1%	778	0.2%	2,962	0.1%
Wood and cork industries	428	0.2%	1,216	0.3%	8,803	0.2%
Paper industries	1,320	0.5%	5,183	1.2%	13,307	0.4%
Biochemical and pharmaceutical industries	453	0.2%	1,851	0.4%	1,070	0.0%
Biomass for energy	242	0.1%	394	0.1%	39	0.0%
Biodegradable waste	346	0.1%	736	0.2%	7,163	0.2%
BIOECONOMY	**10,932**	**4.5%**	**43,476**	**9.8%**	**191,973**	**5.2%**
Total	221,141		441,410		3,725,000	
Net taxes on products	20,546					
GDP	241,687					

The entirety of activities pertaining to the Catalan circular bioeconomy, in 2018, registered the following numbers (**Figure 8**):

- €43,476 million in **revenues**, equivalent to 9.8% of the total value of domestic production;
- in relation to the **value added**[16], the contribution of the bioeconomy is 4.5% with respect to the GDP;
- in terms of **employment**, it generates 192,000 jobs, or 5.2% of the total.

Figure 8
The circular bioeconomy in Catalonia (GVA 2018, million EUR).
Source: Prepared by the authors (CTFC) using IDESCAT data.



GDP €241,687 M
Bioeconomy (4.5%)
€10,932 M

€5,836 M	Food, beverage and tobacco industries
€2,062 M	Agriculture, livestock, forestry and fishing
€1,320 M	Paper industries
€453 M	Biochemical and pharmaceutical industries
€428 M	Wood and cork industries
€346 M	Biodegradable waste
€245 M	Textile industry (natural fibres) and leather
€242 M	Biomass for energy

16 The gross value added (GVA) is the sum of all additional values acquired by goods and services when transformed in the production process. The GVA is calculated by subtracting the value of the goods and services used during the process of production from the total production value. In accounting, the GVA is the difference between the sum of the company's sales revenues and the purchases made from other companies. The gross domestic product (GDP) is the GVA plus the net taxes on the products.

The weight of each economic sector in the production, employment and GVA of the Catalan circular bioeconomy (2018) is shown in **Figure 9**.

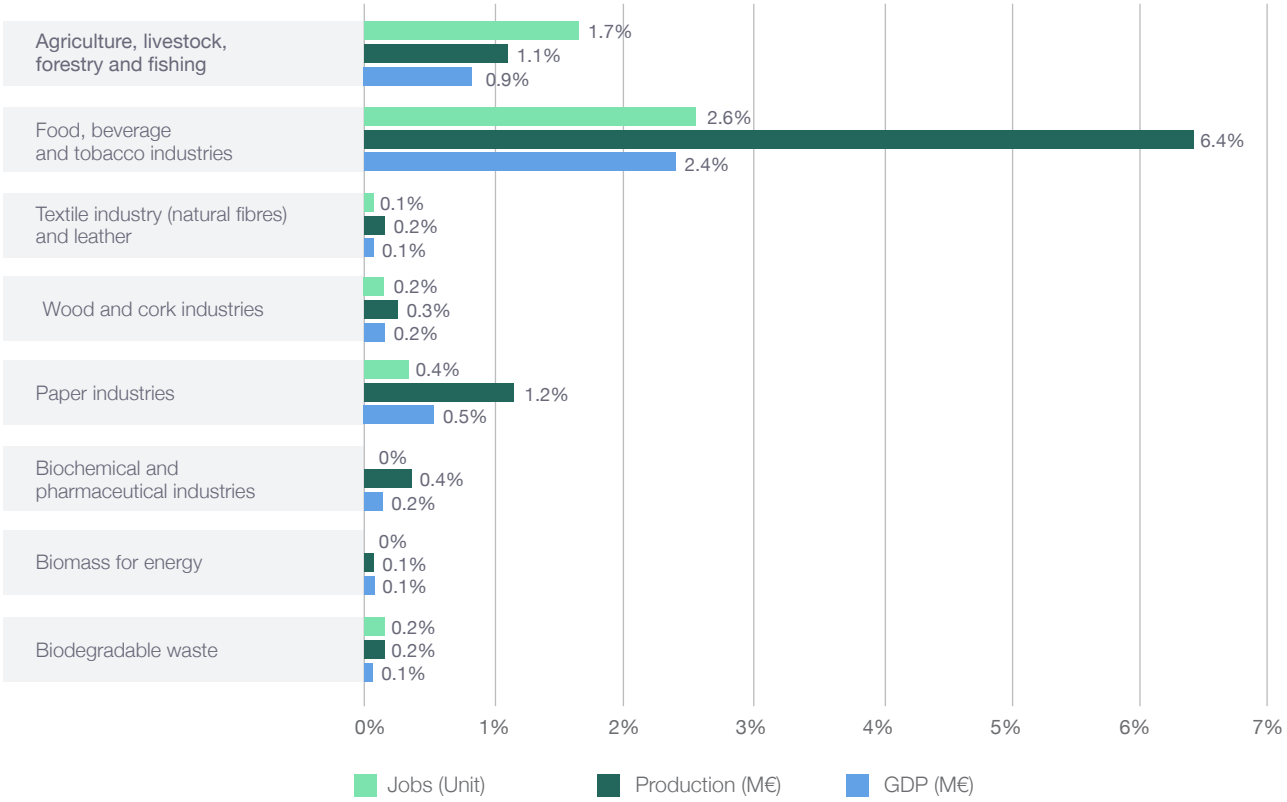
The overall picture is diverse, with a **plurality of sectors, participants and interests**. As demonstrated by the data in **Figure 9**, the dominant sector is the **food industry**, which, in the case of Catalonia, represents 2.4% of the GDP, while the sum of all other sectors amounts to 2% of the GDP.

The development of the circular bioeconomy will require the use and recovery of biodegradable resources and wastes on a larger scale, which, in turn, will require both public and private intervention in regulation, management and infrastructures. These factors make it even more important to adopt a territorial and systemic view as the circular bioeconomy is not just a sum of activities, but rather a way of understanding the balance between humans and the environment.

Figure 9

Contribution of the economic sectors associated with the circular bioeconomy which contribute to the Catalan economy (2018).

Prepared by the authors (CTFC) using IDESCAT data.



3.2

Role of the primary sector in the circular bioeconomy of Catalonia

Recent macroeconomic data from Catalonia shows that the primary sector represents 1.7% of the employed population (in comparison to 4.2% in Spain and 4% in the EU) and amounts to 0.9% of the Catalan GDP. Nonetheless, the Catalan primary sector has a large territorial presence, with 25% of the territory allocated to crops and 64%[17] covered by forest.

The transition towards a feasible bioeconomy model will depend upon a strong, highly independent and sustainable primary sector for the provision of food and other essential goods and services. The forest sector is an important part in the food and industrial product supply chain (through pallets, packing materials and packages) and also in the supply of biomass to produce bioenergy.
The Catalan farming sector has undergone an important transformation over the last few decades. It is currently distinguished, above all, by a high degree of mechanisation, the use of intensive techniques and high productivity, which has been possible, in large part, by the development in irrigation and the reduction of the number of agricultural companies (which are increasingly large, capitalised, integrated, and geared toward both exportation and the domestic market). This trend has entailed a progressive improvement in agrarian revenues.

As for fishing and aquaculture, the opportunities arising from the bioeconomy must be taken advantage of, given that, in recent years, the sector has remained in a state of constant decline, both in terms of catch data and employment, as well as in the value of these catches.

17 http://economia.gencat.cat/ca/ambits-actuacio/economia-catalana/estudis-publicacions/nota-conjuntura/numero-108/index.html.
http://agricultura.gencat.cat/ca/detalls/Article/Radiografia-de-les-explotacions-agricoles-de-Catalunya-2019

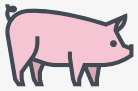
However, this model of continued growth and intensification has been brought into question precisely because of the environmental sustainability problems it generates. The reports published by the Government of Catalonia "Changes in Catalan farm companies 1999-2007"[18] and "Evolution of the main farm sector indicators: macroeconomic indicators 2015-2019"[19], and "Statistics of the ecological sector 2019"[20] indicate some significant changes which could determine new trends in the middle and long term (**Figure 10**).

Figure 10
Catalan farm sector profile.

In 2019, in Catalonia, there were 48,891 agricultural companies which farmed 25% of the total area. Over the last 5 years, the farmed area has been maintained, but the number of owners has fallen by 12%. This means the area for each farm company has risen; 88% of these owners are physical persons, while the remaining 12% are legal persons.

In terms of the total farmed area, the majority crop continues to be cereal (44%), followed by olive trees (12%), forage crops (11%), vines and nuts (7%), and sweet fruit (6%).

The typical farmer is a man of over 65 years, who grows cereal on private lands with an average size of 13 ha per agricultural company. Secondly, taking priority farm holdings (*explotació agrària prioritària*, or EAP, a Catalan administrative qualification for a farm which employs at least one person and is owned by a professional farmer), the typical farmer is a man between 41 and 55 years in age who grows cereals under a lease agreement and with an average area of 28 ha per agricultural company. Women only manage 23% of the total farmed area and own 32% of all agricultural businesses. In the case of EAPs, 13% are run by women, managing 12% of the farmed area.



With regard to livestock, in 2016 there were 11,927 agrarian companies with a total of 2,591,406 livestock units (216 LUs per company on average). The principal sector was pig production, with 36% of the livestock companies and 61% of the LUs which, with a total of 6,564,718 pigs, put Catalonia in first place on a country-wide basis. Other important livestock sectors were bovine (34% of all companies and 13% of LUs) and poultry (23% of companies and 22% of LUs). The number of pigs, in 2020, has risen to 9,572,904 heads, distributed among 5,924 companies, but in spite of this growth, Catalonia has been surpassed by Aragon in terms of pig production.

Despite the intensification of agriculture and livestock, organic production has begun to increase in importance. In 2019, there were 4,148 companies registered with the Catalan Council of Organic Agrarian Production (CCPAE), 2,338 of which are dedicated to plant production, 709 to livestock production, and 2,042 to manufacturing, marketing, importation or sale. As for the total farmed area, in 2019 as much as 229,609 ha was dedicated to organic production (this total farmed area includes forests and pastures), which represents a 9% increase from 2018.

18 https://www.idescat.cat/serveis/biblioteca/docs/cat/dossier02.pdf.

19 DARP (2019). Evolution of the main farm sector indicators: macroeconomic indicators 2015-2019. https://govern.cat/govern/docs/2019/11/28/11/29/d31c5075-83bf-416a-bcc5-eae643fae5f1.pdf

20 CCPAE (2019). 2019 statistics from the organic sector. http://pae.gencat.cat/web/.content/al_alimentacio/al01_pae/13_observatori_pae/Fitxers/estadistiques_ccpae_2019.pdf

> Figure 10 continued / Catalan farm sector profile.

Non-agricultural activities contribute to rural development (in 2007, 840 companies performed contract work using company staff, 715 activities related to tourism and 551 transformations of agricultural products). The activity which increased most in the 1999-2007 period was agrotourism[17].

3.3

Biomass use and recovery potential in Catalonia

The data on Catalonia's biomass potential is characterised by its high dispersion, the difficulty when it comes to quantifying the different resource and waste flows, and the different methodologies of quantification. Biomass is understood to be the entirety of **all organic material of plant, animal or microbial origin**, including the materials produced by natural or artificial transformation.

According to data from the Catalan Waste Agency, the **biomass potential includes the following resources**: algae, forest biomass, biowaste (OFMSW), nutshells, eggshells, biowaste compost, plant waste compost, manure compost, WWTP sludge compost, intensive agriculture sludge compost, biowaste digestate, organic waste digestate, WWTP sludge, intensive agriculture sludge, paper sludge, manure, wood from forestry use, grass, dredge spoil, food waste, coffee husks, straw, food loss, olive mill solid waste (dry/wet pomace) and wastewater, tree trimmings, slurry, slaughterhouse waste, harvest remains, natural sawdust, industrial byproducts, cork and vinasse.

Figure 11 lists the biomass resources, productive sectors, locations, competent organisations and quantities. Clearly, a great deal of data is missing, a fact which demonstrates the **need to more effectively characterise both the current quantity and the potential of biomass in Catalonia**.

Figura 11

List of biomass resources, productive sectors, locations, competent organisations and quantities produced in Catalonia in 2019.

Source: Catalan Waste Agency.

Biomass / Resource	Productive sector	Where it is produced	Competent organisations	Quantity (t/year)	
				2019	Potential
Algae	Natural systems, aquaculture	Lakes, sea, dams, beaches, rivers	EELL / ACA / CHE / DACC / ICAEN	n.d.	n.d.
Biomass (forest)	Timber harvesting operations, wood and biomass industries	Forests, sawmills, biomass industry	DACC / CTFC / CPF / FC / EELL / ICAEN / ARC	600,000	n.d.
Biowaste (OFMSW)	Municipal waste	Households, businesses, lodging (hotels, campsites, etc.), restaurant industry (restaurants, bars, etc.), schools, etc.	ARC / EELL	400,000	1,200,000
Nutshells	Nut industry	Nut shelling companies	DACC / ARC	2,000	n.d.
Eggshells	Poultry industry	Egg incubators, egg-laying farms	DACC / ARC	525	n.d.
Biowaste compost	Waste treatment	Composting plants. In Catalonia, these plants are mostly public	ARC / DACC / EELL	35,000	180,000
Plant waste compost	Waste treatment	Composting plants (public and private), gardening companies	ARC / DACC / EELL	n.d.	n.d.
Manure compost	Waste treatment	Private composting plants, farms	ARC / DACC	n.d.	n.d.
WWTP sludge compost	Waste treatment	Composting plants (public and private)	ARC / ACA	266,130	n.d.
Intensive agriculture sludge compost	Waste treatment	Private composting plants	ARC / DACC	n.d.	n.d.
Biowaste digestate	Waste treatment	Biowaste digestion and co-digestion plants (centralised or decentralised)	ARC	1,600	n.d.
Organic waste digestate	Waste treatment	Digestion and co-digestion plants for other wastes (centralised or decentralised)	ARC / ACA / DACC	230,000	n.d.
WWTP sludges	Waste treatment	Urban wastewater treatment plants	ACA / ARC	500,000	n.d.
Intensive agriculture sludge	Intensive agriculture sector	Food industry treatment plants	ARC / DACC	210,000	n.d.
Paper sludge	Paper industry	Paper industry treatment plants	ARC / DACC	n.d.	n.d.
Manure	Livestock	Animal farms (cattle, sheep, goats, pigs, poultry, horses, rabbits, others)	ARC / DACC	9,954,096	n.d.

