Interreg Mediterranean

EUROPEAN UNION

PEFMED PLUS

Project co-financed by the European Regional Development Fund

2022

INNOVATIONS IN THE AGRIFOOD SECTOR TO REDUCE FOOD PRODUCTS ENVIRONMENTAL FOOTPRINT

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FOREWORD

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Innovation is the keyword for interpreting the challenges that environmental goals pose to the agrifood sector. The international objectives, in relation to the Paris Agreement of 2015 and the commitments of the UN agenda for 2030, as well as the European ones which are made explicit in the Green Deal and specifically for the agrifood sector in the From Farm to Fork strategy, require an overall reflection on the entire agrifood system to start an effective environmental transition.

Rethinking ways and forms of producing and consuming is the invitation and the objective of the UN Sustainable Development Goals 12 and we should also achieve the expected goals in a short time, by spreading solutions and technologies with a speed never seen before. All this requires a decisive acceleration in the innovation processes so that these objectives are, at least in part, achieved. The term "innovate", in a broad sense, means changing the way we act and produce, but also distribute and consume, and to do it effectively we must go beyond the technological approach towards innovation to adopt a point of view in which knowledge and its spreading become central.
The technology is the hardware but the software, i.e. the skills upstream and downstream of the technology, and the orgware, i.e. the organization that guides and helps to spread the knowledge, are important and essential.
Only the combination of hardware, software and orgware enables an organization to meet its system and strategic goals.

Due to its heterogeneity, the length of the supply chains and the set of actors involved, the agrifood sector requires an important effort to be able to follow the path of sustainability.

A central role is played by entrepreneurs' awareness of the problems and of the opportunities. On the first aspect it is necessary for companies to measure their actions to be aware of what they do and how they do it in quantitative terms. On the second, they must know the opportunities, i.e. the set of technologies and methods that can allow them to reduce their environmental and social impacts and at the same time to remain competitive on the market.

In this sense, the method of calculating and evaluating the environmental footprint of a product considering the entire life cycle, promoted by the European Union (Product Environmental Footprint, PEF) can represent a way of fostering continuous improvement and efficiency of the company itself and towards consumers

The PEFMED PLUS project fits into this groove and continued the activities of the previous PEFMED project whose ultimate objective was to help and stimulate the companies and their supply chains to become aware, measure their impacts and deal with the use of resources and the efficiency of their processes to then evaluate which organizational changes or technological innovations could help them to improve their performance.

This volume, which has involved various players in the PEFMED PLUS project, wants to testify some experiences and propose shared reflections on the theme of environmental assessments in the agrifood sector in the belief that it is necessary to spread and disseminate what has been done to contribute effectively to the environmental transition of the entire production system.

THE GREEN GROWTH COMMUNITY

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THE GREEN GROWTH COMMUNITY CAPITALIZATION PLATFORM

Green Growth and Circular Economy in the Euro-Mediterranean region are the main objectives of the **Interreg MED Green Growth Community**, to be developed through the adoption and promotion of sustainability and cooperation synergies between Quadruple Helix stakeholders (public authorities, academia, civil society, industry & business).

The Community, **labelled by the Union for the Mediterranean** for its support to the transition to a green and circular economy and to deliver concrete benefits to the citizens of the Mediterranean region, involved **165 partners from 13 Mediterranean countries**, gathering **17 Thematic Projects** clustered around **4 Focus Areas** - food systems, eco-innovation, smart cities and waste management - tackling the key priorities of the **EU Green Deal** and the **EU Circular Economy Action Plan**.
The **Green Growth Capitalisation Platform** concretely allow the knowledge sharing of its 17 Thematic Projects results and materials and the networking and developing of new partnerships and synergies between institutions and stakeholders, supporting them in communication and capitalisation efforts through its network.
The **Food Systems Focus Area** collects all the thematic projects focusing on the goal of a healthier and more sustainable EU food system, as a cornerstone of the European Green Deal and of the Green Growth Community, with the aim to create sustainable food environments improving lifestyles by boosting the efficient use of resources and building efficient food chains for consumers, producers, climate and environment.

In this frame, **PEFMED and PEFMED PLUS projects represented a flagship of the Green Growth Community in the Food System Area**, working in collaboration with agrifood federations and regional policymakers to effectively contribute **to lower the environmental and socio-economic impacts to improve agrifood companies' capacity to respond to consumers' needs and to expand the market for green products**.

More in detail, they strongly contributed to the common goals of the Green Growth Community towards the EU Green Deal and its Farm to Fork Strategy by:
- helping agrifood companies and national agrifood associations to take stock of their environmental footprint throughout their supply chains.
- clearing the way for the introduction of more eco-innovative and sustainable practices within the target sectors.
- developing a holistic approach to greening the agrifood system, by integrating in its method even socio-economic criteria (SE-KPIs).

Furthermore, the implementation of PEFMED PLUS project, despite its different approaches and activities, contributed to enhance the former PEFMED project's main results in the short and medium-long period. In general, it affected the overall Community results on three main aspects:
- the enhancement of the role of the countries involved in the previous project, allowing partners belonging from these countries to play a fundamental role as driver towards the implementations of effective tools and best practices in new countries, involving new partners.
- the shift towards the Adriatic regions, as the

best new beneficiaries of their activities.
- the data improvement after the project's implementation: the capitalization of such relevant project, offered to the project and to the Green Growth Community the opportunity to focus on some aspects, allowing better expectations for the period in the long period.

On one hand, the capitalization of PEFMED contributed to increase the impact of the Green Growth Community project as a whole on the Mediterranean region, paving the way for further perspectives in the pursuing of the green growth goals and to test the added value of its tools and results. Mostly, it contributed to widen the number of regions, stakeholders and institutions involved, showing once again the high relevance of the Green Growth Community and replicability of its best practices in all the Mediterranean area.
Last but not least, PEFMED PLUS project, as active project within the Green Growth Community, contributed to identify a series of environmental, social and especially economic indicators and goals specific for the Adriatic basin to be used in order to build a clearer vision about their possible impact and further development in the future in this area.

GREEN GROWTH COMMUNITY FOCUS AREA FOOD SYSTEMS

- **ARISTOIL and ARISTOIL Plus Reinforcement of Mediterranean olive oil sector competitiveness** through development and application of innovative production and quality control methodologies related to olive oil health protecting properties.
- **CAMARG Clusters of Innovative Zero-km Agro-food Marketplaces for Growth**. Testing and validating an advanced e-commerce solution to support small producers in MED territories characterized by agro-food excellences.
- **EMBRACE European Med-clusters Boosting Remunerative Agro-Wine Circular Economy**. Development of a model and implementation of a toolkit for the establishment of transnational circular economy meta-clusters.
- **MADRE Metropolitan Agriculture for Developing an innovative, sustainable and Responsible Economy**. Gathering key metropolitan and peri-urban agriculture stakeholders to encourage transnational cooperation in the MED area.
- **PEFMED and PEFMED Plus Uptake of the Product Environmental Footprint across the MED agro-food regional productive systems to enhance innovation and market value**. Fostering targeted systemic interventions to green the agrofood supply chain.
- **MED GREENHOUSES Green Growth through the capitalization of innovative Greenhouses**. Promoting, disseminating & transferring innovative approaches for the establishment of efficient greenhouses in the MED area.

GREEN INNOVATION: OPPORTUNITIES AND NEEDS FOR THE COMPETITIVENESS AND SUSTAINABILITY OF AGRI-FOOD COMPANIES

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Keywords: ***supply chain, competitivity, innovation***

Green innovation: opportunities and needs for the competitiveness and sustainability of agrifood companies.

Our goal is to explore the imperative for greener innovation within the agrifood supply chain, by emphasizing the opportunities it may presents for enhancing the competitiveness and sustainability of producers operating in this sector. As global concerns about climate change, resource depletion and environmental degradation intensify more and more, also agrifood companies face increasing pressure to adopt sustainable practices. Therefore, the concept of green innovation, by encompassing technological advancements, sustainable farming practices and eco-friendly supply chains, emerges as a crucial strategy for companies in order to thrive in an environmentally conscious market and to actively participate in the decarbonisation goals [1].

During the last years the sector was strongly affected by challenges like the Covid-19 pandemia and the energy crisis with a large increase of costs with an effect on the reduction of economic margins and the need for agrifood companies to save energy or to produce energy for self-consumption to recover or, at least, to keep their competitivity on the market.

Moreover the climate change scenarios suggests that reducing GHG emissions from the global food system will likely be essential to meeting the 1.5°C or 2°C target and this could require extensive and unprecedented changes to the global food system [2].

As described above, the agrifood industry seems to be at a crossroads, by coping with the need for enhanced competitiveness and sustainability at the same time. In this light, green innovation serves as a catalyst to address these dual challenges, by offering a myriad of opportunities for agrifood companies to prosper in an evolving business landscape. This article will delve into the various aspects of green innovation and its potential to revolutionize the agrifood sector starting from a Mediterranean perspective.

In the Mediterranean basin the agrifood industry is one of the largest and most important productive sectors but it is mostly composed by SMEs, mainly small and microenterprises, with lack of resources and qualified personnel for investing in the greening of the supply chain innovation. Furthermore, SMEs typically consider potential investments to improve their overall efficiency as a loss in a low-price approach or as a major change in their product market characteristics already assimilated by target consumers [3].

But in the medium-term perspective, sustainability will become a must-have prerequisite for companies in the sector and any ongoing optional requirements or fulfilments today will presumably be mandatory in the next decade.

Sectoral policies and consumer requests converge towards certified and transparent sustainability goals capable of responding to the ambitious objectives for 2030 and 2050 set by EU Green Deal and to the evolution of consumer sensitivity in purchasing products with a lower environmental impact [4].

This mix of factors will push the sector to innovate in order to "survive" and recover economic margins and this need meets the ongoing technological and digital evolution which makes available new solutions capable of reducing costs by increasing efficiency and modifying production processes.Nowadays it is not so much the fact of producing innovation that matters but it is above all important to focus on the rapid diffusion of innovation. To involve and make aware the companies operating in the agrifood sector is a strategic element of innovation policies. But reaching and informing the myriad of small and medium-sized enterprises in the sector in Europe is not easy and, at this regard, many efforts have been made by the European community to spread out innovation through research and transnational cooperation Programmes.