Figure 11 continued

Biomass / Resource	Productive sector	Where it is produced	Competent organisations	Quantity (t/year)	
				2019	Potential
Wood from timber harvesting	Timber harvesting	Forest work	ARC / CPF / CREAF / CTFC / DACC / FC	n.d.	n.d.
Grass	Gardening	Garden maintenance (public and private), athletic fields, golf courses, etc.	ARC / EELL	n.d.	n.d.
Dredge spoil	Maintenance of hydraulic infrastructures	In drainage operations for rivers, canals, ports, reservoirs, dams, etc.	ACA / ARC / EELL / CHE	n.d.	n.d.
Food waste	Food production sector, distribution sector, restaurant sector	Throughout the food production and consumption chain	ARC / DACC	260,000	n.d.
Coffee husks	Food production sector	Coffee roasting industry	ARC / DACC	8,000	n.d.
Olive oil wastewater	Food production sector	Olive oil industry	ARC / DACC	11,000	n.d.
Straw	Agricultural sector	Cereal crops	DACC	n.d.	n.d.
Food loss	Food production sector	Produce industry	DACC / ARC	n.d.	n.d.
Olive dry/wet pomace	Food production sector	Olive oil industry	ARC / DACC	n.d.	n.d.
Tree trimmings	Municipal waste	Parks and gardens	ARC / EELL	1,900	n.d.
Slurry	Livestock	Animal farms	ARC / DACC	$9.4*10^6$ t[21]	n.d.
Slaughterhouse waste	Food production sector	Slaughterhouses	ARC / DACC	19,000	n.d.
Harvest remains	Agricultural sector	Cereals, horticulture	DACC	n.d.	n.d.
Sawdust (from natural wood)	Forest sector	Sawmills	DACC / CPF / CREAF / CTFC / FC / ARC	31,000	n.d.
Industrial by-products	Food production sector	Food industry	DACC / ARC	n.d.	n.d.
Cork	Forest sector	Cork industry	DACC / CPF / CREAF / CTFC / FC / ARC	n.d.	n.d.
Vinasse	Food production sector	Winemaking industry	DACC / ARC	47,000	n.d.

21 Prenafeta-Boldú, F.X. i Parera, J. (2020) Guide to livestock dejection treatment technologies in Catalonia. Department of Agriculture, Livestock, Fisheries and Food (DARP), Barcelona, 72 pages.

Figure 12 shows the potential sectors where each of the 33 previously mentioned resources can be used. The final use identified is for food and drink industries; agriculture, forestry and fishing; manufacture of paper and paper products; manufacture of textiles and garments; manufacture of wood and products of wood and cork; manufacture of articles of straw; manufacture of biobased pharmaceutical products; manufacture of biobased chemical products; and bioenergy. Evidently, most potential uses involve agriculture, silviculture and fishing; manufacture of biobased pharmaceutical products; manufacture of biobased chemical products; and production of bioenergy.

Figure 12
List of potential uses by sectors of the identified biomass resources.
Source: Catalan Waste Agency.

	Food and beverage industries	**Agriculture, forestry and fishing**	Manufacture of **paper** and paper products	Manufacture of **textiles** and garments	Manufacture of **wood** and products of wood and cork. Manufacture of articles of **straw**	Manufacture of biobased **pharmaceutical products**	Manufacture of biobased **chemical products**	**Bioenergy**
Algae	●					●	●	●
Biomass (forest)		●	●		●	●	●	●
Biowaste (OFMSW)		●					●	●
Nutshells	●	●			●	●	●	●
Eggshells	●	●				●	●	●
Biowaste compost		●				●	●	●
Plant waste compost		●				●	●	
Manure compost		●						
WWTP sludge compost		●						
Intensive agriculture sludge compost	●	●				●	●	
Biowaste digestate	●	●				●	●	●
Organic waste digestate	●	●				●	●	●
WWTP sludges		●				●	●	●
Intensive agriculture sludge		●				●	●	●

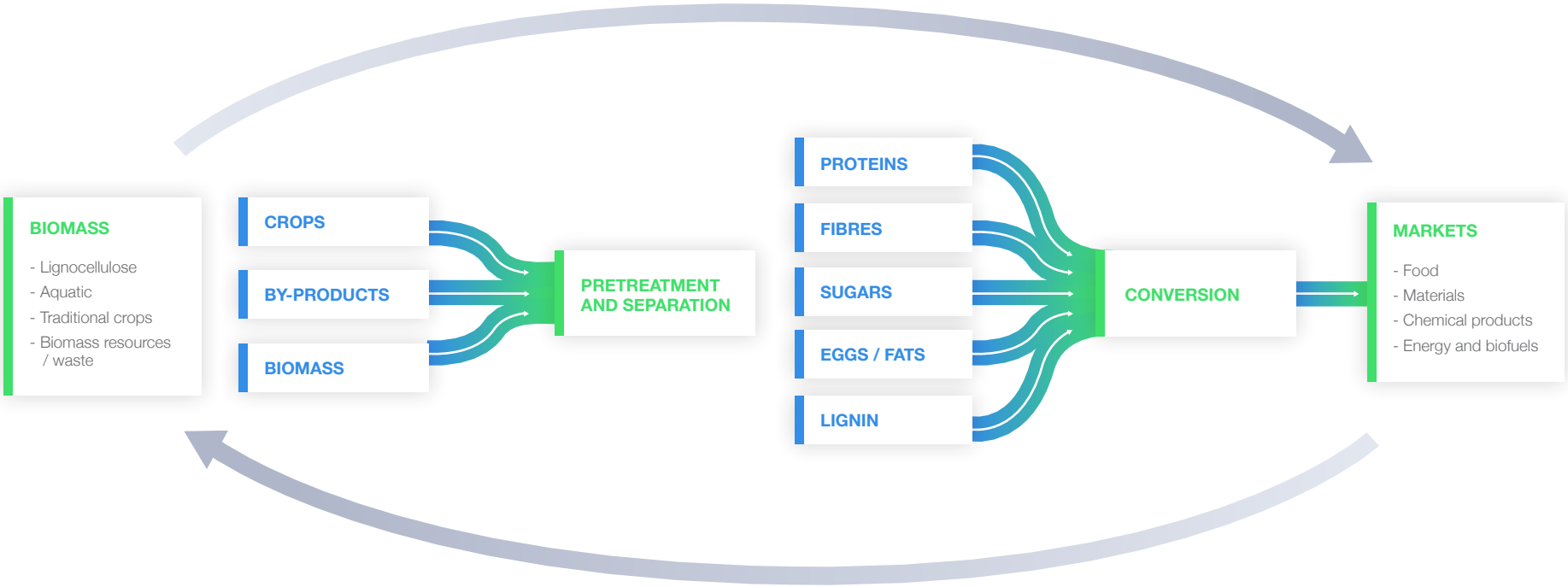
Figure 12 continued

Paper sludge		●	●				●	●
Manure		●					●	●
Wood from timber harvesting	●	●	●	●	●	●	●	●
Grass		●				●	●	
Dredge spoil	●	●	●	●	●	●	●	●
Food waste		●				●	●	●
Coffee husks		●				●	●	●
Olive oil wastewater		●				●	●	●
Straw		●			●	●	●	●
Food loss[22]	●	●				●	●	●
Olive dry/wet pomace		●				●	●	●
Tree trimmings		●	●	●	●	●	●	●
Slurry		●				●	●	●
Slaughterhouse waste		●				●	●	●
Harvest remains		●	●	●	●	●	●	●
Sawdust (from natural wood)		●	●		●			●
Industrial by-products		●				●	●	●
Cork		●	●		●			●
Vinasse	●	●				●	●	

22 Since the passing of Law 3/2020, of 11 March, on food loss and waste prevention, food losses can only be reincorporated into the soil or used for composting *in situ*

These resources and potential uses can be recovered in different ways using diverse technologies and processes. **Figure 13** shows the complete biomass recovery chain for value-added products.

Figure 13
Recovery potential of value-added products using biomass.



3.3.1
Value of the forestry sector

The **forested area** of Catalonia is **2,076,134 ha, or 64.6% of the total area. 65% of the forested area** (1,341,798 ha) **corresponds to woodlands** (Land Cover Map of Catalonia; MCSC – 2018). Between the years 1993 and 2018, the wooded forest area of the country has increased by 123,225 hectares (see **Figure 14**).

The **ownership of Catalan forests is 75.1% private and the remaining 24.9% is public**. With regard to private forest planning, 40.1% of the area is covered by Forest Ordination Instruments (Technical Plans for Forest Management and Improvement) (PTGMF) and Simple Forest Management Plans (PSGF), while 59.9% is not.

Employment in the Catalan forest sector has been decreasing in recent years. In 2000, there were 68,888 workers including salaried employees and freelancers, while by 2019, the figure had dropped to 30,928. A similar trend has been observed with respect to the number of companies, which dropped from 6,360 in 2000 to 2,545 in 2019.

Timber harvesting includes the entirety of operations consisting of the partial preparation, extraction and transport of the wood and timber obtained from the cuts effectuated, following a proper planning process, in a forest. Timber harvesting operations have increased in recent years, although they currently represent only 28% of total forest growth (see **Figure 15**).

Figure 14
Evolution of forest terrains in Catalonia 1993 through 2018.
Source: (MCSC - CREAF) / Graph:@OFC.

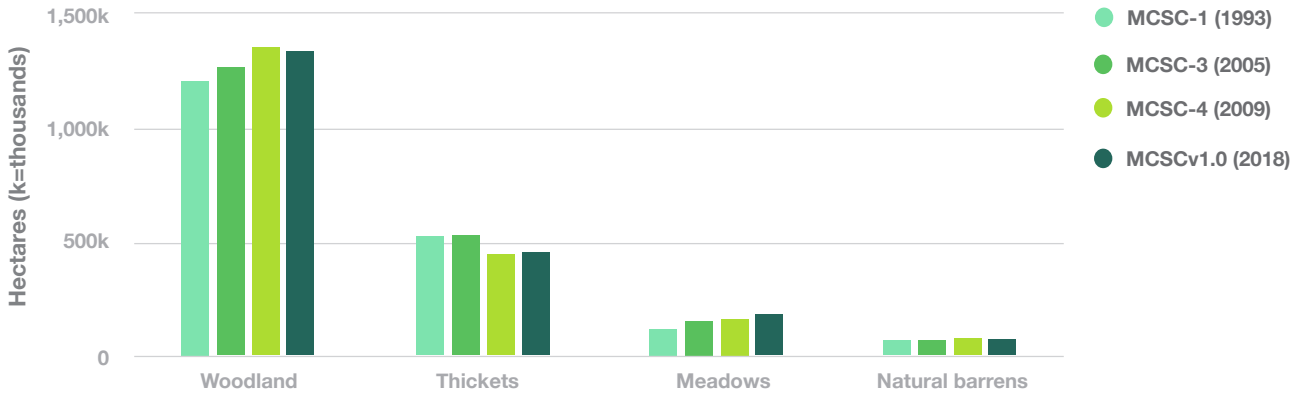
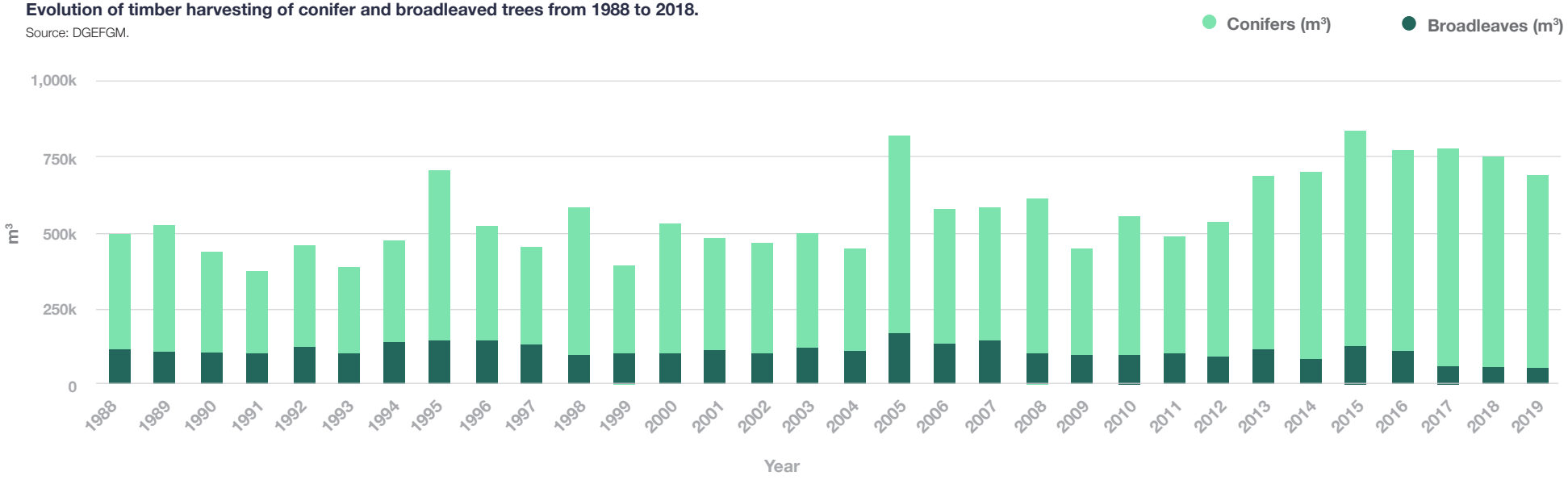


Figure 15
Evolution of timber harvesting of conifer and broadleaved trees from 1988 to 2018.
Source: DGEFGM.



As for inventory, the main species in terms of wood volume in Catalan forests are **Scots pine, Aleppo pine and holm oak**. According to the fourth and latest National Forest Inventory (2013-2016), the total wood volume of Catalan forests is **151,492,338 m³** (volume with bark). This represents a volume **increase of 22% in 15 years** with respect to the previous inventory. Given that the forested area has slightly decreased, this represents an increase in tree cover density (see **Figure 16**).

Apart from wood production, Catalan forests produce forest biomass destined to be used for the production of bioenergy and cork as well as non-wood forest products (NWFPs) such as mushrooms, truffles, pine cones and pine nuts, honey and wax, and medicinal and aromatic plants.

Thus, the forest sector in Catalonia is distinguished by the following features:

- Catalonia is an eminently forested country. Over half of its area is taken up by forest terrains: meadows, scrub, natural barrens and, above all, woodlands.

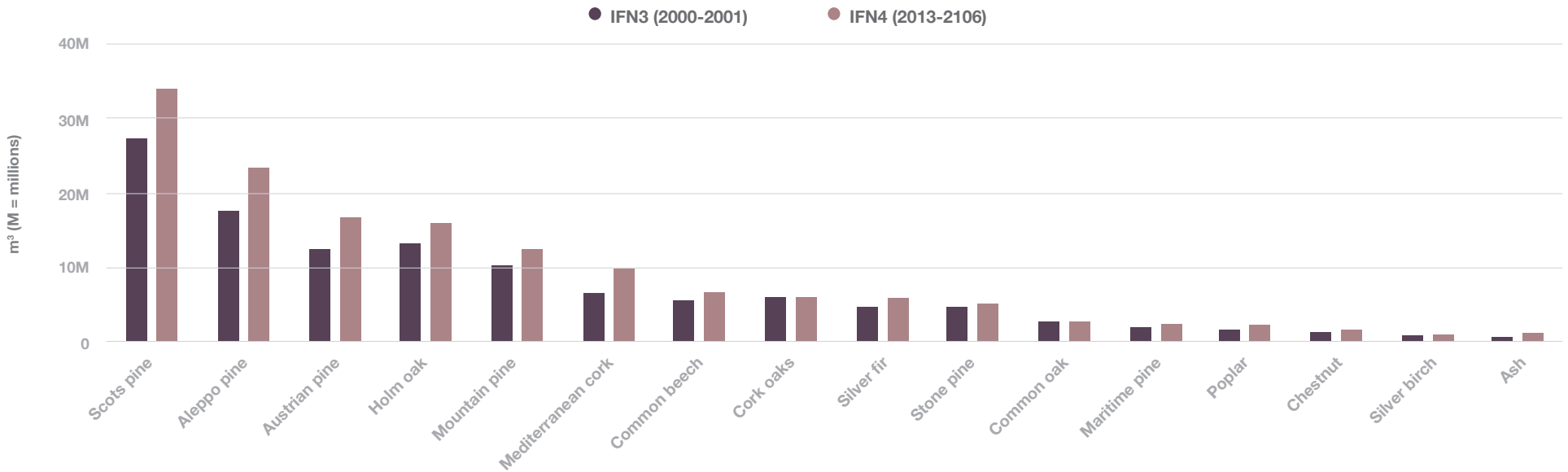
- In recent years, the woodlands have grown in both area and inventory as a result of the intense and progressive abandonment of farm land. This fact is caused by the existing value chains' lack of economic competitiveness given the main type of wood/forest (high density of low-diameter trees).