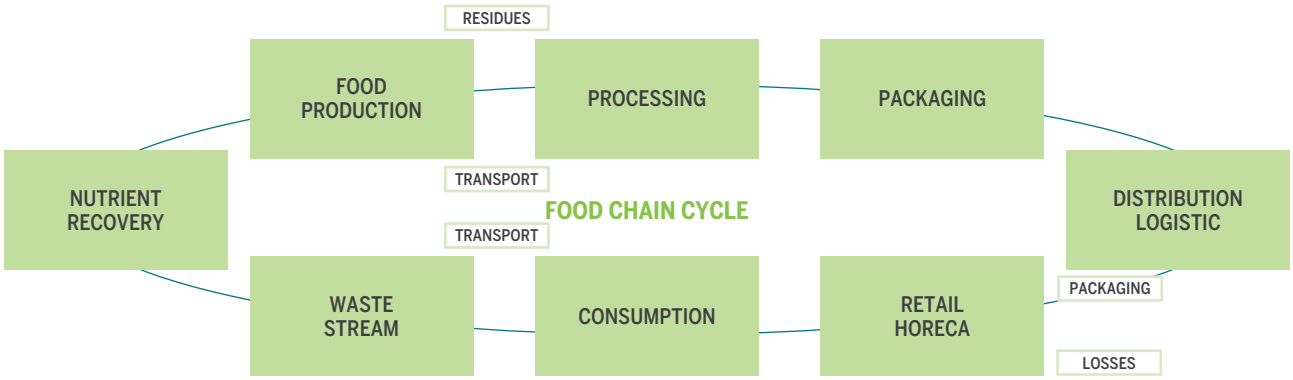
Since the different agrifood productive branches are so heterogeneous and complex, it is not simple to describe and to list all the available opportunities which can introduce innovation along the different supply chain phases. While there is room to innovate along all phases of the supply chain but certainly in some of them it is more urgent or easier to do so taking into account the current regulatory and technological framework. In the following figure the phases of the supply chain where innovations are most expected or possible have been summarised.

A number of opportunities for agrifood companies and agriculture farms include vertical innovation as well transversal actions to overcome obstacles and to promote innovation uptake such as training, education and digitalization.

Moreover, technical solutions deal mainly with energy, water, productions inputs, soil management, packaging and wastes.

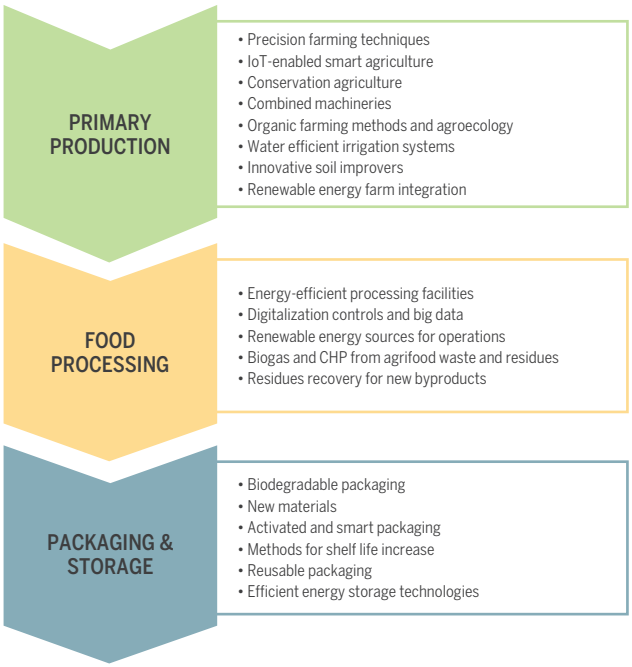
In the following scheme (Figure 2) some areas of innovation and different solutions that could be applied have been highlighted, even if this does not represent an exhaustive list of solutions but it is certainly a group which is looked at most carefully by the agrifood supply chain operators as they were identified as solutions that already found mature, affordable and replicable applications.

Figure 1. Agrifood supply chain stages where innovation can play a major role



PHASES OF THE AGRIFOOD CHAIN AND INNOVATIONS NODES

Figure 2. Potential innovative solutions along the supply chain



In research laboratories many other solutions are being studied and some of them are very close to

the demonstration level, but they still require time to prove full reliability and cost-effectiveness, while many others are commercial and affordable but still need time to be implemented and diffused within the European agrifood system.
When taking into account the priorities of the food industry, as safety and quality, and the size of European companies, it is clear that these solutions encounter various obstacles in their adoption and diffusion. There are multiple projects and initiatives that have identified and analysed both the barriers and the directions necessary to encourage the adoption of innovations [5] (Figure 3).
Any future green action requires investments, collaboration and training and no innovation will be effective if these three elements will be not included and balanced in an improvement path.

Figure 3. Actions to be taken by agrifood companies to adopt innovative technologies and solutions

The list of actions can be expanded and declined differently for the specific subjects involved in the supply chain, but it is needed that each enterprise or product "greening" process is accompanied by a study and analysis of its specific needs to achieve a certain goal.

Closing remarks

Green innovation stands as a transformative force for agrifood companies, by offering a pathway to increased competitiveness and sustainability. Embracing technological advancements, adopting sustainable farming practices, and building eco-friendly supply chains are key steps for companies seeking long-term success in a society where environmental concerns are central. Addressing the needs for research and development, education, policy support, and consumer awareness will facilitate the widespread adoption of green innovation in the agrifood industry, by ensuring a more resilient and sustainable future.

The environmental crisis calls all the stakeholders together to build a more resilient system capable of adapting to socio-economic and environmental changes. This is, precisely, the challenge of adapting to climate change that is the most complex for the food system because it risks undermining the production bases on which the system is based and opens up the prospect of food security as a theme to be re-appropriated in the future. Any innovation which is able to reduce the use of resources is potentially a useful adaptation measure for the future providing at the same time mitigation opportunities. "Sustainable intensification" is one of the new paradigm to deal with the food systems challenges in the near future [6]. The concept is open and it does not privilege any particular vision of agrifood production but emphasizes ends rather than means and does not pre-determine technologies. So all solutions listed above are eligible to provide their services to reach the EU goals.

But it is not enough if we do not put more efforts on research. Agrifood research with a systemic perspective is crucial not only to deal with the abovementioned challenges but also to contribute towards sustainable development and we must pursue it having in mind a rural perspective. There is no healthy, high quality and cheap food production without having in mind a rural perspective and making farmers protagonist of the agrifood system and to reach a goal so complex we need both interdisciplinary collaborations, local actor engagement and a participatory approach to innovation [7].
There is no doubt that Agrifood Systems Research has much to offer to answer the challenges faced by food security and safety in the current complex and uncertain times, but no one can reach results by putting efforts only on technological solutions without analysing and involving farmers (as landowners) and all the other stake-

holders part of the agrifood supply chain.
Many efforts have been made in projects and initiatives financed and promoted at European community level, but others need to be implemented. In national communities, promoting a multi-actor dialogue along the agrifood supply chains seems to be a complex but necessary path and projects such as PEFMED and PEFMED PLUS have specifically contributed to promoting it.
The topic of product sustainability certifications requires joint efforts amongst the different players in the agrifood supply chain in order to achieve this goal by sharing the disclosure and the use of already existing green solutions. At this aim, the Product Environmental Footprint (PEF) method is a part of the European political agenda, and it is an important instrument for implementing circular economy actions and reach environmental goals. Furthermore, consumers have changed their behaviour by asking for clearer and more scientifically based information about the sustainability of products and the producers as well as better transparency.

All these considerations establish the foundations for an effective "push" for process and product innovation in order to support not only businesses to be more competitive and sustainable but the overall agrifood system to improve its resilience.

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COMPANIES AT THE CROSSROADS OF SUSTAINABILITY

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Keywords: ***food industry, green business, sustainability***

The EU food and drink manufacturing industry is made up of 290,000 businesses employing 4.5 million people. It generates €222 billion in value added every year and is the largest manufacturing industry in terms of jobs created. As an industry comprised of 99% SMEs our enterprises are intimately linked with their local communities [see Table 1].

The food and drink industries of the European Union would like to underline their unwavering support for the swift implementation of the European Green Deal and the Farm to Fork Strategy agenda in the current volatile times. While many food and drink companies are confronted with unseen challenges today resulting from an amalgamation of external shocks, such as the pandemic, war, inflation, labour shortages and more, immediate crisis and emergency measures are justified to uphold the production capacity and economic viability of the agri-food sector.

At the same time, the need to accelerate public and private action, investment and collaboration has never been so great to ensure that citizens in Europe and the rest of the world continue being able to rely on guaranteed access to food – today, but especially with a view to the future.

Table 1. EU Food and Drink industry figures

EU FOOD AND DRINK INDUSTRY FIGURES		
Turnover **€1,093 billion** A leading manufacturing sector	**Value added** **1.9%** of EU gross value added	**Consumption** **21.5%** of household expenditure on food and drinks
Employment **4.5 million people** Leading employer in the EU	**Number of companies** **289,000**	**R&D expenditure** **€1.9 billion**

Sales within the Single Market **88%** of food and drink turnover	**Small and med,um-sized companies** **40.5%** of food and drink turnover	**58.4%** of food and drink employment

External trade **€145 billion** Exports	**€78 billion** Imports	**€67 billion** Trade balance	**#1** exporter of food and drinks

Source: elaborated from Food Drink Europe Data & Trends 2021

Securing a high level of global food security for future generations requires food systems to transform, uniting the concepts of food security, productivity and sustainability.

The concept of sustainability includes not only environmental aspects, but also economic and social ones. Without attention to these aspects, any action to reduce the impact on the ecosystems would be short-term. The challenge is to rebuild the foundations on which growth and development are based from a global perspective, including the environment, society and the economy.

The food industry is committed to environmental sustainability through four main key areas for action, all consistent with the principles of the Circular Economy underlying the new EU framework rules on environmental and industrial policies:

- Efficient use of basic inputs (primarily water and energy, through process efficiency and optimization);
- Greater use of agricultural raw materials in all their components, which are intended for human consumption, feed industry and other valuable supply chains, such as cosmetics, pharmaceuticals, chemicals, bio-energy, to fully exploit resources and minimize waste production according to the circular economy principles;
- Eco-design packaging and proper management of post-use packaging;
- Food waste prevention.

The EU food industry is committed to constantly and significantly reducing water use in its production processes, to improve efficiency and ensure compliance with stringent EU hygiene requirements.

The food sector accounts for 1-1.8% of water use in the EU, with continuous process innovation leading to a progressive reduction in the quantities used and company case histories showing a reduction of 40% and in some cases more than 60%.
Water consumption by European industry has decreased by an average of around 30-40% since the 1990s. Over the same period of time, important Italian food companies had excellent experiences in reducing water consumption up to 60%-70% (per ton of product) and 40-50% in absolute value (consumption efficiency is however compared to an increase in production volumes). This is important and even more relevant if we take into account the fact that due to its manufacturing, food and wine, social and market traditions, the Italian food industry –unlike in other countries, for example the North European ones, where food companies are very specialized in single productions –produces many and varied food products in its plants. This inevitably requires the use of greater quantities of water for the necessary washing of the plants in the transition from one production to another.

The food industry, the leading one in EU, has a relatively low energy impact compared to other industrial sectors. This sector's electric energy consumption accounts for 8% of industrial electricity use in OECD countries and 1.5% of global energy consumption in Europe, while European food and drink manufacturing accounts for approximately 1.5% of total EU GHG emissions
The use of agricultural resources – the main input of industrial food processes – and all their valuable components (including by-products and residues), in compliance with health and environmental protection regulations, creates a real virtuous circle. Making greater use of agricultural raw material means multiplying the value of its production inputs (water, air, soil, energy), reducing the supply of alternative resources, minimizing waste and implementing the notion of Circular Economy– which is the basis of the regulatory policies on environment and sustainable production that the European Union is rewriting.
In addition, the fish processing sector has long been committed to promoting sustainable fishing practices to ensure a balance between when and how renewable natural resources are made available and the need for raw materials.
As for quantities, the food industry by-products account for 2- 3% of the total volume of "dry" produce and 7-10% of "wet" products, determining a significant direct and indirect commercial value. By-products can be used for different purposes, mainly as ingredients for food and feed production within the food-chain –about 90 million tons are used in feed production in the EU every year. When food or feed production is not

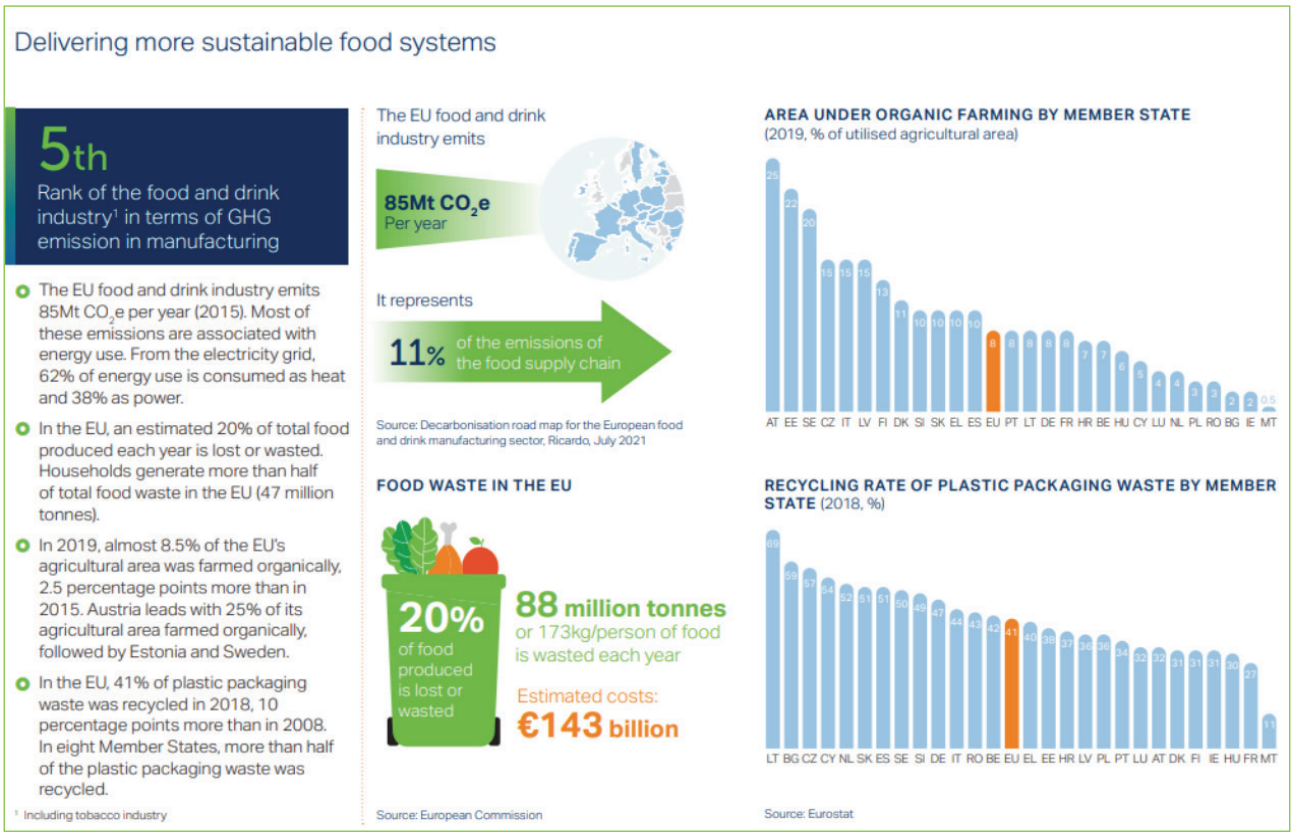
possible, they are mainly used in the cosmetics and pharmaceutical industry, chemical industries and, subordinately, in fertilizer and bioenergy production.

On the same theme, it is essential to maintain full compliance with the EU regulatory framework, avoiding rushing ahead and unilateral national legislations that fragment the Internal Market and undermine the competitiveness of our businesses.
The food industry alone uses 2/3 of the packaging produced and devotes considerable resources to preventing and reducing the environmental impact of packaging. Packaging plays a key role: it helps to ensure the quality and safety of food, protects the product integrity during transport, distribution and consumption, and conveys brand values as well as essential nutritional and service information for the consumer. In addition, packaging has a direct positive effect on the environment: it improves the shelf-life of food products, both at the distribution and final consumer level, reducing food waste and ensuring significant savings in upstream resources.

The food industry is committed to reducing the materials used for packaging without compromising the consumer requirements or the integrity, quality and safety of the products. Some results: in the last ten years, plastics have decreased by 30/40%, aluminum by 30%, glass up to 60%. As for cardboard, 73% of the material is now renewable and recycled (see figure 1 below).

The sustainable use of resources, the reduction of waste and the full exploitation and use of all the components of agricultural raw materials and related processing by-products constitute the historical tradition of Italian food processing and are therefore already deeply rooted in the DNA of the food industry. As a central link in the supply chain, we are naturally inclined to maximize the use of the agricultural raw mate-

Figure 1. Sustainability in EU F&B industry



Source: FoodDrinkEurope Data & Trends 2021

rials that we process. Even the fact that we consider food that for various reasons was not sold or consumed, but still suitable for human consumption –the so-called food surplus– confirms the virtuous example of the Food Industry.

The Food Industry is also committed to preventing waste before it even occurs, in the phase of domestic consumption – which accounts for 45% of food waste–, through a series of actions aimed to encourage consumers to more conscious consumption patterns:

- Food portions proportionate to new lifestyles and consumption habits;
- Advanced packaging able to preserve food safety and quality for longer;
- Shelf-life extension;
- Products with high added service that minimize domestic handling and wastage;
- Increasingly accurate information for the correct preparation and preservation of food.

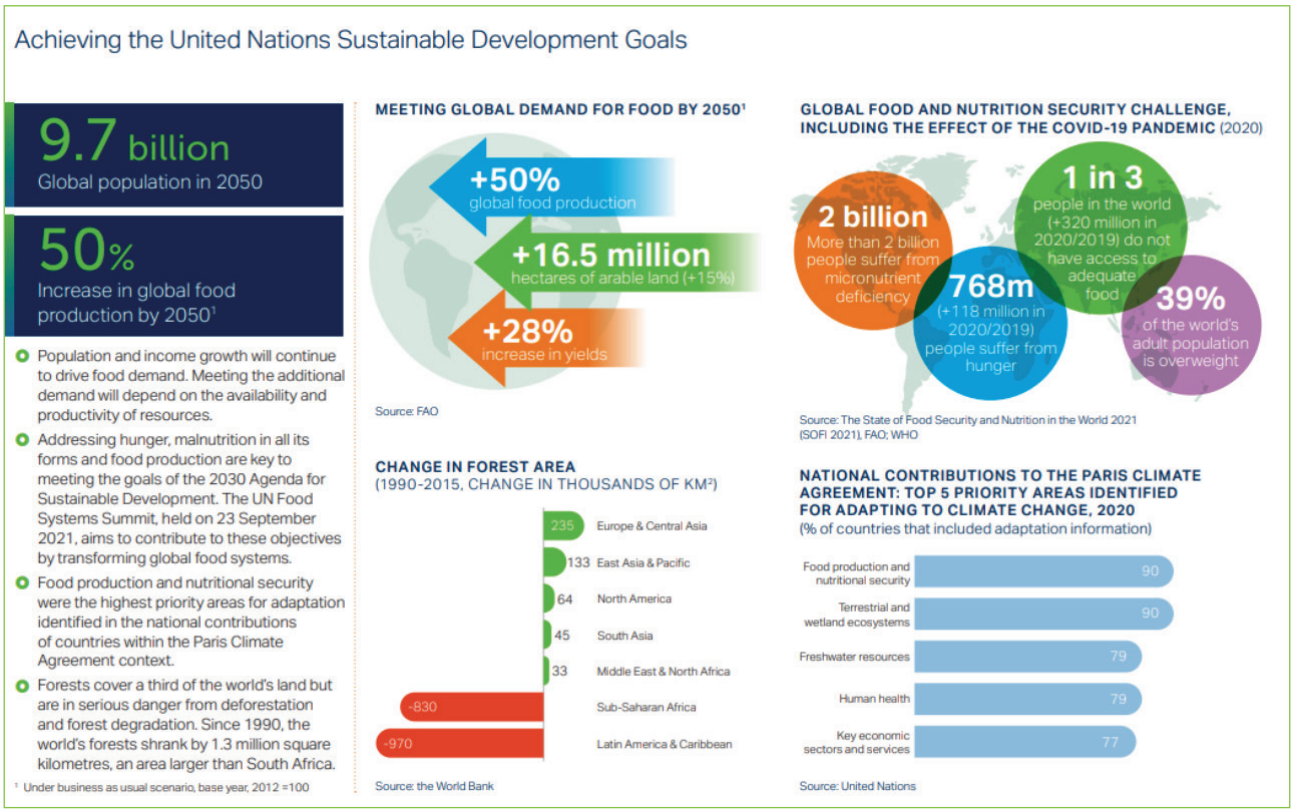
In addition to this, hundreds of food companies donate food to Food Banks, non-profit and third sector organizations supporting the most impoverished in various ways.