- The lack of economic viability due to the Catalan forests' intrinsic orography and features entails rural depopulation linked to the forest sector. Added to this is the lack of experts and technicians trained in forest work, one of the most limiting factors at the present time.

- Forest management must guarantee the persistence of forest cover, quantifying it with the supply of goods and services and the multi-purpose nature of forests. The sustainable use of forest resources must cover the needs of a key economic sector in the territory, thereby enabling the persistence and improvement of the forests against risks such as forest fires and climate change.

- Annual wood and timber production currently represents just 28% of total forest growth; thus, the forests maintain a high carbon sink capacity.

Figure 16
Most abundant forest species in Catalonia.
Source: Inventario Forestal Nacional.



A great diversity of products may be obtained from forest biomass (**Figure 17**):

- **Wood construction:** one of the most innovative uses of timber is CLT (cross-laminated timber), which represents an opportunity to improve energy efficiency and reduce CO_2 emissions in the construction sector. Every tonne of wood used instead of cement prevents the emission of 2 tonnes of CO_2[23] .

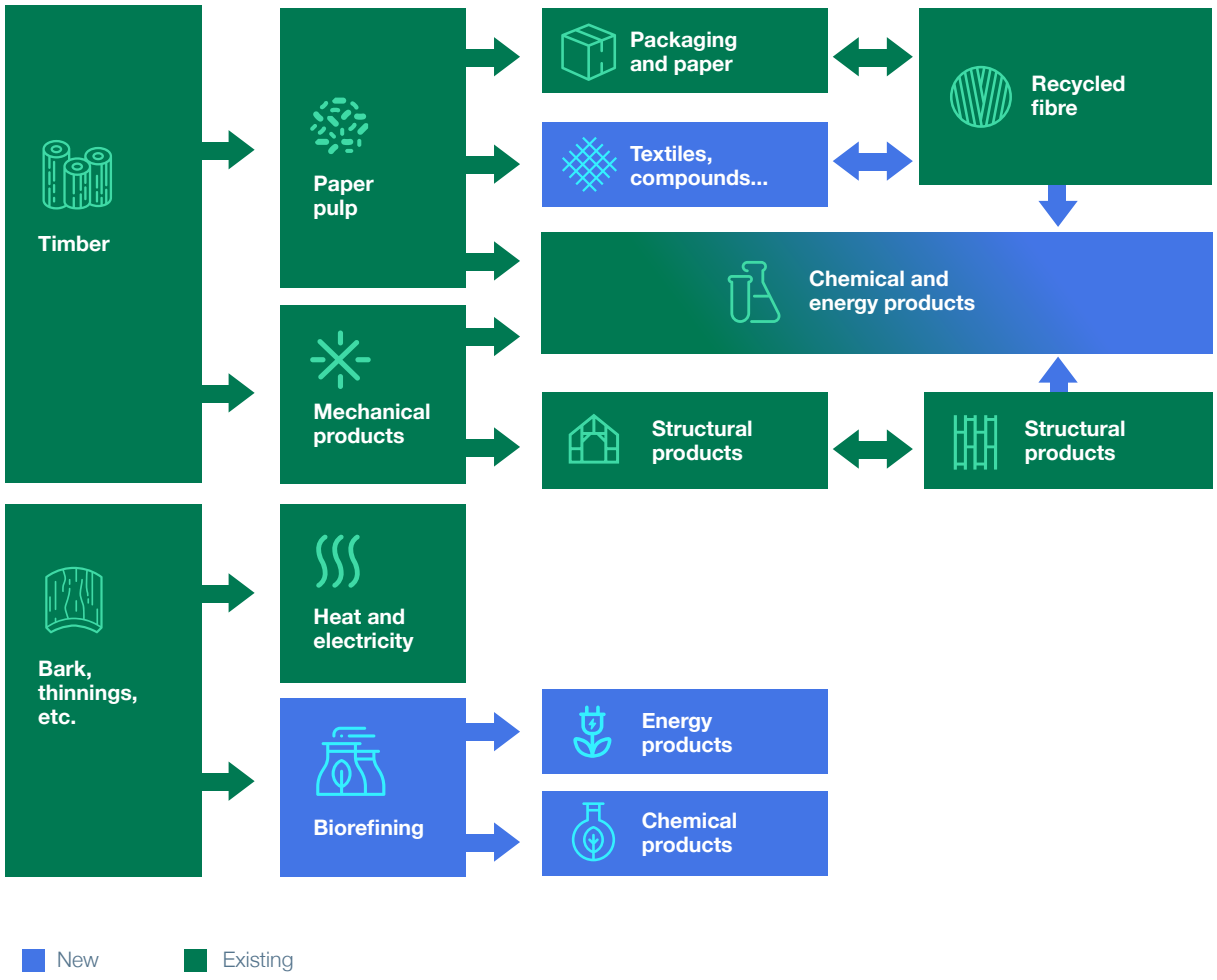
- **Solid biofuels:** fundamentally chips and pellets for thermal uses (boilers) and to generate electricity, whether in its natural state or with thermochemical treatments (torrefied biomass and biochar/biocoal) to increase its heating potential and resistance to degradation.

- **Liquid and gaseous biofuels:** bioethanol, bio-oil (liquids from biomass pyrolysis), biohydrogen, synthetic natural gas (bioSNG), among others.

- **Bioproducts:** natural and/or recycled fibres for the manufacture of packaging, textile and composite products; value-added chemical products, for the chemical, pharmaceutical and nutraceutical industry; bioplastics and biopolymers, and fertilisers and biostimulants, manufactured from lignin.

All these products fall within the framework of integrated forest biorefineries, through which a large variety of products are produced, as they make the most of the diverse components of lignocellulosic biomass (cellulose, hemicellulose and lignin), maximising the added value of the products obtained (biomaterials, biofuels, bioproducts and bioenergy).

Figure 17
Products which may be obtained from forest biomass.



23 Hurmekoski, E. 2017. How can wood construction reduce environmental degradation? European Forest Institute.

3.3.2 Value of the food production sector

Food constitutes a valuable resource which must be managed and consumed as carefully and responsibly as possible. Thus, food production must be governed by criteria which capitalise on all the nutritional capacity these foods can offer. In this sense, **no food item may be viewed as a waste** in itself, but, frequently, some or all of any given food item may be wasted. In this way, throughout the food chain, from primary production to the end consumer, large quantities of **very valuable resources** are discarded. To face this issue, the European Commission has established an approach from the viewpoint of waste management and efficient resource use, and it defines **food waste**[24] as all food which has become waste.

Also of note, however, is the concept of **food waste**[25] defined by Law 3/2020, of 11 March, on preventing food loss and waste, recently passed by the Parliament of Catalonia. Food waste is recognised as a separate part of the **food loss** originating in the primary sector. Responsibility for food loss and waste is spread throughout the value chain: from producers to consumers, including distributors and retailers[26]. Food waste is a problem typical of the most highly developed societies; in Catalonia, every year the loss of 262,471 tonnes of food occurs in homes, retail and restaurants with an economic value of €841 million, the equivalent of 7% of the annual expenditure in solid food products (ARC2013).

Food production involves two fundamental sectors: primary production by the agricultural sector and the processing of agrarian products, including their distribution to the end consumer, by the food industry. Both sectors play a very large social and economic role in Catalonia, but they also cause significant impacts on the natural world. The complexity of food production, as well as the wide variety of companies involved, offers a broad range of opportunities for implementing new circular bioeconomy-based models, with the goal of exploiting the **secondary biological resources** which are currently lost or inefficiently used. **Figure18** charts the interrelationships between the streams of the main types of raw materials and bioproducts, bioenergy and biomaterials which can be obtained, in the food production sphere.

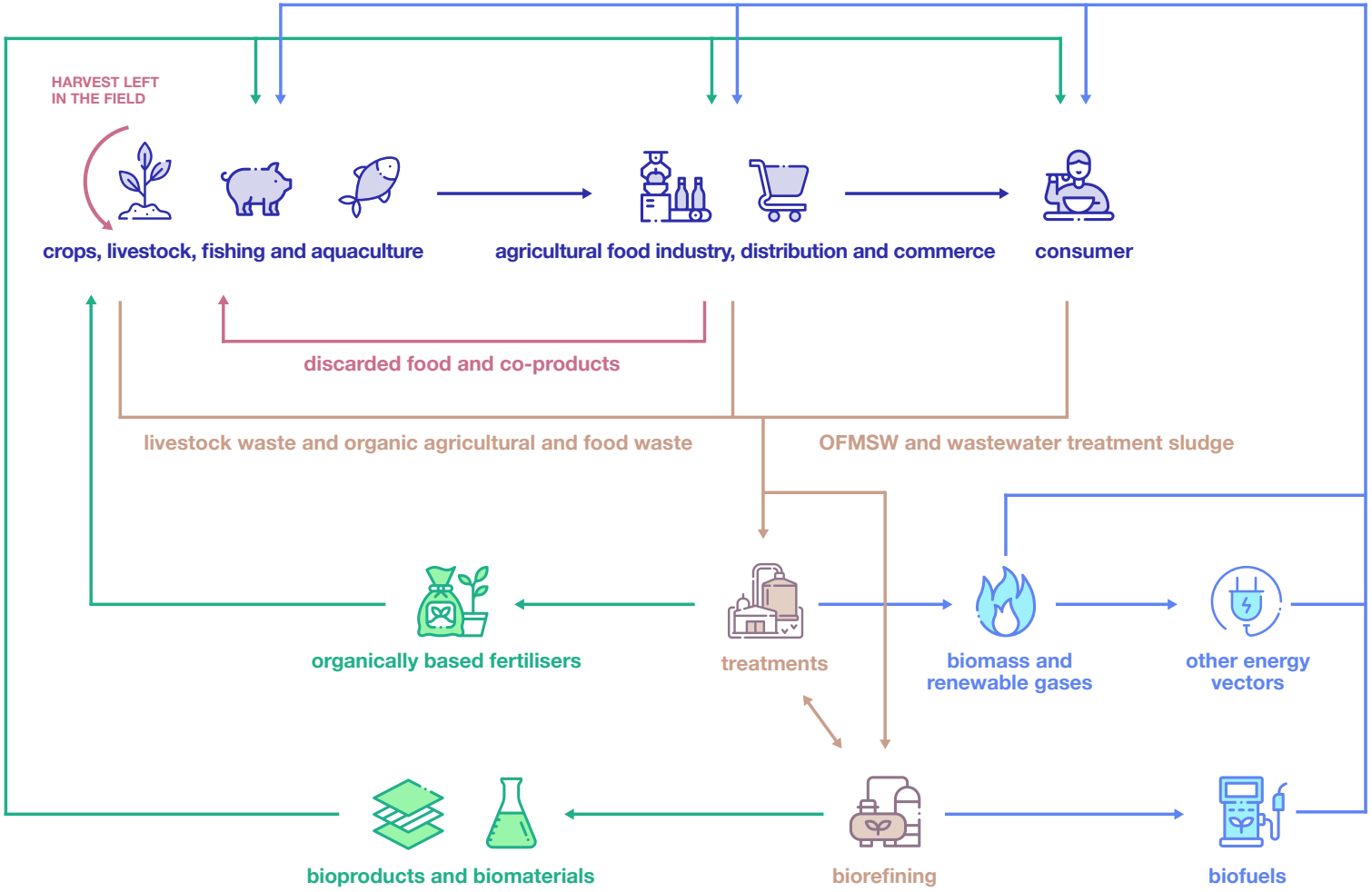
24 Article 3 item 4 of Directive (EU) 2018/851 modifying Directive 2008/98/EC on waste

25 Food waste: food intended for human consumption, in a suitable state to be ingested or not, which is removed from the production or supply chain to be discarded in the phases of primary production, transformation, manufacturing, transport, storage, distribution and the end consumer, with the exception of loss in primary production.

26 http://residus.gencat.cat/web/.content/home/lagencia/publicacions/prevencio/guia_consum_responsable.pdf.

Figure 18
Diagram of the food production system in Catalonia with the interrelationships in the agricultural production sectors, and the transformation and distribution of foods, in terms of the principal value chains related to the circular bioeconomy, as described in the main text.

Source: IRTA.



The main organic material streams generated during the production and transformation of foods, once they have acquired the condition of waste (in brown in **Figure 18**), are grouped into three main categories: organic food waste, OFMSW and sewage sludge. Two more categories of secondary biomass which are derived from food manufacturing but have not yet received the consideration of waste (in pink in **Figure 18**) have also been taken into account: the part of the harvest which remains in the field and discarded food.

Meanwhile, the range of uses constituting the main value chains in the realm of the circular bioeconomy are grouped into four large categories (in green for biomaterials and blue for bioenergy in **Figure 18**), which include the following product types:

- **Organic fertilisers:** nutrients generally derived from organic waste, transformed to a greater or lesser degree, used as fertilisers and agricultural supplements. The most well-known example is compost.

- **Bioproducts:**

  / **Products for animal feed:** material added to the diet of farm animals, derived from discarded food (co-products) or from the transformation of waste biomass in accordance with biosafety regulations.