As the largest food and drink producer in the world, Europe's food value chain has a major responsibility to contribute to global food production, and thereby food security, in the most sustainable way. The European food and drink industry is determined to be at the forefront of the sustainability transition, which is a conditio sine qua non for the wellbeing, prosperity and longevity of our economies, our societies and our planet.

Principles of food sustainability information

The European food and drink industry is committed to provide transparent information to consumers on the sustainability of food and drink products. Food information is a key tool to allow consumers to make informed choices that fit their individual diets and lifestyles. The

Figure 2. Food Future



Source: FoodDrinkEurope Data & Trends 2021

EU food and drink industry therefore welcomes the opportunity that the future legislative framework on sustainable food systems offers towards developing a science based EU common framework for sustainable food labelling. The European food and drink industry is committed to improve transparency and provide clear, factual and relevant information about the sustainability of food and drink products. The sector herewith would like to offer its technical knowledge and consumer insights to find common, harmonised solutions to further enhance food sustainability information to consumers.

The food sector is strongly interested in establishing sustainable production and consumption patterns on a global scale to meet the challenges that lie ahead in the coming years, i.e. producing 70% more food to feed the 9 billion planet's inhabitants estimated by the FAO in 2050, with safe, quality and sufficient food. The european food system is a model of sustainable production and consumption, able to meet the growing needs of the world's population and ensure the competitiveness of agri-food systems while respecting the environment, local communities, economic development and social growth (see Figure 2).

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03 CHAPTER

THE EUROPEAN PRODUCT ENVIRONMENTAL FOOTPRINT METHOD

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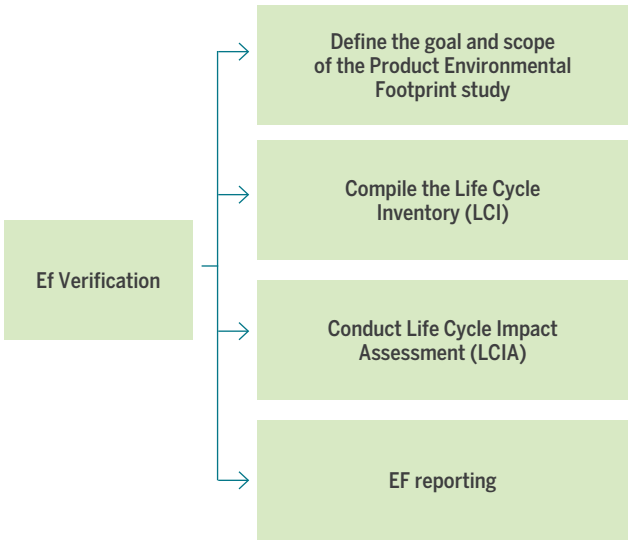
Keywords: ***Product life cycle, Environmental Footprint, Environmental Impacts***

In the last years, both companies and consumers have increased their awareness on the environmental impacts caused by consumption and production models, especially in the agri-food sector. For these reasons, several different standards and technical guidelines have been developed at international level for assessing the potential environmental impacts of products and services, such as the PAS 2050, the Greenhouse Gas Protocol and the BPX 30-323-0 [1]. Furthermore, eco-labels, i.e. product labels which provide information about the overall environmental performance of products (e.g. Environmental Product Declaration according to ISO 14025 or European Ecolabel according to ISO 14024) have been used increasingly by companies to communicate their commitment towards sustainable development topics and to obtain competitive advantages in the market.
Some methods include only the impacts on climate change, such as the PAS 2050 and the Greenhouse Gas Protocol, which are focused only on the Carbon Footprint calculation, whereas other account for a limited group of environmental indicators, and therefore they do not comprehensively assess all the environmental aspects connected to products life cycle. Moreover, the results obtained by the application of those methods are not fully consistent or comparable [1; 2; 3], since all these methods are not harmonised and apply different methodological choices. One of the objectives of the "Roadmap to a Resource Efficient Europe" was to "Establish a common methodological approach to enable member states and the private sector to evaluate and communicate the environmental performance of products, services and companies based on a comprehensive assessment of environmental impacts over the life-cycle" [4]. Therefore in 2013 the European Commission adopted the Communication "Building a Single Market for Green Products [5] and published the "Recommendation on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations" [6], both aimed at developing a common European framework for the assessment of products and organisations environmental performances throughout their entire life cycle as well as their communication to consumers, with the general purpose to facilitate and promote the development of environmentally-friendly products in the internal market and to promote competitiveness among companies [5].
The Recommendation established two harmonised methods for measuring environmental performance along the life cycle, the Product Environmental Footprint (PEF) and the Organisation Environmental Footprint Organization (OEF), both based on the standardised ISO LCA method. The PEF initiative therefore arises from the need to harmonize the methods for the environmental assessments of products and organisations as well as the related environmental labels, which have proliferated over the last years, leading to ineffective communication towards consumers and other companies, a scarce comparability among similar products, an increased difficulty in their use and a subsequent costs increase for companies.

The main purpose of the PEF method is to pro-

vide a common harmonised method which aims to increase the robustness, consistency, comparability and reproducibility of life cycle results [1]. Furthermore, the PEF considers several different impact indicators related to environmental, health and resource use impacts of the product's life cycle, thus reducing any possible burden shifting [5].

Figure 1. Main phases of a PEF study



Source: personal elaboration from Partl et al., 2021 [7].

In order to increase methodological harmonization and comparability among different studies of the same product category, the PEF method provides also general guidance on how to develop specific methodological requirements for several product categories (Product Environmental Footprint Category Rules - PEFCRs), which have been developed during a pilot phase which lasted from 2015 to 2018 and which involved several product groups, with a great participation of agri-food product categories (olive oil, dairy products, feed, beer, pasta, etc.). Moreover, a PEFCR guidance [8] has been developed during the pilot phase of the PEF method, which describes the procedure to be followed for developing the PEFCRs of a specific product category. PEF pilots involved several kinds of stakeholders who were grouped in Technical Secretariats for each pilot, consisting of technical experts such as companies and industry association (representing over 51% of the total European market for each product category), non-governmental organisations, research centres and universities. The Technical Secretariats were supported by a Steering Committee with representatives from member countries and the European Commission as well as by a Technical Advisory Board for providing technical support to specific methodological issues [9]. At the moment, the final PEFCRs are available for several product categories, with most of them representing the agri-food sector (i.e. beer, dairy, feed, packed water, pasta, wine). Figure 2 and 3 show the PEFCR available and those in development.

Figure 2. PEFCRs available

Finalised PEFCRs in April 2018	Finalised PEFCRs in November 2018
• Rechargeable batteries • Decorative paints • IT equipment (HDD systems) • Leather • Thermal insulation (housing) • Beer • Dairy products • Feed for food prod. animals • Pet food • Pasta • Wine • Packed water	• Hot & cold water pipe systems • Liquid household detergents • Uninterruptable power supply • Photovoltaic electricity generation • Intermediate paper product • Metal sheets • T-shirt

Source: personal elaboration from Partl et al., 2021 [7]

IN DEVELOPMENT:

Figure 3. PEFCRs in development

Apparel (including accessories dresses hosiery underwear, leqgings/ tights baselayer, jacket jersey pants shirts skirt socks sweater and cardiaans swimwear t·shirt boots cleats court dress shoes/ heel other athletjç sboes sandals and sneakers)	Sustainable Apparel Coalition pef@apparelcoalition.org
Cut flowers and potted plants	CoOperatie Royal FloraHolland U.A. alberthaasnoot@royalfloraholland.com
Flexible packaging (low, medium and high functionality flexible packaging)	Amcor Group GmbH isabellei ennv@amcocro m
Synthetic turf	EMEA Synthetic Turf Council (ESTC) stefan@estcin fo
Marine fish (wild caught marine fish and marine fish from marine open net pen aquaculture)	Norwegian Seafood Federation (NSF) henrik.stenwig@sjomatnorge.no

Source: personal elaboration from Partl et al., 2021 [7]

In addition to the development of the PEFCRs, the pilot phase has defined, for each product category, the most relevant impact categories as well as environmental benchmarks which will be potentially compared with the results of a PEF study performed by a company on their product. Moreover, the PEF pilot has worked together with the main developers of LCA databases to develop PEF compliant LCA datasets to be used in the PEF studies, with the aim to increase the comparability of PEF results. Table 1 shows an example of benchmark (characterised results) for 1000 ml of liquid milk.
In the transition phase, which has started in May 2018 and will end in 2022, new PEFCRs will be developed (i.e. apparel and footwear, cut flowers and potted plants, flexible packaging, synthetic turf, marine fish), and both the applicability of the method and the use of the PEF as an environmental label will be tested, which will include also the possible use of benchmarks for comparing different products available on the market.
The application of the harmonised PEF method in the agri-food sector, coupled with the development of the PEFCRs for several food and drink product groups, should therefore facilitate the calculation and evaluation of the environmental impacts of agri-food products, by defining common methodological rules to be applied by the practitioner, together with a detailed support in any methodological problem which can occur during the PEF study. This should result in better accuracy, reliability and reproducibility of PEF results and therefore should contribute to the transition towards circular economy models.