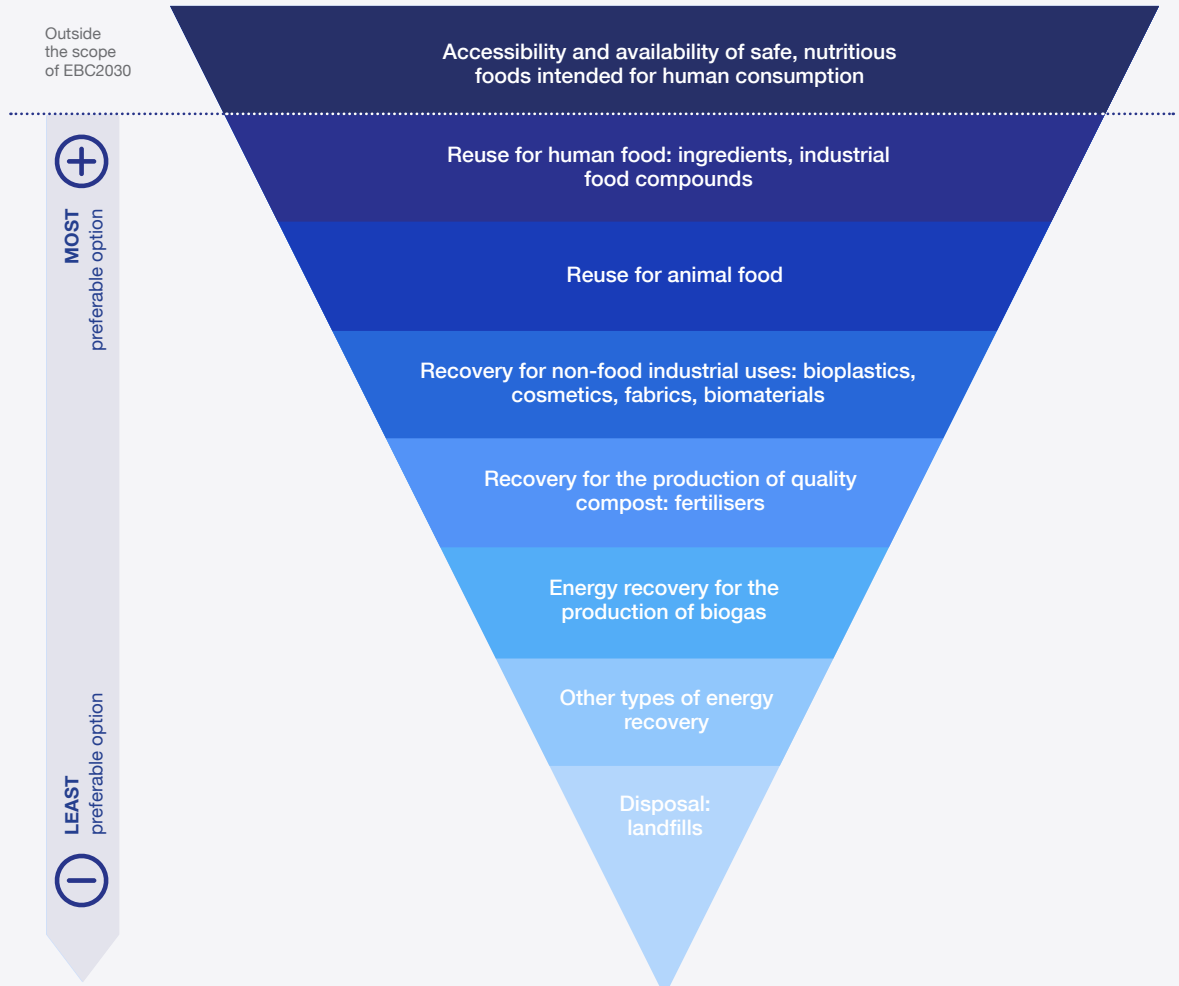
  / **Specialised chemical products:** substances and bioactive compounds with an added value as food additives, or for the chemical industry and pharmaceutical industry.

- **Biomaterials:** fibres made from plant remains which may be used for different purposes, such as in the manufacture of biopackages, or bioplastics and biopolymers obtained through fermentative processes.

- **Liquid and gaseous biofuels:** fundamentally biogas/biomethane derived from anaerobic digestion, synthetic gas from the pyrolysis of organic matter, as well as the bioethanol or biodiesel generally obtained through different fermentative and/or chemical processes.

The authors of the "Guide to the implementation of a plan for preventing and reducing food loss and waste at food production companies"[27] designed a hierarchy of food uses from the perspective of preventing food loss and waste. A version of this hierarchy is shown in **Figure 19** with the different destinations of use (reuse) and recovery of the biomass derived from the food chains intended for human consumption with potential for the circular bioeconomy. Different levels are established for the reuse of discarded foods as co-products and food waste recovery: 1) reuse for human consumption, 2) reuse for animal consumption, 3) recovery for non-food industrial uses, 4) recovery for the obtainment of quality compost, 5) energy recovery for the obtainment of biogas, 6) other types of energy recovery, and 7) disposal. Thus, the approach for developing a circular bioeconomy strategy should prioritise the upper levels of the inverse pyramid shown in **Figure 19**.

Figure 19
Adaptation of the food use hierarchy
Source: CREDA-UPC-IRTA & DACC, 2019.



27 http://agricultura.gencat.cat/web/.content/de_departament/de10_publicacions_dar/de10_a02_04_guies/enllacos-documents/fitxers-binaris/2019-guia-pla-prevencio-perdues-malbaratament.pdf

The agricultural sector

Primary plant production generates a significant quantity of available biomass for the circular bioeconomy. In productive and economic terms, the key sectors in Catalonia are cereal production, fruit, winemaking and olive oil. With regard to cereals (mainly wheat and barley), the grain/straw ratio ranges from 1:1 in very short straw varieties to 1:2.5 in long straw varieties. Given that, according to IDESCAT data, 827,631 tonnes of grain was produced in Catalonia in 2019, the production of straw would surpass this quantity, in spite of the fact that a significant portion of straw ends up getting left in the field. Similarly, **Figure 20** shows an estimate of the non-edible biomass generated annually by the main products which are mostly consumed fresh and which, therefore, are susceptible to being recovered in the sphere of the circular bioeconomy. When these products have not been subjected to any form of treatment before reaching the consumer (products in processing class I), most of this non-edible biomass is generated in the domestic sphere and incorporated into OFMSW, whereas the more highly processed organic waste (products in processing classes II to V) is mainly generated by the food industry[28].

Figure 20
Annual waste biomass production potential of the main crops in Catalonia, based on the non-edible weight of the final product.

Category		Product	Production [a] (tonnes)	Non-edible fraction [b] (%)	NON-edible biomass (tonnes)
SWEET FRUIT		Peach and nectarine	507,270	9.00	4,565
		Apple	315,533	12.25	38,653
		Pear	141,163	13.75	19,410
CITRUS		Mandarin orange	102,307	20.75	21,229
		Orange	40,511	23.75	9,621
VEGETABLES		Tomato	43,992	0.25	110
		Onion	40,500	14.00	5,670
		Lettuce	21,099	8.25	1,741
TUBERS		Potato	24,567	17.00	4,176

a According to the data collected by IDESCAT for 2019.

b Average figure calculated from the data published in De Laurentiis *et al.* (2018)[29].

28 http://agricultura.gencat.cat/web/.content/de_departament/de02_estadistiques_observatoris/08_observatoris_sectorials/03_observatori_de_la_fruita_fresca/b6/fitxers_estatics/b6_ind_transformadora_2012_05.pdf

29 De Laurentiis V, Corrado S & Sala S (2018) Quantifying household waste of fresh fruit and vegetables in the EU. Waste Management 77: 238-251.

In terms of animal production, the proper management of livestock waste is one of the main challenges which the sector must confront to continue serving as a pillar of the country's food production. In Catalonia, there are approximately 7.9 million pigs, 637,000 heads of cattle, and 44.6 million units of poultry (DARP, 2020), generating 9.4 million tonnes of slurry and 2.8 million tonnes of manure. Probably, the most efficient option is to manage the waste in the agricultural context as fertiliser or soil supplements, thereby using the nutritional content (**Figure 21**) and organic matter contained by these local resources to nourish crops. From a bioeconomy viewpoint, the use of nutrients from livestock waste should correspond to a reduction, not a replacement, of mineral fertilisers, which would be used as a supplement and when the application of organic fertilisers is not feasible. It is also necessary to encourage the use of livestock waste as fertiliser to increase the organic matter of our soils, to make them more fertile and resilient.

The use of "fresh" –that is, completely untreated– livestock waste has its limitations, including their elevated water content (especially important in slurry), the potential mismatch in the ratio of N:P:K nutrients in relation to the needs of the crops, the variability of composition, or the presence of certain pathogens, a relevant factor when attempting to fertilise close to the edible part of certain crops. In these cases, treating livestock waste to adjust it to the needs of the moment is a very valid and increasingly implemented option.

The treatments used most frequently in Catalan livestock operations are the solid-liquid separation of slurry and the composting of solid livestock waste, basically of manure or the solid phase of previously separated slurry. Treating these materials solves some of their initial disadvantages; for example, the water content is lowered and the proportion of certain nutrients and organic matter is increased (as occurs with compost and the solid fraction of slurry,

Figure 21

Characteristics and indicative composition of different types of livestock waste and the organic products obtained via their treatment. Nutrient content is expressed in kg per tonne in the case of solid waste and kg per m^3 in the case of slurry.

Source: Guide to livestock waste treatment technologies in Catalonia[30].

Type of livestock waste	Organic matter (kg/t)	Total N (kg/t)	Organic N (kg/t)	P_2O_5 (kg/t)	K_2O (kg/t)	Density (t/m^3)
Cattle manure	230	8.8	7.4	5.0	7.8	0.75
Poultry manure	514	22.6	18.7	18.2	19.0	0.85
Broiler litter	600	22.8	18.5	21.1	17.7	0.75
Pig (fattening) slurry	47	5.7	1.8	3.2	4.2	1.05
Pig (closed-cycle) slurry	21	3.4	1.0	1.3	2.5	1.03
Pig (farrowing) slurry	16	2.9	0.7	0.7	2.5	1.02
Cattle slurry	61	5.2	2.9	1.7	3.6	1.02
Solid fraction from slurry separation (sifting + screw/press)	189	6.7	4.1	8.4	3.4	-
Manure compost	256	15.3	13.3	15.8	11	0.65
Pig slurry digestate from sows	7	2.6	0.6	1.0	1.5	1.02

30 https://ruralcat.gencat.cat/documents/20181/7816840/Guia_tractament_dejeccions.pdf/7d6498f7-4f8f-4152-aa35-f89fa236fd8d

Figure 21), and the treated product is sanitised (as is the case of compost and digestate), among other advantages. The generalisation of the treatments will help the nutrients from livestock waste to be used more effectively, improving the transport, commercialisation and application of these materials, sanitised and more adapted to the needs of the crops. The redistribution of nutrients and organic matter within the Catalan territory is a key factor for the future of the management of livestock waste and for the future of the livestock sector.

The treatment of livestock waste may also be effectuated outside farms in a more complex way in centralised processing plants, obtaining organically-based commercial fertilisers and even high value-added products designed to cover the specific needs of crops or particular situations. Fertilisers of this type will probably occupy a very important place in the bioeconomy and have a large market to position themselves in.

Finally, the treatment also serves an energy-related purpose. The new demand for clean energies will spur the anaerobic digestion process for the production of biogas. Nonetheless, the implementation of anaerobic digestion plants represents a large initial investment, frequently infeasible for relatively small livestock companies for reasons of economies of scale, above all when the biogas is to be used for electricity generation. Meanwhile, the centralised plants serving various livestock companies are subject to higher administrative complexity in their management and the greater costs and biohazard entailed by the waste transport. The new opportunities for anaerobic digestion are related to the incentives offered for enriching the methane in biogas (biomethane) and injecting it into the natural gas network, and to the co-digestion with other wastes from the food production industry which have greater potential to generate methane and may entail an increase in the processing plant's performance. In the emerging sphere of new technologies, there has been a growing interest in producing hydrogen from organic wastes, known as "green hydrogen"[31].

31 Hydrogen is often classified according to the processes involved in the production; "grey hydrogen" is produced as a by-product of an industrial process; "blue hydrogen" is produced through a production process in which CO_2 is also generated, captured and stored; and finally, "green hydrogen" is produced completely from renewable resources.

The food transformation and distribution sector

An equally important quantity of waste biomass comes from the **food industry**, which can be quantified according to the data from the Catalan Waste Agency's (ARC) Annual Waste Declarations (DARIS). The evolution of these quantities over the coming years can be estimated using future projections of production as factors of scale. To take one example, the streams of **plant waste biomass** derived from the fruit and vegetable juice industry are estimated at 6,831.7 tonnes of pomace (71% of the total) and 2,684.6 tonnes (28% of the total) of products in poor condition, and the remaining 1% are other food wastes (CREDA-UPC-IRTA DARP & ARC, 2020; based on the Annual Waste Declarations - DARIS 2017 "description of the declarer" CCAE 1032).

The apple production chain – the source of the vast majority of food waste biomass in fruit and vegetable juice production – contains a great deal of potential for developing new products.

Another example would be the bread, bakery products and fresh pastry which generate 4,191.8 tonnes of organic matter every year which never reaches the consumer. 78.9% corresponds to dry bread, hard bread or bread which does not fulfil market specifications, 17% is leftover organic material from production, and 4% is made up of fats and oils used in the production process (CREDA-UPC-IRTA DARP & ARC, 2020; based on DARIS 2017 "description of the declarer" CCAE 1071). These discarded foods have an important potential for reintegration into the food chain as co-products, which would prevent waste generation, although it may prove difficult to quantify.

Meanwhile, there are wastes from the animal industry, such as slaughterhouse wastes, 4,124 tonnes of which were generated in 2017 (CREDA-UPC-IRTA DARP & ARC, 2020); estimate based on DARIS data, from the Catalan Registry of Agrarian and Food Industries (RIAAC), and from the Iberian Accounts Analysis System (SABI). The processes of animal slaughter and butchery generate a wide variety of by-products currently used in a number of value chains, especially in the spheres of animal feed and the cosmetic and pharmaceutical industries. The use of these fractions is subject to European Union regulations on animal by-products not destined for human consumption[32] to guarantee that during these operations, no risks are generated for human health, animal health or the environment, and the safety of the food chain.

As for the end consumer, and according to the latest ARC data on waste managed at a municipal level in Catalonia, in 2019, selective collection reached 45% of the total, the highest figure in history. The quantity of recovered biodegradable waste (mainly pruning scraps and OFMSW) rose by 6% from the previous year, to 439,968.47 tonnes (ARC, 2019[33]). This waste is allocated primarily to compost and biogas production. As a benchmark figure, it is frequently held that 1 tonne of OFMSW can generate 100 m^3 of biogas, meaning that if this waste was treated entirely in anaerobic digesters, it could satisfy 0.5% of the annual demand for natural gas in Catalonia.

32 Regulation (EC) Nº 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) Nº 1774/2002 (Animal By-products Regulation).

33 http://residus.gencat.cat/ca/actualitat/noticies/detall/np_presentacio_dades_RS

3.3.3
Value of the maritime sector

Following the criteria established by the European Commission in its multiple reports[34], the **blue bioeconomy** is understood to be any economic activity associated with using renewable aquatic biological resources to manufacture products. A few examples of these products include new foods and food additives, animal feed, nutraceuticals, pharmaceuticals, cosmetics, materials (for example, clothing and construction materials) and energy. Traditional aquaculture and fishing, where fish[35] or seafood is captured or produced for human consumption, is excluded from this definition. Nonetheless, there are two exceptional cases: fish waste (the part currently unused for human consumption) and algae (both macroalgae and microalgae).

The blue economy in Catalonia and around the world is a clearly emerging sector with great potential for development and, thus, is considered on of the emerging sectors within the Blue Economy in Europe. It constitutes a sector which clearly depends on the utilisation of still unexploited (and in many cases unknown) marine organisms and is also based on the use of by-products derived from fishing and aquaculture and their commercial applications.