In December 2021, the European Commission adopted a revised Recommendation on the use of Environmental Footprint methods [11] which revises the previous 2013 Recommendation and incorporates the methodological results of the pilot phase. During the pilot phase, the method was tested with more than 300 companies and 2000 contributing stakeholders in different sectors. This was very important for strengthening methodological approaches, and produced a significant amount of knowledge from different experts and sectors involved. The fundamental principles

Table 1. Benchmark values (characterised results) for 1000 ml of liquid milk

Impact category	Unit	Life cycle excl. Use stage	Use stage
Cli mate change	kg C02eq	1.53E+00	8.29E-02
Climate change - biogenic		7.36E-01	I.67E-03
Climate change - land use and land transformation		I.92E-01	9.45E-05
Ozone depletion	kg CFC-11	4.69E-09	3.26E-10
Particulate matter disease incidence	disease incidence	1.03E-07	2-SOE-09
Ionising radiation, kBq u23s eq	kBq u23s eq	5.63E-02	3.23E-02
Photochemical ozone formation, human health kg NMVOC	kg NMVOC	3.37E-03	I.38E-04
Acidification mal H+eq	H+eq	1.25E-02	2.51E-04
Eutrophication, terrestrial mol Neq	mol Neq	5.34E-02	5.22E-04
Eutrophication, freshwater kg P	kg P	I.04E-04	I.04E-05
Eutrophication, marine kg N	kg N	3. 75E-03	7.71E-05
Land use Dimensionless (pi)	Dimensionless (pi)	1.51E+02	7.51E-01
Water use m3 worldeq	m3 worldeq	3.11E-01	7.10E-02
Resource use, minerals and metals kg Sb	kg Sb	1.24E-06	I.OSE-07
Resource use, fossils MJ	MJ	6.79E+00	I.36E+00

Source: Personal elaboration from European Dairy Association, 2016 [10].

of PEF method is still Life Cycle Assessment, but the Recommendation introduces some methodological changes, mainly on modelling requirements, data and data quality requirements and life cycle impact assessment. It also includes the development of category and sector rules, and therefore provides a solid basis for policy development and implementation.
Finally, the European Commission is now working on an "Initiative on substantiating green claims" (foreseen in 2022) which will require companies to substantiate claims they make about the environmental footprint of their products/services by using standard methods for quantifying them, such as the PEF method. The aim is to make the claims reliable, comparable and verifiable across the EU, thus reducing 'greenwashing'. This should help companies and investors to make more sustainable decisions and increase consumer confidence in green labels and information and should reinforce the use of PEF for the communication of products environmental performance.

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04 CHAPTER

THE PEFMED METHOD TO IMPROVE THE ENVIRONMENTAL AND SOCIAL FOOTPRINT OF AGRI-FOOD SUPPLY CHAIN

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Keywords: ***Eco-innovation, LCA, KPI, Testing***

Introduction

Over 200 companies, mainly SMEs, from nine Mediterranean regions involved in initiatives aiming at reducing the environmental footprint of six consumer goods: olive oil (in France), wine (in Italy), bottled water (in France), feed (in Portugal), cured meats (in Spain) and cheese (in Slovenia, Italy, Greece). But also methods and tools, solutions and over 60 good practices for the sector, with the aim to support in particular SMEs in the transition towards eco-innovation and a low carbon and circular economy. These are the outputs of European PEFMED project (Uptake of the Product Environmental Footprint across the MED agri-food regional productive systems to enhance innovation and market value), for the transition to a production model oriented towards PEF (Product Environmental Footprint), a common methodology at EU level for assessing the environmental footprint of products in their life cycle and promoting a sustainable and competitive production [1].

PEFMED project, running from November 2016 till July 2019, was financed by the Interreg Mediterranean Programme (budget of 2.4 M euro) to promote eco-innovation in the food and drink industry in the Euro-Mediterranean area, by coupling environmental and socio-economic aspects.

The project starting point was the Recommendation published in 2013 by the European Commission on the use of the Product Environmental Footprint (PEF) method (2013/179/ EU), with the aim of supporting the development of environmentally- friendly products to be sold on the European market and promoting competitiveness among companies.

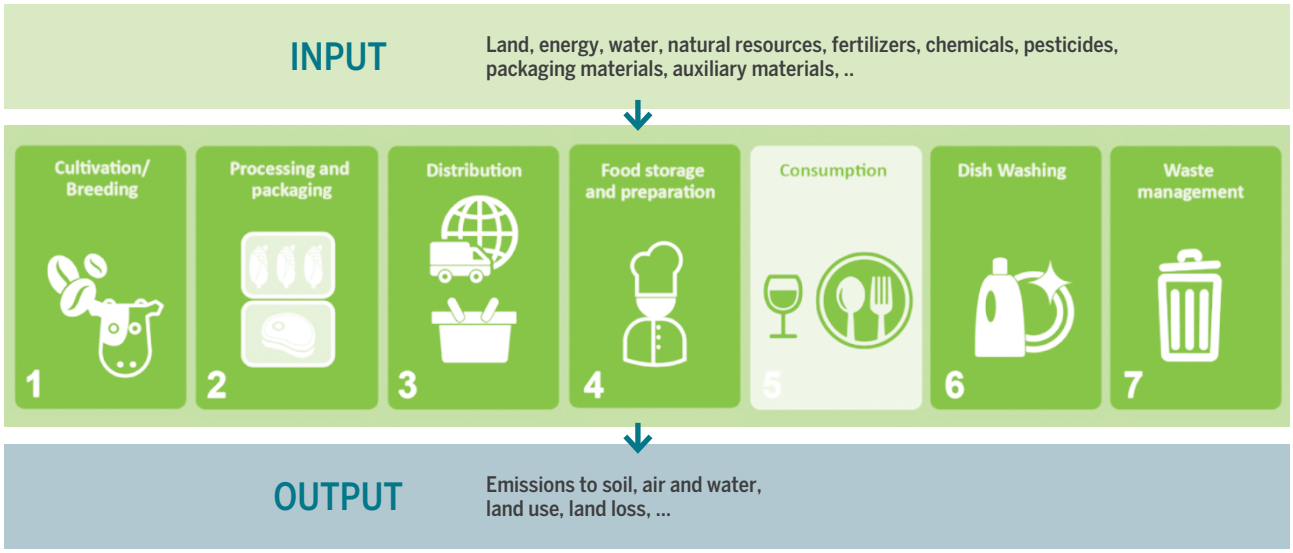
PEF is a harmonized life cycle-based method to assess the potential environmental impacts of products throughout their whole supply chain [Figure 1]. Its main purpose is to increase the robustness, consistency, comparability, and reproducibility of the measurement of the life cycle environmental performance of products. It is based on the existing standards and methodologies, such as the ISO-standards for Life Cycle Assessment and considers 16 potential impacts of the products' life cycle on the environment, human health, and resource use [2,3].

Within this context, PEFMED aimed to:

1. Promote systemic eco-innovation interventions and the use of environmentally friendly technologies, especially in Small and Medium Enterprises (SMEs), with the purpose to increase the sustainability of Mediterranean agri-food supply chains, providing tools, methods, and case studies.

2. Guide a mind change from the traditional production model towards a PEF-oriented approach, by means of training, transfer and dis-

Figure 1. Life cycle stages of agri-food products



Source: P. Sposato, ENEA, 2016

semination actions, based on the results of the project pilot phase.

3. Support the objectives of the Smart Specialization Strategies (S3) of the Mediterranean regions involved in the project regarding the agri-food sector, also by means of an active involvement of S3 managers of the pilot regions, who participated in the development of national roadmaps to promote the application of the PEF method to the Mediterranean agri-food sector.

PEFMED was coordinated by ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) and involved the major agri-industrial federations of Italy (Federalimentare), Greece (SEVT), France (ANIA), Portugal (FIPA), Slovenia (GZS) and Spain (FIAB) and technological experts on agri-food sector (CRITT, France) and on socio-economic issues in companies (DNV GL, Spain). In addition, the Italy the Ministry of the Environment participated as Associated partner.

The PEFMED Method

The PEFMED method is based on the application of the European Product Environmental Footprint (PEF) method combined with a set of territorial-based socio-economic indicators and aims to evaluate the environmental and socio- economic performance of products throughout their life cycle, i.e. from the extraction of raw materials, through processing, distribution, use, and end-of-life, and along their supply chains [Figure 2,3]. The PEFMED method supports the identification of both environmental and socio-economic hot-spots and potential improvement options, within a systemic eco-innovation perspective. The final objective of the PEFMED method is the definition of a Sustainable Business Plan, aimed at reducing the environmental and socio-economic impacts of both the analyzed product and its supply chain, as well as to enhance any potential positive aspects integrated in the company strategy [4,5].

Figure 2. PEFMED Method

After assessing the environmental and socio-economic performances of the products, the most effective technological and management solutions were identified by a team of researchers, entrepreneurs and experts to improve the environmental and socio-economic footprint along the supply chain [6]. Thanks to the support of the territorial clusters and regional referents of the Smart Specialization Strategies (S3), the solutions were analyzed in relation to the available economic policy tools. This led to the development of the "sustainable business plan", including eco-innovation and marketing strategies that the company can implement.

pany implements policies, actions and controls in relation to 4 stakeholders, i.e. workers, local community, consumers and value chain (suppliers and partners), and several "subcategories", e.g. Health & Safety, Training, Working conditions. The final output of the assessment is both a numerical result representing the level of maturity of the company in relation to each KPI (i.e. absence, basic, continuous improvement, proactive) and a graphic rendition of the results, where companies can see at a glance what to improve.

Moreover a "Protocol" for the development of a sustainable business has been provided and over

Figure 3. PEFMED method target groups

Source: P. Sposato, ENEA, 2016

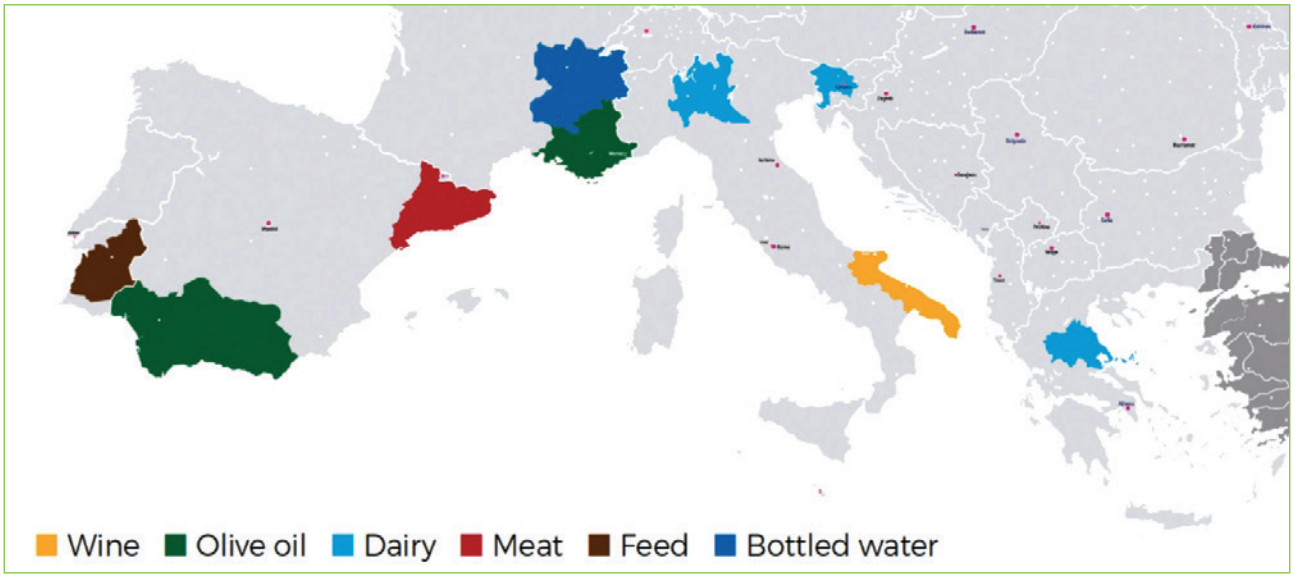
Different tools have been developed during the project to support the use of the PEFMED method, in particular by SMEs. Three tools have been created to facilitate the realization of PEF studies for olive oil, wine and packed waters, in compliance with the relevant PEF Category Rules. In order to deal with socio-economic aspects, an Excel-based tool with social and economic key performance indicators (SE-KPIs tool) has been developed to assess the performance of companies and identify areas of possible improvement, considering aspects related to human rights, working conditions, health and safety, cultural heritage, governance and socio-economic impacts on the territory. The tool was tailored according to SMEs characteristics and needs and, after the first application with external expert support, companies can apply it according to their own needs in order to pursue continuous improvement. The chosen SE-KPIs follow a life cycle approach and include the whole product supply chain. The 14 KPIs are both qualitative and quantitative and study in 36 questions how a com-

60 environmental good practices were collected (info sheets), that can be easily transferred and adapted to other agri-food products and in other MED regions. The infosheets sheets describe technological and management good practices to be used by companies willing to improve their environmental and socio-economic profile as a source of information and inspiration.
These methods, tools, good practices, technical and policy documents (feedback on the pilot studies on nine agri-food product chains and six national roadmaps) and much more are available on the dedicated website: pefmed-wiki.eu [1] (which has been further improved and implemented during PEFMED PLUS project) and they are described chapter 5 of this publication.

Testing and transferring of PEFMED method

The PEFMED method was tested in nine agri-food product chains and clusters located in different Mediterranean regions [Figure 4]:

Figure 4 . Mediterranean regions involved in the 9 pilot studies



- Cheese in Lombardy (Italy), Thessaly (Greece) and Western Slovenia (Slovenia)
- Cured meat in Catalonia (Spain)
- Olive oil in Andalusia (Spain) and in Provence-Alpes-Côte d'Azur (France)
- Wine in Apulia (Italy)
- Feed in Alentejo (Portugal)
- Bottled water in Auvergne-Rhône-Alpes (France).

Companies of different sizes participated in this pilot phase: in particular, both SMEs and large companies were involved for the cheese and olive oil production chains, whereas either SMEs or large companies were involved for other productive sectors. Results of the pilot phase for each product chain analyzed are described in the Project final publication: main environmental and socio-economic hot spots and improvement solutions identified [1, 6].
PEFMED transferred its outputs, method and tools to nine new industrial product chains located in different MED areas, through training activities and dissemination events called "PEFDAYS" and "Changeovers workshops" with the participation of companies, Smart Specialization Strategy managers, cluster managers, industrial associations, consultants and other stakeholders.

Conclusion

The method and tools used in the project have proven to be effective for companies and supply chains and could be used to adequately meet the needs of consumers, especially if associated with a certification scheme, (such as the Italian national label "Made Green in Italy" [7]), or if it would become mandatory and more regulated by EU member states.

The food companies had the chance to be familiar with a new EU methodology and to get benefit of the real application of it. It was explored the chance to give in products new marketing capacity, by exploiting their environmental performance. The companies evaluated the strengths and weaknesses of their product system and highlighted possible future improvements and needs.

The results yielded three main recommendations to encourage a wider application of the PEF method in the EU by:
- Increasing the availability of final PEF Category Rules and of specific datasets for the Mediterranean region
- Supporting measures for the application of PEF: i.e. "consultancy vouchers", training for consultants and companies involved in agrifood supply chains and local helpdesks
- Developing simplified tools for applying PEF to SMEs.

From the point of view of S3 managers, PEF methodology should be more integrated in re-

gional policies concerned with sustainability and financial incentives should be provided to SMEs. PEF application could be conducted at a larger scale with a strong policy support, both national and regional. Moreover, transnational cooperation and exchange of experiences has been a good opportunity for increasing knowledge and networking.With the support of regional policy makers and political choices which enable the increase of PEF scientific robustness and significance, the transfer of the PEFMED approach, particularly through the agri-food Federations could lower the sector's environmental and socio-economic impacts, improve the companies' response to consumers' needs and support the implementation of circular economy actions.

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SIMPLIFIED TOOLS TO HELP COMPANIES

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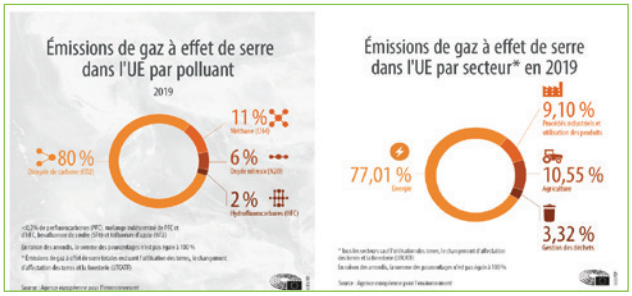
Keywords: ***DSS, tools, footprint***

The EU strategy for food sustainability aims to protect the environment and provide healthy food for all, protecting farmers livelihoods

The food system, from production to waste consumption, has a significant impact on the environment, health and food safety. With the « Farm to Fork » strategy presented on May 2020 the 20th, the Commission aims to deliver a sustainable food system at EU level taht safeguards food safety and protects people and the natural world. Although EU agriculture is the only major agricultural sector in the world to have reduced its greenhouse gas emissions (by 20% since 1990), it is still responsible for around 10% of greenhouse (of which 70% is due to animals) [Figure 1].



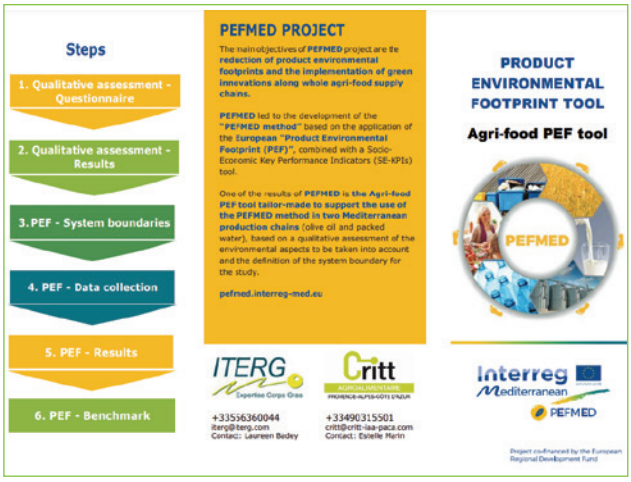
Along with manufacturing, processing, packaging and transport, the food sector is one of the main drivers of cliante change.
Knowing that 20% of the food produced in the Union is waste, we must change the way we produce, buy and consume food in order to reduce our environmental footprint and contribute to mitigating climate change, while protecting livelihoods of all economic actors in the food chain, generating fairer economic returns and opening up new opportunities for businesses.
4 tools have been designed during the project, to help companies to assess their environmental footprint and socio-economic footprint:

- 3 agrifood tools on packed water, olive oil and wine sector [1].
- 1 socio-economic tool [1].

Description and advantages of these tools

These 3 Agri-food PEF tools enable the calculation of PEF for olive oil, packed water and wine product. It can be extended to other product categories and is easily applicable, even by SMEs. It presents a global vision of the environmental impacts generated by product's life cycle and of the processes responsible for those impacts [Figure 2].

Figure 2: Pefmed project tool description sheet



Source: Pefmed Project Leaflet, ENEA

Since datasets and impacts indicators are included in Agri-food PEF tool, it helps to reduce the need for external experts support.
It can be combined with the SE-KPIs tool developed within PEFMED to evaluate also socio-economic impacts during the product's life cycle.