Currently, Europe's most prominent subsector in the sphere of blue technology and bioeconomy, and one which is undergoing major growth, is algae production. It constitutes a subsector which also has great potential for development in Catalonia. One example is the spirulina which started being farmed in Catalonia in 2018 both for direct consumption and for the manufacture of food supplements, or for its use in nutraceuticals and cosmetics.

Out of all fishing and aquaculture activities, it has been calculated that nearly 50% of the total weight produced are products which are currently not consumed (fins, heads, skin, etc.), a reality which generates an environmental and economic issue in terms of these products' management. All these products show great potential for the bioeconomy and marine biotechnology and should contribute to resolving the previously mentioned problems and generate, moreover, new economic activity. This activity would not only create new jobs but would also diversify the fishing sector's activity, something very necessary in the current situation in which fishing efforts must be reduced to allow the recovery of resources.

Aquaculture is also a source of diverse biocomponents with numerous industrial purposes. Mollusc shells, which represent between 40 and 70% of the total weight, are the main sources of bioproducts. Among the potential uses we could highlight several associated with biomedicine and cosmetics, but there are also uses related to construction, agriculture (as a fertiliser component or soil acidity corrector) and animal feed.

Finally, we must mention the potential linked to the use of non-native species, such as the blue crab (*Callinectes sapidus*), currently an invasive species in Catalonia. In the case of this species, numerous bioactive compounds have been identified in its shell, with potential uses in the production of pigments or biodegradable films.

34 Blue Bioeconomy-situation report and perspectives (2018); Blue Bioeconomy Forum-Roadmap for the Blue Bioeconomy (2019); and The EU Blue Economy Report 2020 (2020).

35 Fishery and aquaculture production intended for human consumption is addressed in the 2030 Catalan Maritime Strategy

3.4

Ecosystem services in the context of the circular bioeconomy

Nature supports all human activity and life. The goods and services it provides are vital both to our wellbeing and to present and future economic and social development. These goods and services are known as ecosystem services.

There are four types of ecosystem services, depending on the benefit they offer:

(1) provisioning services are the goods or raw materials an ecosystem offers, such as wood, water or food;

(2) regulating services are derived from key ecosystem functions and help reduce certain local and global impacts (for example, climate and water cycle regulation, soil erosion control, pollination, etc.);

(3) cultural services are related to leisure or more general aspects of culture; and

(4) supporting services, such as biodiversity and the ecosystem's natural processes, providing the basis for the other ecosystem services. The most important services are the ones which enable the maintenance of biological, geological, and ecological diversity, nutrient cycle continuity, soil formation and retention and the production of atmospheric oxygen and carbon sequestration (plants and microorganisms).

Ecosystem services, therefore, combine the preservation of the natural environment with its sustainable use and development.

The ecosystem services in the forest and agricultural sphere are listed below.

3.4.1 Forest ecosystem services in Catalonia

The complexity of the global change implies that forests and agroforestry landscapes must take on a new role and that the socio-ecological resilience of these landscapes must be promoted. In this sense, it will be necessary to better understand the effects of climate change and the disruptions caused in landscapes and to know how they can be managed to preserve biodiversity and the provision of ecosystem services.

Tools and models must be developed to design resilient landscapes in order to adapt them to the possible disturbances (for example, fires, droughts) which will be favoured by climate change. Thus, it will be necessary to design territory management plans to optimise forest and agroforestry management, creating more disturbance-resilient landscapes in which biodiversity can be preserved, and to stimulate the economic and social development of the agroforestry mosaic by promoting the use of ecosystem services.

The forest ecosystem services of Catalonia are very diverse and can be classified into: water supply; carbon sequestration; conservation of biodiversity; erosion control; recreational service; production of food and raw materials, and hunting for sport.

Figure 22 displays the economic value of forest ecosystem services in Catalonia. The estimation method created by the Ministry of Environment, Rural and Marine Areas between 2005 and 2010 (Estimation of Natural Assets in Spain, VANE) has been taken as a reference. The figures are expressed in € for the year 2019 and quantify the ecosystem services in Catalonia[36].

Catalonia's main forest ecosystem services have been assessed and mapped using the tool ForESMap based on the assessment of biophysical indicators of provisioning, regulating and cultural[37] services alike.

Figure 22
Value of forest ecosystem services in Catalonia.
Source: Prepared by the authors (CTFC) from IFN4 data.

36 The value of these calculations has, in some cases, probably been underestimated, as other values associated with conservation (for example, social value) or recreational services (for example, health and wellbeing) have not been considered.

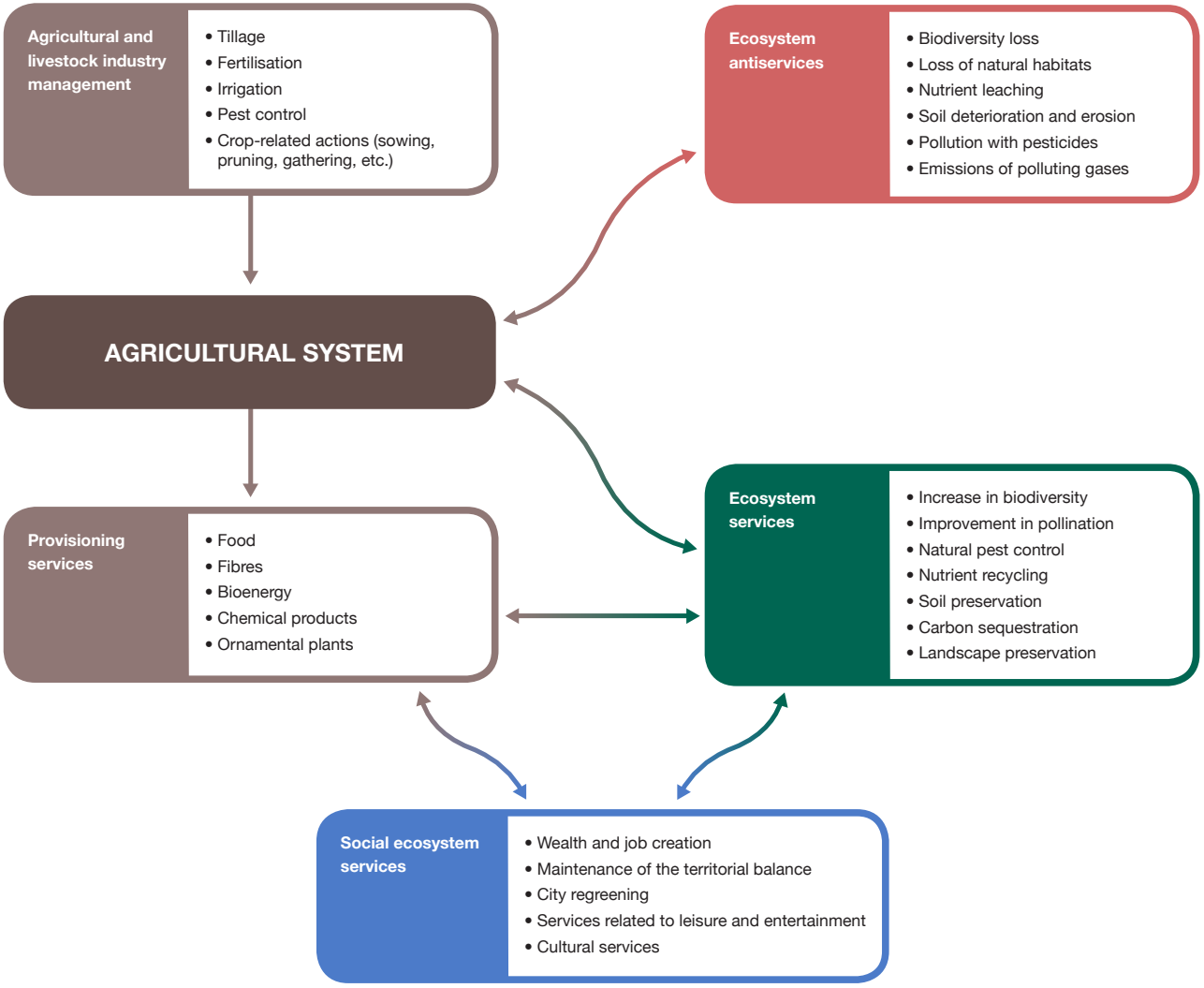
37 http://www.creaf.cat/ca/cartografia-dels-serveis-ecosistemics-dels-boscos-de-catalunya.

3.4.2 Agricultural ecosystem services in Catalonia

Agricultural ecosystems supply food, forage, bioenergy, bioproducts and pharmaceutical products, and they are essential for human welfare. Thus, if good practices are applied, these productive systems can provide a range of ecosystem services, such as pollination, biological pest control, the maintenance of soil structure and fertility, and water availability. The value of these ecosystem services for agricultural production and for society as a whole is enormous and often underestimated. However, agricultural systems also produce other ecosystem services which affect sustainability in a broader sense, beyond the productive sphere in the short or long term, such as the regulation of soil quality and hydrological fluxes, the sequestration of carbon in the soil, support for biodiversity and cultural services. These benefits depend on management practices and, in fact, agriculture can also be the source of numerous negative impacts (antiservices), such as habitat loss for wildlife, nutrient leaching and aquifer pollution, soil erosion and degradation and emissions of greenhouse gases and compounds toxic to humans and non-target species (pesticides).

The balances occurring between the production services, ecosystem services and "antiservices" of agricultural systems must be assessed in terms of spatial scale, time and reversibility. As more effective methods for evaluating ecosystem services become available, it will be possible to establish policies intended to foster more suitable agricultural management practices to take advantage of the benefits provided by ecosystem services, while simultaneously guaranteeing production and reducing "antiservices"[38].

Figure 23
Impacts of agricultural company and landscape management in the flux of ecosystem services and dysfunctions or "antiservices" of agricultural ecosystems.



38 Power AG. 2010. Ecosystem services and agriculture: tradeoffs and synergies. Philosophical Transactions of the Royal Society B: Biological Sciences 365(1554):2959-2971. https://royalsocietypublishing.org/doi/10.1098/rstb.2010.0143

At the same time, in the face of the growing urban population, as is mentioned in the FAO report on cities and biodiversity[39], it is essential for city growth planning to contemplate ecosystem services and, in particular, the services related to urban and peri-urban agriculture. A formula which has been successfully rehearsed in Catalonia for fostering the ecosystem services associated with agricultural activity is to publicly protect these environments against the threat of urban development, for example, by establishing what are known as agricultural parks. An agricultural park is an open, delimited space whose purpose is to facilitate and guarantee the continuity of this space's agricultural use, preserving it from its incorporation into the urban process, running specific programmes to improve and develop its economic, environmental and sociocultural potential and to protect the natural heritage around it. In Catalonia, the most important agricultural parks are the Baix Llobregat Agricultural Park and the Sabadell Agricultural Park. Also of note is the rural space of great landscape value Gallecs, integrated into the Natura 2000 network. It constitutes one of the last non-urbanised areas in the county of Vallès Occidental, between the municipalities of Mollet del Vallès and Parets del Vallès. The preservation and extension of these spaces where agricultural activities are performed close to urban centres is fundamental, both for the important ecosystem services they provide and for the role they play in stimulating the local economy.

With regard to urban agriculture, Barcelona has run, since 2013, the "2020 Plan for Greening and Biodiversity", on the contribution of urban gardens to biodiversity, the promotion of a new agro-ecological model which encourages citizen engagement in food sovereignty, and the maximisation of environmental and social services. As of today, there are 129 urban gardens in Barcelona[40]. This new model of citizen participation and socioeconomic activation is also being applied in the sphere of food processing with initiatives known as "shared workshops"[41]. They are envisioned as nurseries for small food processing companies which need a conveniently equipped space to begin their activity, without having to face an high and immediate investment in infrastructure. In turn, the shared workshops serve as incentives for local agricultural and livestock production, which in general has a lower carbon footprint.

39 Secretariat of the Convention on Biological Diversity (2012) Cities and Biodiversity Outlook. Montreal, 64 pages
https://www.cbd.int/doc/publications/cbo-booklet-2012-en.pdf

40 https://ajuntament.barcelona.cat/ecologiaurbana/ca/que-fem-i-per-que/ciutat-verda-i-biodiversitat/estrategia-agricultura-urbana

41 Shared workshops, a rising trend. Agrocultura no. 77.
https://www.agrocultura.org/obradors-compartits-tendencia-lalca/

3.5

The Catalan R+D+i ecosystem in circular bioeconomy themes

There are a total of 131 bioeconomy projects of the Horizon 2020 Programme in Catalonia, putting Catalonia in fourth place in the ranking of European regions participating in circular bioeconomy projects.

These projects are specialised in different fields. If Catalonia's position is compared to the main leading regions in each thematic area (see **Figures 24** and **25**), it is observed that, despite being the region with the fourth highest number of circular bioeconomy projects, Catalonia fails to appear in a leadership position in either food production (it occupies 10th place) or bioenergy and biofuels (it occupies 13th place), two fundamental thematic areas in terms of sectors and the green transition.

However, Catalonia is positioned well with respect to ecosystems, ecosystem services and climate change; aquaculture and marine ecosystems; forestry and wood products; organic waste recovery; urban area policies and bioeconomy; and wastewater and treatment sludge. In the future, it will have to be seen whether this thematic leadership is translated into comparative advantages for the Catalan productive network and differentiated capacities for addressing the territory's challenges.

Figure 24

Percentage of H2020 projects, in Catalonia and in the European Union, by thematic circular bioeconomy area.

Source: Monitoring of the RIS3CAT 15. Analysis of specialisation in circular bioeconomy (January 2021).