Methodology

The 3 tools have a similar content, and follow the same methodology :
1. Qualitative assessment – Questionnaire
It is a first qualitative assessment of the environmental practices of the company.
2. Qualitative assessment – Results
This step provides the results of the qualitative assessment of the environmental practices. It identifies the hotspots to be improved.
3. PEF – System boundaries
A flowchart describes the entire life cycle of the product. The user can choose the type of data (specific or generic), to use in the analysis.
4. PEF – Data collection
The user fills in all the requested data.
5. PEF – Results
Results of the Product Environmental Footprint are calculated, in compliance with both choices done in "PEF – System boundaries" sheet and data provided in "PEF – Data collection" sheet.
6. PEF benchmark
The environmental impacts calculated with this tool are compared with the European benchmarks.

The benefits for companies

The Agri-food PEFMED tools allow companies to obtain a comprehensive overview of their product's environmental impacts. It helps them to avoid environmental burdens shifting when decisions have to be made. Indeed this analysis helps to identify if a reduction of the impact in one stage will cause an increase of the impact in other stages, or in the same stage but on other impact categories. It helps to map inventory input and output flows (materials, energy, water, emissions, waste) of the production system / the organization. It covers all the main environmental impacts through the use of impact indicators.
The results can contribute to the definition of an improvement action plan for the analyzed product. For example, for the products studied during the project:
- advices about packaging and material used,
- ideas of improvement on processes and on transports organization [Figure 3].

Figure 3: Sustainability aspects for measuring and evaluating the performance of manufacturing processes

Source: National Institute Of Standards And Technology (Nist)

The limits of the method

The existing assessment tools, simplified or not, are quite difficult to use directly by companies. Their is a big work to do to gather all the input data, that are often not very precise. That mean a hard work to collect the information from the raw material and packaging suppliers, from the data company process (consumption energy, water, waste...), and from upstream and downstream transport data. All these information are often hypotheses, for a lack of specific data.
That means that companies need an external expertise to help them to gather the right data, to calculate the footprint by different software (simplified or not), and to interpret the results of the footprint.

Example of the Montenegrin PLANTAZE company, helped during Pemfed Plus project

The study has been performed by Yvan Deloche,

environmental expert from CRITT Agrofood PACA, on 16 and 17 of may 2022, with the collaboration of Plantaze team, enable to deliver first interesting results using the wine tool to assess the enviromental impacts of a bottel of wine [2].

After having introduced the PEF methodology, and the wine tool used, the expert started to collect some data, that have been entered in the wine tool to calculate the environmental impacts of a bottle of wine (on all the steps of the product life cycle). This testing also conducted to identify and correct few bugs that were remaining in the tool.

Some recommandations have been done to the company, to continue the testing phase of the study:

Some more data need to be collected for a better analysis of Plantaze results.

The main missing data are the following:

- **Some distance from providers for some of the inputs**

Those data could be easily found by the company.

- **Water consumption for irrigation of the vineyards and for the winery**

As the company use its own well to provide water for its winery process or for watering, at the moment no data are available. We recommend installing water counters in a pilot plant to measure the water consumption.

- **Wastewater from winery**

Installing of water counters for incoming on winery should help to evaluate the amount of wastewater produced by wineries.

- **Fuel consumption for grape production**

If there is a specific diesel dedicated to the grape production, an average ratio should be calculated at the company level.

After completing those data, next step is to make a benchmark of Plantaze results with other companies or PEFCR European data. It is recommended to do this benchmark, separately for each production stage. It is particularly recommended to do this comparison separately for the grape production stage.

Other recommandations have been done to reduce the impacts of the company :

- **Vine yards fertilization**

According to the LCA analysis, and with the actual data, fertilization has an important environmental impact. Any modification that lead to a reduction of fertilization will a have effective results in Plantaze environmental footprint.

- **Wastewater treatment of wineries**

At the moment, there is no water treatment: a bio Laguna is under study to enable water reuse for vineyards irrigation.

It could also be interesting to study the potential of anaerobic digestion, in this purpose some investigation need to be done on wastewater : pollutant load, volume, to evaluate the amount of biogas that could be produced thanks to this technology.

- **Packaging**

Weight reducing can be studied. For the local market (30% of Plantaze sales), it would be interesting to implement of system of bottle reusing, this require the investment in a bottle washing unit.

- **Energy consumption in wineries**

Some energy diagnosis could be performed in the wineries.

In parallel other tools produced during the PEFMED project can help companies to know the new environmental technologies. For example 60 infosheets have been produced on different subjects as energy, water, waste, packaging, socio-economic, resource efficiency, eco-labeling, and other new environmental technologies or methodologies [1].

What are these infosheets :

- Technically-oriented, two pages sheets made with the aim of easy spreading information about sustainable practices and technologies in the agro-food industry.
- Description of solutions (from technological or management to analytic tools) effective to be used by companies for improving the environmental footprint of agro-food value chains.
- Both innovative solutions and technologies/

tools/good practices developed for some time, but still not much adopted by SMEs in the agri-food sector.

They were adressed to agri-food SME(s) (generic target - e.g. Agro-Food Industry) or both generic and specific Agro-food sector and other stakeholders of agri-food sector (industrial associations, technological centers...).

They were selected for PEFMED PLUS project for the transfer potential, that is to say for the high potential to widely spread information about sustainable practices in the agro-food industry, and for the "ready to be used", without any direct economic cost. Another point is the possibility to extend the number of models available to other sectors and to organize them in a database.

Advantages/challenges: Possibility to be constantly updated with new/innovative best practices, technologies and solutions.

Conclusion

To encourage companies to reduce their environmental impacts to be more sustainable in their practices, it is clear that we need to help them to understand the challenges they have to include into their strategy, the methods and tools they can use, and the stakeholders they can contact to be more efficient. It's important to follow and train them into the implementation of the environmental impact reduction methodology, and into the way they can include it in their daily practices.

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A SURVEY ABOUT ECO LABELS IN BOSNIA AND ERZEGOVINA, MONTENEGRO AND CROAZIA

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Keywords: ***eco-label, environment, survey***

The three countries that are the subject of this paper are at different levels of implementation of environmental protection and the use of ecological labels. Bosnia and Herzegovina and Montenegro are just preparing for EU accession, while Croatia entered the EU in 2013. The impact of agricultural and food sector production on the environment is not too high in all three countries, mainly because extensive production prevails, but it will be necessary to introduce impact control measures in these countries as well. This is likely to be achieved mostly through the adoption of eco-labels, such as the P.E.F. label.

The State of the Environment Report of Bosnia and Herzegovina 2012 is the first report of this kind in the country of BiH and it presents one of the founding documents on environmental protection in BiH. It stated that GHG emissions originating from the agricultural sector had a slight growth trend in the period 2005 – 2010, but are still far from the emission levels in 1990. Since BIH agriculture is characterized by small and fragmented estates, inadequate equipment on estates and poor use of agricultural inputs, it is estimated that the current impacts of this sector on the environment are not significant in comparison to certain other sectors [1].

Report on the State of the Environment of Montenegro is one of the basic documents in the field of environment and is adapting annually. It is stated that the agriculture is not the main polluter but the further actions are needed in order to prevent the potential negative effects. Still, increase of agriculture production and food processing, more intensified agricultural production and diversification and development of economic activities in rural areas can lead to additional pressures and negative impact on nature and environment [2].

Due to its natural and climatic features water resources and unpolluted land, the Republic of Croatia has great potential in the development of agriculture and therefore agriculture is recognized as a strategic branch of the economy of the Republic of Croatia [3]. The Rural Development Program of the Republic of Croatia for the period 2014-2020, among other things, defines sustainable integration agriculture and environment, which is implemented through a set of agri-environmental measures. In 2016, Croatia had 543,414 ha of agricultural land under agri-environmental measures, which is a share of 35% in relation to the used agricultural land. The share of areas under organic agricultural production in relation to the area of used agricultural land has increased from 2.6% in 2013 to as much as 6.1% in 2016. In accordance with these increases, the number of farms engaged in organic agricultural production increased from 1,609 in 2013 to 3,673 in 2016 [4].

"Eco-labels" is the short form for ecological labels. They contain information regarding potential impacts on the environment of the production, consumption and waste phases of the products/services consumed [5]. Republic of Croatia, thanks to its membership in the EU, is much more advanced in all aspects of environmental protection. European eco-labels are also in force in Croatia, and it has developed its own label called "Environmentally Friendly". Unlike

BiH, which also has its own national eco-label of the same name, in Croatia it is regularly awarded to interested producers and it is legally equated with the European eco-label (EU flower). Bosnia and Herzegovina, at least a part of it (FBiH Entity), has adopted the legal basis and introduced the label "Environmental Friend", but so far it is not implemented and there is no information on the holders of this label.

Montenegro adopted the Law on Environment which contains general provisions on the environmental management scheme and environmental labelling to encourage environmental improvements by private sector; however, there are no national systems of eco-labelling or environmental management in place.

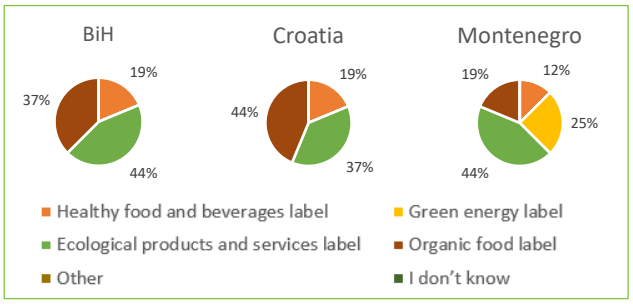
The survey

On the eve of the launch of the new P.E.F. eco-label in the EU, we were interested in what opinions about eco-labelling are in the countries that are part of the PEFMED PLUS project: Bosnia and Herzegovina, Montenegro and Croatia.

The survey was created for small sample of 15-20 respondents per country. Bosnia and Herzegovina had 17 questionnaires answered, and the Republic of Croatia and Montenegro had 16 each. When sending the questionnaires, efforts were made to send them to as diverse SMEs in agri-food sectors as possible, in order to obtain a better sample of answers. A total of 19 questions were asked and six most important are shown in this paper.