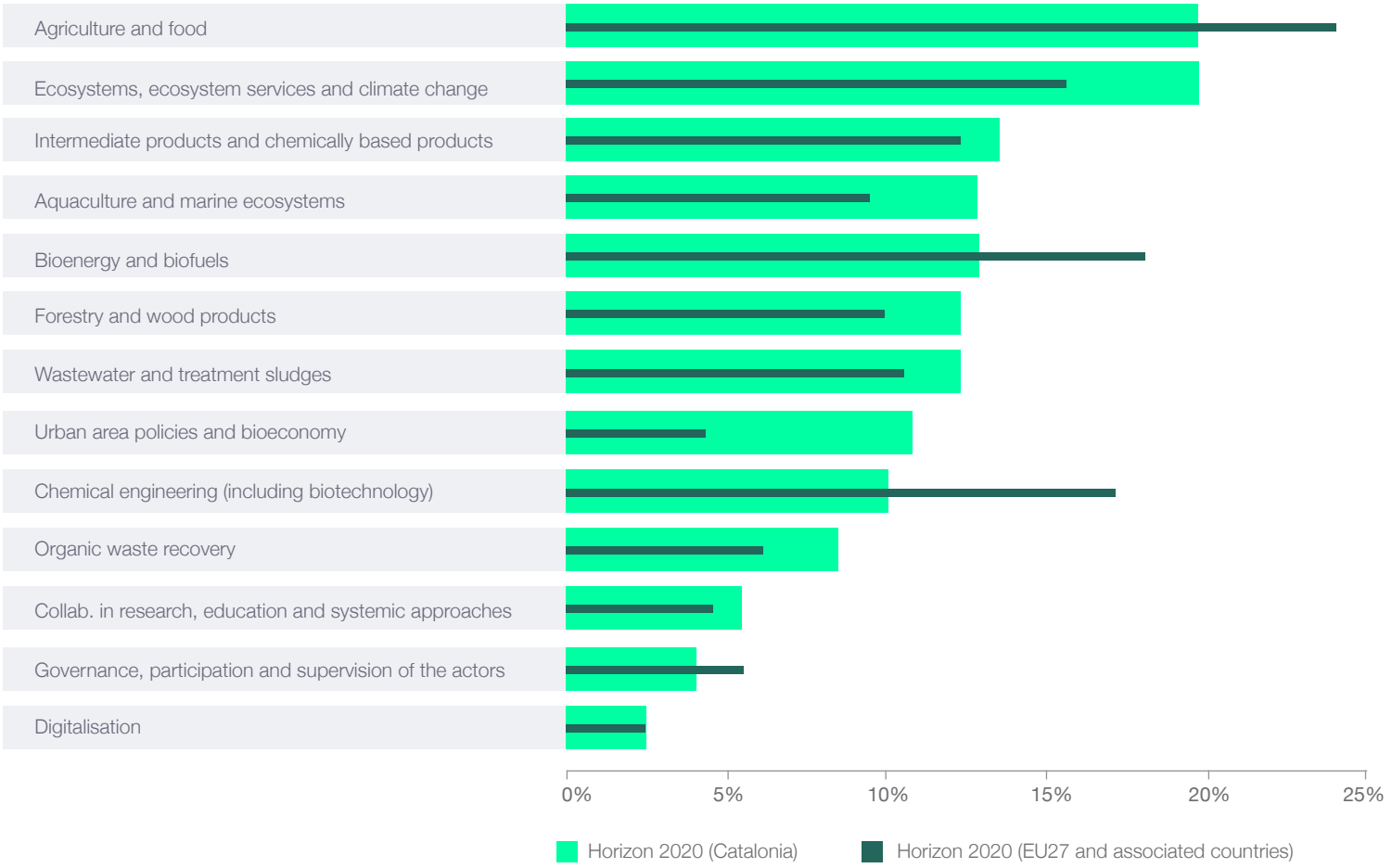
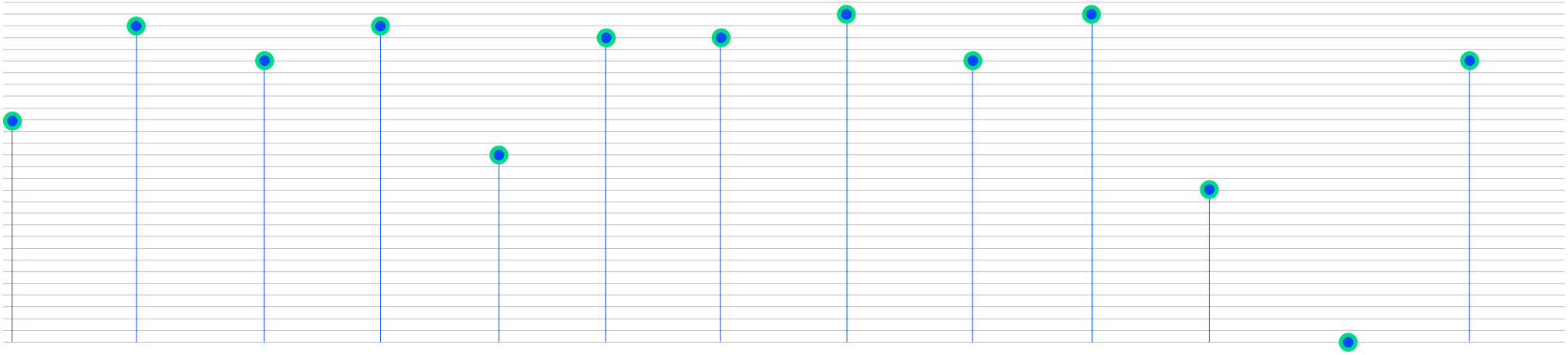


Figure 25

Relative position of Catalonia with respect to the main European regions by thematic area in H2020 projects.

Source: Monitoring of the RIS3CAT 15. Analysis of specialisation in circular bioeconomy (January 2021).



#10	#3	#6	#3	#13	#4	#4	#2	#6	#2	#16	#30	#6
Sphere: **Agriculture and food**	Sphere: **Ecosystems, ecosystem services and climate change**	Sphere: **Intermediate products and organically based products**	Sphere: **Aquaculture and marine ecosystems**	Sphere: **Bioenergy and biofuels**	Sphere: **Forestry and wood products**	Sphere: **Organic waste recovery**	Sphere: **Urban area policies and bioeconomy**	Sphere: **Chemical engineering (including biotechnology)**	Sphere: **Wastewater and treatment sludges**	Sphere: **Collab. in research, education and systemic approaches**	Sphere: **Governance, participation and mobilisation of the actors**	Sphere: **Digitalisation**
26 projects	**26** projects	**18** projects	**17** projects	**17** projects	**16** projects	**16** projects	**14** projects	**13** projects	**11** projects	**7** projects	**5** projects	**3** projects

3.6

Financial instruments

Although the Strategy does not have its own funding, multiple sources of available funding on a European level related to circular bioeconomy have been identified, particularly: **1**_ the Horizon Europe research and innovation programme, **2**_ loans from the European Investment Bank, **3**_ InnovFin fund for innovation **4**_ European Circular Bioeconomy Fund (ECBF), **5**_ European Structural Funds, **6**_ Innovation Fund, **7**_ LIFE projects, **8**_ European Green Deal proposal calls, **9**_ Next Generation EU fund and **10**_ funds from the EU's Common Agricultural Policy, among others.

These funding sources are supplemented by the resources available in the ordinary budgets of the Spanish and Catalan governments.

The itemisation of necessary means to effectuate the measures proposed in EBC2030 will be included in the triennial Action Plans.

3.7 Strength, weakness, opportunity and threat analysis of the implementation of the circular bioeconomy in Catalonia

Weakenesses

- Atomised (decentralised) forest ownership.
- Decentralisation and lack of quality information in relation to the available biomass.
- Deficit in forest management and in the use of the existing biomass.
- Lack of cross-disciplinary knowledge and opportunities in bioeconomy projects.
- Legal and administrative barriers which pose obstacles to commercialisation.
- Logistics and transportation barrier to recovering biomass and waste.
- Absence of local technology for certain waste types and potentially recoverable resources.
- Deficit of initiatives, of implementation of R+D+i projects and of recovery networks, especially in the rural sphere.
- Need for initial investment in the creation of new industries.
- Gap between research, escalation of production and commercialisation of bioproducts.
- Lack of diagnosis, monitoring and penalisations from the public administration of the streams which are not being used and managed.
- Lack of knowledge on the challenges and needs of the private sector.
- Lack of information on the generation of losses and waste (at the different links in the chain) and how to prevent them.
- Difficulties in the escalation of technologies and industry labs/pilots in the implementation of biorefineries.

Threats

- Biomass's lack of competitiveness in relation to the international market.
- Outdated logistics and machinery with high CO_2 emissions.
- Low cost of fossil fuels.
- Budgetary limits on funding and investing in pilot projects/infrastructures.
- Energy monopolies of large companies.
- Elevated investment of the first processing industry of the by-products.
- Deficit in public and private demand.
- Regulatory obstacles to generating synergies between participants or launching bioproduct generation projects.
- Dependence on European and state legislation which hinders changes in waste laws.
- Technological dependence on other countries.

Strengths

- Profitability of the processes of use and recovery of resources and waste.
- Availability of local recoverable biomass (forests, livestock waste, industrial by-products, ...).
- Availability of leading universities and research centres with expertise in circular bioeconomy.
- Existence of numerous circular bioeconomy success stories.
- Availability of a powerful, competitive and innovative food production sector.
- Availabilities of logistical structures which could complete the availabilities of biomass such as the ports of Barcelona and Tarragona.
- Consolidated experience and long track record in preventing food loss and waste.

Opportunities

- Increased profitability of heat and cold generation from biomass.
- Competitiveness of bioenergy and its use on a small scale.
- Generation of greater added value for driving the value chains of the primary sector.
- Growing demand for bioproducts.
- Employability in the rural sphere and the primary sector.
- Greater focus on the impact of research projects.
- Increase in consumer-directed communication on the advantages of bioproducts.
- Transferability of knowledge between companies, universities, research centres and administration.
- Greater social awareness on more sustainable and circular production models.
- Existence of new legal frameworks favouring circular bioeconomy (replacing fossil fuels, lowering emissions, better by-product management...).
- Creation of European, state and national funds and programmes to promote the circular bioeconomy.
- Alignment of the principles and goals of EBC2030 with European strategies and global agendas.

4 /

Vision and mission of EBC2030

4 /
Mission and vision
of EBC2030

Mission

To encourage the transition toward an economic model based on the optimal use of local and renewable biological resources to create products of greater added value, while the competitiveness and sustainability of the sectors involved and, especially, of underdeveloped value chains improve through the creation of quality jobs and the promotion of knowledge generation as a motor for change, with special attention paid to the primary sector.

Vision

To transform Catalonia into a leading Southern European region in the transition toward more sustainable, inclusive and resilient models, employing the circular bioeconomy as a motor for change.

5 /

Scope
of EBC2030

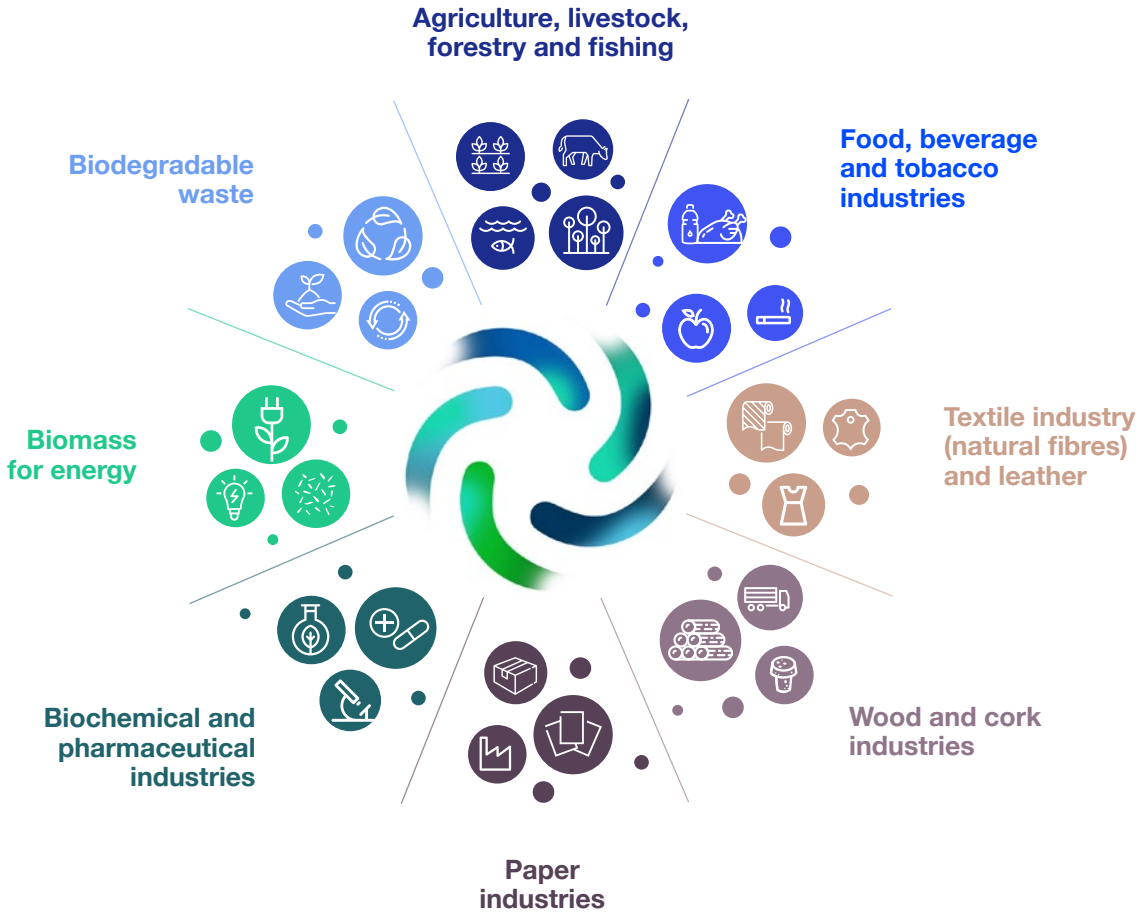
5 / **Scope** of EBC2030

EBC2030 includes the production of resources based on the biomass produced by the primary sector (agriculture, livestock, silviculture, aquaculture and fishing). The sectors affected by EBC2030 are shown in **Figure 26**:

Catalonia's EBC2030 revolves around spheres and activities of the circular bioeconomy which are currently underdeveloped and therefore require more institutional support through the implementation of specific measures and interventions which facilitate their medium- and long-term impetus and consolidation. This approach would not prevent the strategy's scope from being broadened in the future once the initially established sphere has been consolidated.

The scope of EBC2030 includes the production of bioproducts, bioconstruction, biopackaging and bioenergy from biomass, excluding the biomass produced in the primary sector corresponding to food intended for human consumption[42]. The primary sector as a whole is considered within the scope of EBC2030 not only as a biomass producer but also as a consumer of bioproducts and bioenergy.

Figure 26
Sectors included in the scope of EBC2030



42 Biomass intended for human consumption is included in the 2021-2026 Catalan Strategic Food Plan (PEAC). The corresponding data on the maritime sector is addressed in the 2030 Catalan Maritime Strategy. The deployment of EBC2030 will also take into account the Strategic Plan for Food Loss and Waste Prevention which must be elaborated by the Government, in collaboration with the Catalan Food Council, in the framework of Law 3/2020 on food loss and waste prevention

6 /

Major targets of EBC2030

6 / **Major targets** of EBC2030

The Catalan Bioeconomy Strategy establishes a series of targets to achieve by 2030. These targets are in line with the goals proposed on a European level in the framework of the Green Deal, and on an international scale with the UN Sustainable Development Goals and climate goals.

In the absence of one single target which would make it possible to assess the impact of the circular bioeconomy in Catalonia, a series of targets must be established to demonstrate the bioeconomy's complexity and multiple dimensions.

The targets proposed are to be viewed as guideline targets to achieve in the coming decade, non-binding in nature until included in the corresponding law.

Figure 27
Major targets of the 2030 Bioeconomy Strategy.

CODE	MAJOR TARGETS
F1	Increase the contribution of the bioeconomy in Catalonia's GVA by up to 5%
F2	Increase primary sector jobs by 10% Increase youth incorporation into the rural and maritime sphere by 15%
F3	Ensure that 30% of new businesses in the food production sector are based on the circular bioeconomy
F4	Increase the number of start-ups and scale-ups in the bioeconomy sphere by 20% Increase the number of companies developing technologies in the bioeconomy sphere by 10%
F5	Increase the use of forest resources by 30%
F6	Increase the use and recovery of co-products and by-products from the food chain by 40%
F7	Prevent the loss of agricultural areas and recover the management of at least 10% of agrarian zones abandoned in the last 30 years
F8	Lower emissions associated with the management of livestock waste and food waste by 30%
F9	Increase the use of renewable fuels in the primary sector by 100%
F10	Increase the organic carbon in the agricultural soils of Catalonia by 0.4% per year

7 /

Strategic goals, strategic lines and measures of EBC2030

7 /
Strategic goals, strategic lines and measures of EBC2030

The **7 main strategic goals** which form the backbone of EBC2030 are the following:

GOALS ASSOCIATED WITH THE GENERATION OF ECONOMIC ACTIVITY:	
1 /	Improve the use of biomass in Catalonia through the characterisation, quantification and optimisation of its management and distribution
2 /	Develop a business community based on the circular bioeconomy throughout the territory, with special attention paid to the primary sector
3 /	Encourage the use and consumption of bioproducts, bioenergy and biomaterials on the market
4 /	Promote resilient agricultural and forest landscapes and the sustainable provision of ecosystem services in the context of the Catalan circular bioeconomy
AUXILIARY GOALS OF A CROSS-DISCIPLINARY NATURE:	
5 /	Situate knowledge as a motor of the circular bioeconomy
6 /	Strengthen the role of the Administration and adapt the legal and regulatory framework to favour the circular bioeconomy in Catalonia
7 /	Prepare the Catalan society for the change toward the circular bioeconomy

These strategic goals are expanded through a total of **17 strategic lines (L)**, through which **37 measures (M)** are proposed for the development of EBC2030:

Goal 1

Improve the use of biomass in Catalonia through the characterisation, quantification and optimisation of its management and distribution

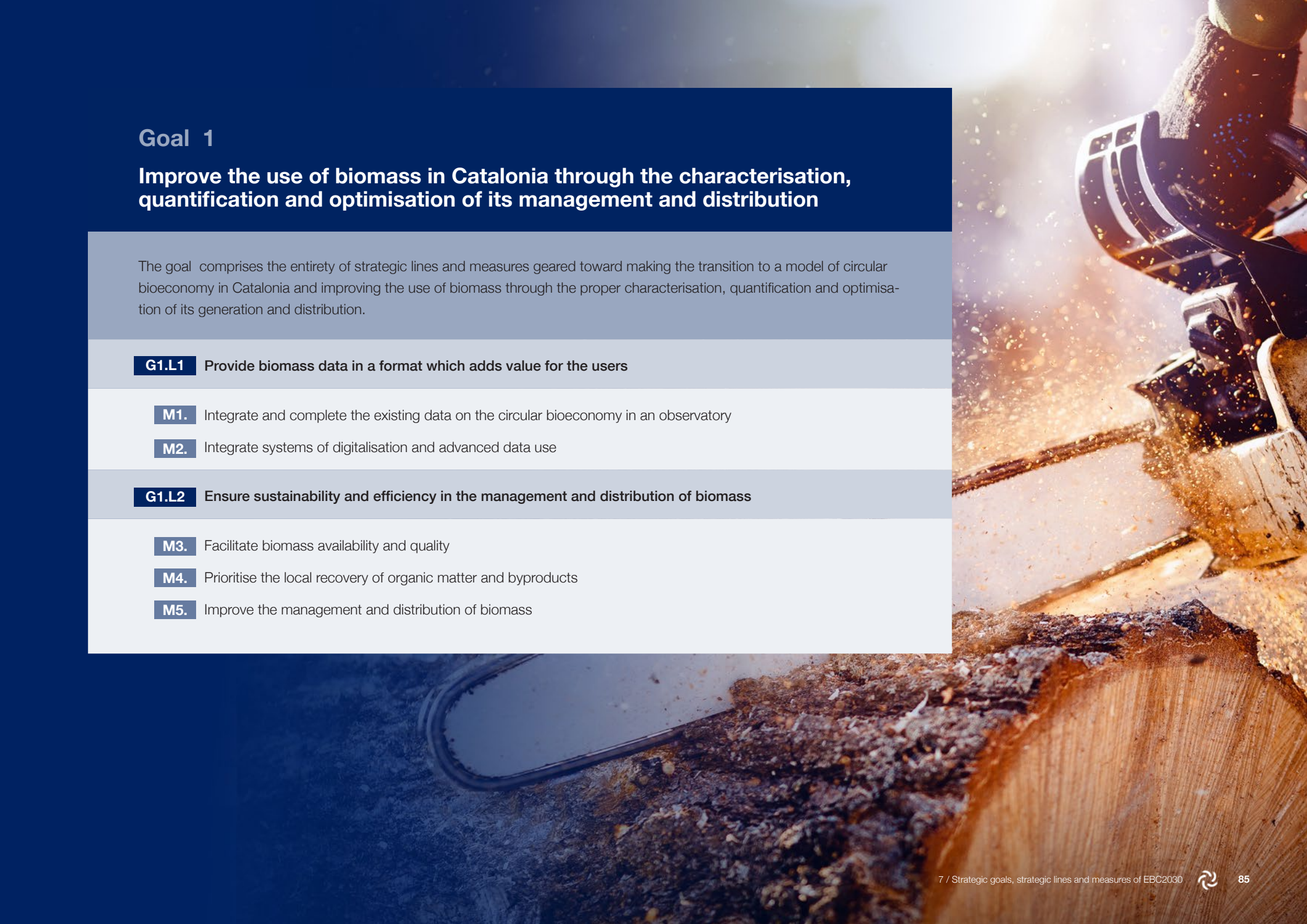
The goal comprises the entirety of strategic lines and measures geared toward making the transition to a model of circular bioeconomy in Catalonia and improving the use of biomass through the proper characterisation, quantification and optimisation of its generation and distribution.

G1.L1 **Provide biomass data in a format which adds value for the users**

- **M1.** Integrate and complete the existing data on the circular bioeconomy in an observatory
- **M2.** Integrate systems of digitalisation and advanced data use

G1.L2 **Ensure sustainability and efficiency in the management and distribution of biomass**

- **M3.** Facilitate biomass availability and quality
- **M4.** Prioritise the local recovery of organic matter and byproducts
- **M5.** Improve the management and distribution of biomass



Goal 2

Develop a business community based on the circular bioeconomy throughout the territory, paying special attention to the primary sector

The goal encompasses all strategic lines and measures designed to empower the business sector and weave synergies between the private and public sector to advance toward a technological transformation to produce bioproducts, biomaterials and bioenergy.

G2.L1 **Promote cooperative work between companies throughout the supply chain to attract supply and demand**

- **M6.** Develop the Bioeconomy Hub using existing infrastructures
- **M7.** Foster the creation of industrial symbiosis initiatives
- **M8.** Identify and inventory the value chains, necessary technology and market potential of bioproducts, biomaterials and bioenergy while simultaneously geolocating producers, logistics operators, tech companies and end consumers

G2.L2 **Strengthen the growth of existing companies based on the circular bioeconomy**

- **M9.** Reinforce lines of aid and funding for investment and development in circular bioeconomy

G2.L3 **Provide incentives for the creation of new companies and business models based on the circular bioeconomy**

- **M10.** Foster the design of viability studies (economic, social and environmental) and business models
- **M11.** Reinforce lines of aid and funding for new businesses in circular bioeconomy
- **M12.** Facilitate the ceding of venues for the implementation of businesses

Goal 3

Encourage the use and consumption of bioproducts, bioenergy and biomaterials on the market

The goal encompasses the strategic lines and measures aimed at fostering the use and consumption of local products and bioproducts and improving their positioning in the market.

G3.L1 **Generate demand for the use and consumption of bioproducts, biomaterials and bioenergy**

- **M13.** Use tenders and public purchasing as a tool for furthering the circular bioeconomy
- **M14.** Spearhead communication and marketing plans and publicise success stories on bioproducts, biomaterials and bioenergy

G3.L2 **Improve the positioning of bioproducts, biomaterials and bioenergy on the market**

- **M15.** Promote the commercialisation and differentiation of the bioproducts on the market and facilitate informed decision-making by consumers
- **M16.** Encourage manufacturers to affiliate themselves with environmental statements and labelling systems

Goal 4

Promote resilient agricultural and forest landscapes and the sustainable provision of ecosystem services in the context of the Catalan circular bioeconomy

The goal encompasses the strategic lines and measures aimed at promoting resilient landscapes and the sustainable provision of ecosystem services.

G4.L1 **Promote the establishment of resilient agricultural and forest landscapes using advanced tools and expertise**

- **M17.** Support a form of territory management which fosters resilient landscapes and the definition of priority areas for their establishment
- **M18.** Foster the creation of new economic activities which facilitate the management of resilient landscapes

G4.L2 **Conserve and improve the quality of agricultural soils and foster their role as a carbon sink**

- **M19.** Foster a more sustainable form of organic fertilisation on agricultural soils
- **M20.** Implement agronomic practices designed to conserve and improve soil quality

G4.L3 **Foster the provision of ecosystem services**

- **M21.** Identify ecosystem services in the context of the Catalan bioeconomy
- **M22.** Establish payment mechanisms for environmental services which favour territorial management and facilitate the social and economic viability of the territory

Goal 5

Situate knowledge as a motor of the circular bioeconomy

The goal encompasses the strategic lines and measures designed to spearhead R+D+i and technological transfer to foster more efficient and circular production processes and promote training linked to the circular bioeconomy..

G5.L1 Promote research, innovation and technological transfer associated with the circular bioeconomy

- **M23.** Identify the principal challenges and solutions and promote research/transfer/innovation projects linked to circular bioeconomy
- **M24.** Promote projects which enable proof of concept studies and the preindustrial and industrial escalation of new products and services
- **M25.** Promote technological improvements and technology-based companies, start-ups, spin-offs and scale-ups linked to the circular bioeconomy
- **M26.** Encourage companies to spearhead research and innovation projects in circular bioeconomy

G5.L2 Promote knowledge transfer and exchange

- **M27.** Incorporate companies into collaborative spaces for processes of creativity and experimentation
- **M28.** Create a programme to capitalise on research and innovation linked to the circular bioeconomy and disseminate the knowledge and innovations generated by the programme
- **M29.** Provide advice about the circular bioeconomy throughout the value chain

G5.L3 Provide trained professionals and attract talent

- **M30.** Train the existing professionals, develop new professional profiles and spearhead training projects linked to the circular bioeconomy
- **M31.** Reinforce the capacity to train and recruit talent in the sphere of the circular bioeconomy

Goal 6

Strengthen the role of the Administration and adapt the legal and regulatory framework to favour the circular bioeconomy in Catalonia

The goal encompasses the strategic lines and measures designed to readapt the existing legal framework and create new frameworks when appropriate through the identification of legal and administrative restrictions, with the aim of aligning legal frameworks in relation to the circular bioeconomy.

G6.L1 **Adapt the legal and regulatory framework**

- **M32.** Identify and adapt the legislation and laws which could represent barriers to or opportunities for the development of the circular bioeconomy in Catalonia

G6.L2 **Facilitate the implementation of circular bioeconomy activities in the territory**

- **M33.** Develop the Bioeconomy Office
- **M34.** Orient and coordinate funding sources (European, national and local) to provide impetus to the circular bioeconomy

Goal 7

Prepare Catalan society for the change toward the circular bioeconomy

The goal encompasses the set of strategic lines and measures geared toward making the transition toward a model of circular bioeconomy in Catalonia through the co-participation of the citizenry in order to establish collaboration on a territorial level, improve the positioning of products on the market and of ecosystem services and reinforce consumer-directed communication.

G7.L1 **Inform and raise awareness among the citizenry on the need to implement, and the benefits of, the circular bioeconomy**

- **M35.** Promote awareness-raising and publicity campaigns aimed at citizens to improve their perception of the circular bioeconomy
- **M36.** Integrate the circular bioeconomy into educational and training curricula

G7.L2 **Incorporate civil society into the design and execution of new projects associated with the circular bioeconomy**

- **M37.** Design a system of co-governance with the citizenry and all other parties involved

8 /

Governance of EBC2030

8 / **Governance** of EBC2030

The governance model proposed in EBC2030 aims to provide a response to four goals which must guarantee the Strategy's proper deployment:

1. Verify the suitability of the measures and actions of development of EBC2030 to the established principles.
2. Guarantee maximum coordination within the Government among all departments involved in the implementation of measures and actions foreseen in the Strategy.
3. Guarantee the participation (co-governance) of all economic and social agents engaged in the promotion and initiation of activities framed in EBC2030.
4. Have enough operational capacity to execute the estimates included in the action plans.

To guarantee the proper deployment of EBC2030, the Strategy Co-management Board will be constituted and presided over by the head of the Department of Climate Action, Food and Rural Affairs. This body will monitor the fulfilment of the strategic goals based on the major targets of the document and the action plans' development. It will organise its tasks into thematic working groups (research and innovation, business promotion, territory, sustainability/circularity, market mechanisms...) or by value chains, where all parties' actions will be proposed and analysed.

The Department of Climate Action, Food and Rural Affairs, via the General Secretary, will support the Board and exercise the functions of coordinating and spearheading the forecasts of EBC2030.

The Board will be formed by representatives of the departments of the Catalan government with jurisdiction in the following areas:

- / Rural Agenda
- / Food
- / Climate Action
- / Education
- / Economy
- / Digital Policy
- / Mountain Policy
- / Business
- / Innovation
- / Research

Representatives from local administrations, universities and research centres, the business sector, professional farm organisations and cooperatives, forest owners, consumer rights advocates, environmental defence groups and other civil organisations will also take part.

The implementation of EBC2030 will be based on the following documents:

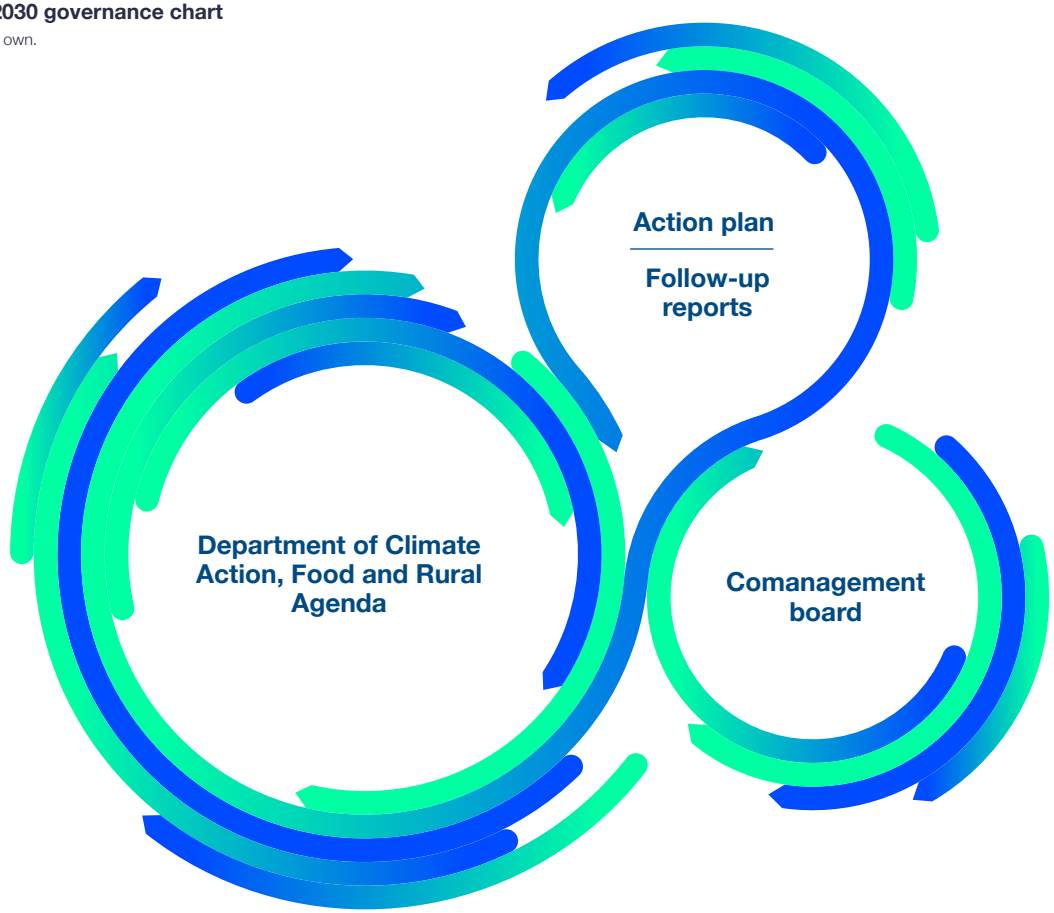
1. **Triennial action plans**, which will specify the actions required to effectuate the measures included in the various strategic objectives. The plan will indicate which governmental body is responsible for the action and which means will be allocated to its execution, as well as the indicators used to evaluate the interventions' results and enable their monitoring.

2. **Regular follow-up reports**, based on the indicators proposed in the strategy itself and in the action plans. They will be issued on an annual basis and will include both EBC2030 in its entirety as well as the results in the execution of the action plans.

3. **Action confirmation system**, designed to check the consistency of the actions proposed with the Strategy's general principles.

4. **Communication plan**, used to anticipate future publicity campaigns about the advances in the implementation of the provisions of EBC2030. The plan will list the various communicative tasks and identify each task's recipients, formats and the mechanism for monitoring the results derived from it.

Figure 28
EBC2030 governance chart
Source: own.



9 /

Monitoring and assessment of EBC2030

9 / **Monitoring and assessment** of EBC2030

The monitoring and assessment of the 2030 Catalan Bioeconomy Strategy will be executed through a series of indicators used to measure the Strategy's major accomplishments. These indicators will coincide with the indicators proposed on a European level[43] and those provided in public sources (see **Figure 29**).

In the end, these indicators will serve not only to evaluate the impacts of the various actions developed in the EBC2030 context through their corresponding action plans, but also to evaluate the suitability of the various measures and actions to the principles established. In essence, these indicators will serve to evaluate the transition toward a circular and sustainable bioeconomy in Catalonia.

In some cases, the available information for monitoring the indicators is incomplete, and crucial data is missing. In this sense, an adequate methodology will be designed internally to improve the data quality and make it possible to study its progression.

Figure 29
Indicators for monitoring the Catalan Bioeconomy Strategy.

CODE	Impact indicators
F1	Contribution of the bioeconomy to the gross value added
F2	Primary sector jobs Youth incorporation into the rural and maritime sphere
F3	New businesses in the food production sector based on circular bioeconomy
F4	Number of start-ups and scale-ups in the bioeconomy sphere Number of companies developing technologies in the bioeconomy sphere
F5	Use of forest resources
F6	Use and recovery of the co-products and by-products of the food production chain and the fishing and aquaculture sector
F7	Loss of agricultural area and recovery of the management of agrarian zones abandoned in the last 30 years
F8	Emissions linked to the management of livestock waste and food waste
F9	Use of renewable fuels in the primary sector
F10	Organic carbon in the soil

43 https://knowledge4policy.ec.europa.eu/bioeconomy/monitoring_en.

Acronyms and abbreviations

ABP	/	Animal by-product not intended for human consumption
ACA	/	Catalan Water Agency
ACCIÓ	/	Agency for Business Competitiveness of Government of Catalonia
ARC	/	Waste Agency of Catalonia
CHE	/	Hydrographical Confederation of the Ebre
CLT	/	Cross-laminated timber
CPF	/	The Forest Owernship Centre
CREAF	/	Centre for Ecological Research and Forestry Applications
CTFC	/	Forest Science and Technology Centre of Catalonia
DACC	/	Ministry of Climate Action, Food and Rural Agenda
EAP	/	Priority farming operation
EBC	/	Catalan Bioeconomy Strategy
EELL	/	Local authorities
EU	/	European Union
FC	/	Forestal Catalana, SA
GDP	/	Gross Domestic Product
GPI	/	Genuine progress indicator
GVA	/	Gross value added
ICAEN	/	Catalan Energy Institute
IDESCAT	/	Statistical Institute of Catalonia
IRTA	/	Institute of Agrifood Research and Technology
LU	/	Livestock unit
n.d.	/	No data
OFMSW	/	Organic fraction of municipal solid waste
R+D+i	/	Research, development and innovation
SDGs	/	Sustainable Development Goals
SWOT	/	Strengths, weaknesses, opportunities and threats
WWTP	/	Wastewater treatment plant

Glossary

Algae: a group of simple autotrophic, generally aquatic plants, characterised by the presence of assimilative pigments of diverse colourations. As a result of eutrophication processes, large quantities of algae are generated and must be removed from riverbanks and beaches; sometimes, invasive algal species must also be removed. Algae (and microalgae) can be cultivated for specific purposes.

Biofuels: high calorific value substances obtained from biomass processing or through biochemical processes; they may be liquid (bioethanol and biodiesel) or gaseous (biogas, biomethane and synthesis gas). Depending on their origin, they are classified into first (derived from crops), second (derived from plant waste), third (derived from algae) and fourth generation (advanced biofuels obtained from genetically modified microorganisms).

Biogas: a combustible gas primarily consisting of methane, obtained through the anaerobic digestion of organic wastes or by-products such as slurry, manure, wastewater treatment sludge, slaughterhouse waste, organic municipal solid waste (MSW).

Biomass: the entirety of all organic matter of plant or animal origin, including the materials derived from natural or artificial transformation.

Biomethane: (also known as “renewable natural gas”) a nearly pure source of methane produced by “upgrading” biogas (a process which eliminates CO_2 or other pollutants present in the biogas) or through the gasification of solid biomass followed by methanation.

Bioplastic: a type of plastic manufactured using biomass, generally from plant products or through fermentative processes, which, in not being derived from petroleum and being biodegradable, have a more favourable environmental footprint.

Bioproduct: a product created by applying biotechnology within the industrial sphere to transform the biomass derived mainly from non-food crops, forest biomass and organic waste. Common bioproducts include bioplastics and biopackaging, biomaterials from construction, additives of biological origin and the products of green chemistry, and biofuels.

Biorefinery: a refinery which converts biomass into value-added biobased products (food, animal feed, chemical products, materials) and bioenergy (biofuels, energy and/or heat).

Biowaste (OFMSW): the selective collection of the **organic fraction of municipal solid waste**, formed by food and food-preparation scraps and small plant remains.

Biowaste compost: product resulting from the composting of organic waste (biowaste with plant waste).

Biowaste digestate: material resulting from the anaerobic digestion of biowaste. Later, it can be composted or applied directly to the soil.

By-products: waste items used as substitutes for commercial products and/or raw materials and which can be recovered without being subjected to treatment operations.

Catch crop: a crop grown between the production cycles of a main crop primarily to reduce or minimise the leaching of nitrogen from the soil. It also helps to prevent soil erosion and the formation of a surface soil crust.

Circular bioeconomy: a circular and sustainable economic model based on the use of local renewable resources to produce goods and services in all economic sectors.

Coffee husks: waste from the production and making of coffee and other derived products.

Co-product: discarded food reintroduced into the food chain, whether for human or animal consumption.

Cork: outermost part of the bark of some trees constituted by a light, porous and impermeable tissue which protects the trunks, branches and large roots. The raw material and processed cork have a wide variety of uses.

Discarded food: food or parts of food which are rejected during processing, but which can still be used for human or animal consumption. See also co-product.

Dredge spoil: sediment materials obtained from the dredging of rivers, canals, ports, reservoirs, dams, etc.

Ecosystem services[44]**:** benefits which an ecosystem gives society and which improve health, the economy and people's quality of life. An ecosystem service is derived from the functions inherent to ecosystems. There are three types of services: the provision of goods like water, food or clean air; the regulation of the climate, waste, floods or disease propagation; and cultural services, which provide recreational values, beauty, inspiration and spirituality.

Eggshells: including the eggshells and dead chicks from poultry and egg production. This material can be used as a fertilizer.

Feed: any substance or product, including additives, whether processed, partially processed or unprocessed, intended to be used for oral feeding to animals.

Food industry by-products: by-products of diverse food industries (extraction, fermentation, conservation, etc.).

Food industry waste[45]**:** organic waste generated during the different processes and stages which make up the food production and processing chain.

Food loss[46]**:** edible parts of food which remain at the primary production site, whether reincorporated into the soil or used for composting in situ.

Food waste[47]**:** food intended for human consumption, whether or not suitable for ingestion, which is removed from the production or supply chain to be discarded at the primary production, processing, manufacturing, transport, storage, distribution and end consumer stages, with the exception of food loss in primary production.
The term also refers to food which has become waste, for example, because it has expired or due to inefficiencies and errors in distribution, and which, according to current law, cannot be used for human or animal consumption.

Forest biomass: trunks, branches, stumps, bark, firewood, chips, shavings, pellets, briquettes, etc.

Grass clippings: plant waste resulting from lawn mowing. It may frequently be mixed with leaves, pine needles, etc. It is usually managed (and quantified) along with the plant waste from trimming in parks and gardens.

Harvest left in the field[48]**:** edible or inedible parts of food left on the farm itself, whether reincorporated into the soil or used for composting in situ.

Harvest remains: waste from harvests of cereals, vegetables and other crops. The non-commercialisable parts which frequently remain and are integrated into the soil or picked to be managed as waste (cornstalks, tomato plants, etc.).

Industrial farm sludge: a semi-solid material, with a sticky appearance, obtained in the in situ treatment process of waste effluents from the preparation and making of: meat, fish, fruits, vegetables, cereals, oils, cocoa, coffee, tea, preserves, yeast and molasses, sugar, dairy products, baked goods, etc.

Industrial farm sludge compost: material resulting from the composting of organic waste (industrial farm sludge with plant waste and other organic waste types).

Livestock waste[49]**:** waste materials excreted by livestock (faeces and urine), and the mixtures of these materials with litter and the remains of the food and water supplied, even if processed. They are classified into manure, slurry and poultry litter.

Manure: solid or semi-solid animal waste, which may include litter (straw or other materials), selectively collected and stored and commonly used to fertilise fields and gardens. It includes manure processing both in and out of the farm operation context.

44 As defined in the 2030 Natural Heritage and Biodiversity Strategy of Catalonia.
45 Article 3 item 4 of Directive (EU) 2018/851 amending Directive 2008/98/EC on waste.
46 Article 4 of Law 3/2020, of 11 March 2020, on food loss and waste prevention.
47 Law 3/2020, of 11 March 2020, on food loss and waste prevention.
48 Definition included in the document *Prevenció de pèrdues i malbaratament alimentari. Fitxes sobre oportunitats d'aprofitament en els principals sectors agroindustrials catalans* (CREDA-UPC-IRTA DARP & ARC, 2020).
49 Decree 153/2019, of 3 July, on the management of soil fertilisation and livestock waste and passing the Intervention Programme in Areas Vulnerable to Nitrate Pollution from Agrarian Sources.

Manure compost: material resulting from the composting of organic waste (manure, soil with straw or plant waste).

Nutshells: the shells of almonds, cashews, hazelnuts, peanuts, walnuts, pine nuts, pistachios, chestnuts, acorns, etc.

Olive mill solid waste (dry/wet pomace): sticky solid waste derived from the olive oil extraction process. Dry pomace is primarily made up of olive pits, after the olives are crushed by a mill and squeezed in a press (three-phase extraction); wet pomace is a mix of dry pomace and olive oil wastewater (two-phase extraction).

Olive mill wastewater: liquid waste derived from the olive oil extraction process. Olive mill wastewater contains plant water from the olives, fats, phenols, polyphenols and potassium. It has a low pH and a high chemical oxygen demand.

Organic fertilisers: nutrients of organic origin (mainly nitrogen, phosphorus and potassium) applied as a fertiliser to crops. They range from the direct application of unprocessed livestock waste, the use of processed organic waste through technologies designed to improve its properties, such as composting or anaerobic digestion, to the making of more complex products, such as organically based commercial fertilisers (organomineral fertilisers or biofertilisers) which may include beneficial microorganisms and biostimulants for the crops.

Organic waste[50]: all biodegradable waste derived from the selective collection of the organic fraction, from agricultural or livestock activity or from the food industry.

Paper sludge: a semi-solid material, with a sticky appearance, obtained in the process of treating effluents from the papermaking industries.

Plant remains[51]: subcategory of organic waste which includes the plant parts of crops which do not form part of the product with food value (straw, trimming remains, etc.).

Plant waste compost: material resulting from the composting of organic waste (plant waste).

Poultry droppings: livestock dejections derived from poultry.

Primary sector: everything related to the agricultural, forest, livestock and fishing sector.

Sawdust (natural wood): remains from the wood sawing process. It has a variable particle size. Although, in principle, it is considered a waste from the wood sawing process, its characteristics mean it has a variety of uses.

Slaughterhouse waste: waste generated at the slaughterhouse during the preparation, cleaning and butchering of the animals. It includes manure, fur, intestinal and stomach content, entrails, hooves, bones, blood, etc.

Slurry: liquid animal waste (usually referring to pig production); it includes waste produced both in and out of the farm operation context.

Straw: plant waste consisting of dry cereal stems (wheat, oats, rye, barley, rice, etc.) after the grain or seed has been separated through threshing.

Synthesis gas: a combustible gas, rich in hydrogen and carbon monoxide, obtained from the pyrolysis of carbon-rich substances (mainly coal or biomass).

Tree trimmings: pruning waste from trees and bushes.

Vinasse: wastewater generated from wine production.

Wood from timber harvesting: wastes resulting from the management of forest biomass (undergrowth and debris removal, clearing, sanitary logging, shredding, trail maintenance, maintenance of safety strips below electrical lines). Sometimes it is extracted from the forest and sometimes it is shredded in situ.

WWTP sludge: a semi-solid material, with a sticky appearance, obtained from the municipal **wastewater treatment process**.

WWTP sludge compost: material resulting from the composting of organic waste (WWTP sludge with plant waste).

50 Directive 2008/98/EC of the European Parliament and of the Council, of 19 November, on waste and repealing certain directives.

51 In the current legal framework, there is no specific definition of these waste types.










Generalitat
de Catalunya