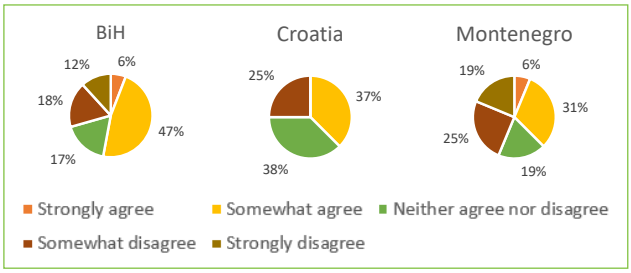
Below we will give an overview of the questions and answers of the respondents for each country separately. Responses were converted into percentages, for better visibility and comparison between countries.

Figure 1. In your opinion, what does Eco-label mean?



This statement is posed in this way, although the issuance of eco-labels from these three countries is in different stages. In Croatia, there is an eco-label issued by the state, and in BiH it is not issued at the state level but by one of the entities (FBIH), while Montenegro has not yet issued its eco-label. In Croatia, the majority of respondents stated that they knew about the issuance of the eco-label, while in BiH 65% had not heard of the state eco-label, although the respondents were from the region belonging to the FBiH. This highlights the poor media coverage of the eco-label issued in BiH and it seems that it was legally adopted, but never came to life. In Montenegro, most of the answers are in line with the lack of the eco-label issued by this country. A small percentage who said they were aware that their country had issued an eco-label had probably heard of some of the international eco-labels, which Montenegro had adopted.

Figure 3. I can easily find information about Eco-labels from different media (TV, Newspaper, and Internet) in my country!



The answers to this question are fairly uniform among states. Respondents mostly opt for more neutral answers such as "Neither agree nor disagree" or "somewhat agree", or "somewhat disagree". Croatia has perhaps the largest number of Internet articles related to eco-labels and the fact that there is no language barrier between these three countries means that people can easily get information through various media that not necessarily originate from their country.

Respondents from all three countries are quite affirmative about the credibility of the eco-label. This could mean that they believe that the mechanisms that control the issuance of the eco-label are appropriate. A smaller number of respondents somewhat disagree with this statement, with highest percentage in BiH (29%), and none

of the respondents strongly oppose it.

Figure 4. I believe that Eco-label is very credible!

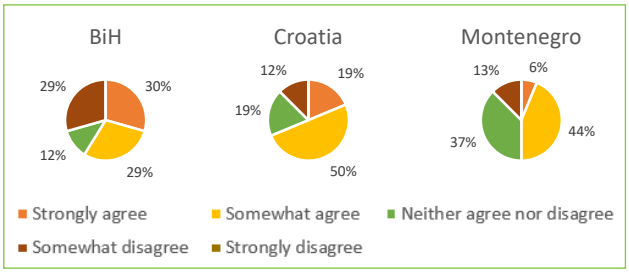
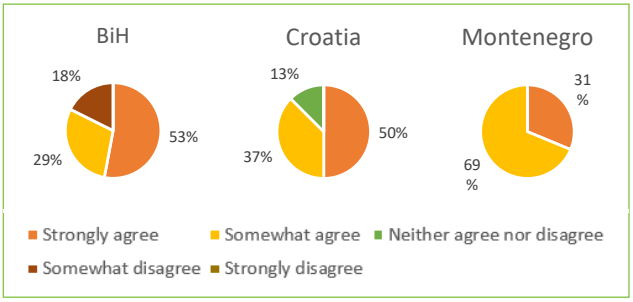
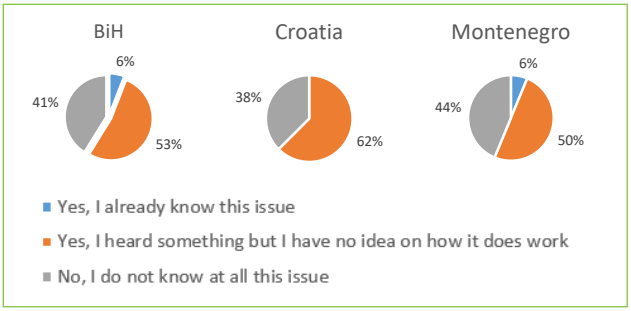


Figure 5. The use of Eco-label on products can benefit companies in agri-food sector!



As in the previous statement, the majority of respondents in all three countries agree with this one as well. Once again, Bosnia and Herzegovina has some respondents who somewhat disagree with the statement that the use of eco-labels would benefit companies in the agri-food sector.

Figure 6. In the European Union Market in the near future a new environmental labelling "P.E.F." will be officially launched also on the food products by quantifying their environmental "weight" and inform consumers about that. Did you know this "news" and the acronym of P.E.F.?



More than 50% of respondents in all three states said they had heard something about the PEF label but did not know much about it. Most of the other respondents had not even heard of this news. As stated in a previous response comment, eco-labels, and in particular the P.E.F. label, should have stronger publicity in these countries. Regarding the level of intensity of production, agriculture cannot be considered a significant polluter of the environment in the BiH, Montenegro and Croatia. The area of these countries is not subject to large-scale air, water and land pollution. Besides a few industrial complexes, located in bigger city areas, there are still areas untouched by civilization, which indicates that the large part of the region is ecologically clean.

Conclusion

Although three countries are at different stages of adopting eco-labelling and aligning their legislation with European ones, according to the survey, the fact that the manufacturing sector in all three countries is very affirmative in terms of eco-labelling of their products is very encouraging. Most of them believe that the eco-label would add value to their products and customers would recognize them as such, which would influence their choice of purchase.

Unlike the government, the manufacturing sector is market-oriented and wants to transform according to customer preferences. It is therefore not surprising that most of them want to know more about eco-labelling, and also about P.E.F. labels, in order to be as prepared as possible for the eventual adjustment of their production. Generally speaking, the current impacts of agri-food sector on the environment are not significant in comparison to certain other sector and there is no a large perception from the public of how much important is food consumption and production in terms of CO_2 emission at global level. Increasing awareness will help to move the food chain to take care of environment and adopt new production methods and standards.

Croatia, as a full member of the EU, has much more developed mechanisms for applying environmental laws. It is expected that both Bosnia and Herzegovina, as well as Montenegro, will solve the environmental issue much better in the future, on their way to EU membership

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ECO-INNOVATION AND SUSTAINABILITY OF AGRO-INDUSTRIAL SUPPLY CHAINS

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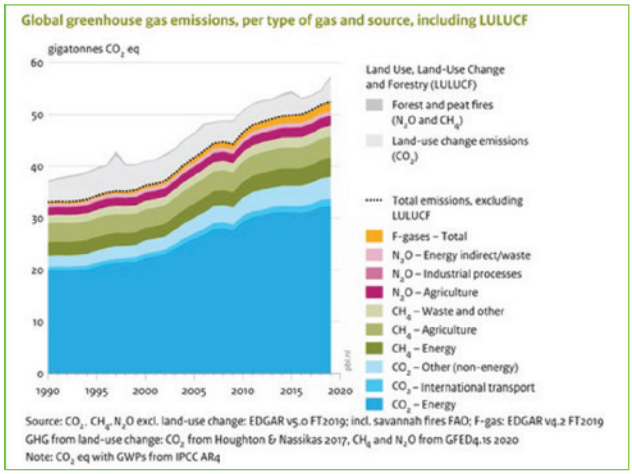
Keywords: *Eco-innovation, Environmental impacts, Green technologies, Sustainability*

In recent years there was an increasing interest with respect to the effective environmental sustainability of the agri-food systems considering the different stages of the **agri-food supply chain,** and their impact categories on the climate change and the environment, such as GHG and CO_2 emissions, depletion of energy and resources, deforestation and the consequences they have on the chain itself with the aim of reducing them.
Recent studies proved that 34% of all global anthropogenic greenhouse gas emissions are correlated to agri-food systems and 70% of them derive from agriculture and land use [1]. In Figure 1 are reported the data of Global CO_2 and Total Greenhouse Gas Emissions related to the year 2021. Therefore, the sustainability of the agri-food supply chain currently represents one of the most ambitious challenges for the European Agri-food System since a better model of Sustainable Growth must also preserve the future and well-being of future generations. At this regard, the concept of *Green Economy* as "one economy that results in improved human well-being and social equity, while significantly reducing environmental and ecological risks. It is low carbon, resource efficient, and socially inclusive" (UNEP, 2011) [2] was adopted since it can play a fundamental role, through economic and regulatory policies aimed to spread more sustainable consumption and lifestyles and eco-efficient products and technologies, complying with the principles of the *Eco-innovation* [3].

Figure 1. Trends in global CO_2 and total greenhouse gas emissions, 2021



Source: Jos G.J. Olivier, Trends in global CO_2 and total greenhouse gas emissions: 2021 Summary Report

But what is meant by *Eco-innovation*?

In 2007 the European Commission released the guidelines "Competitiveness and Innovation Framework Programme" where eco-innovation has been defined as "any form of innovation aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impact on the environment or achieving a more efficient and responsible use of natural resources, including energy"[1].

1 This definition is found in the Guideline Document for the Competitiveness and Innovation FP of the EC www.ec.europa.eu/environment/etap/files/guidelines_for_cip_eco_innovation.pdf

Concerning the environmental aspects, the eco-innovation was defined by "as innovations that consist of new or modified processes, practices, systems and products which benefit the environment and so contribute to environmental sustainability" [3]. Thus, any eco-innovation is conceived as a mean to reach the goals of sustainable use of resources and reduction of environmental impacts related to human activities.

Eco-innovation policies

In the last years, the compliance with the principles of Eco-innovation (EI) and their implementation were strongly promoted by the European Union. An important policy reference document is represented by the "Eco-Innovation Action Plan (EcoAP) published in 2011 by the European Commission (EC) with the aim to foster the adoption of eco-innovation concept by the markets and updated in 2015 by the 7th Environmental Action Plan (7EAP - TAP)[2]

Since its adoption, the EcoAP plan aimed at supporting innovative SMEs and the related policies have been consolidated by the European Union Green Action Plan for SMEs (2014) [5], with the objective to promote resource efficiency too.

This Plan therefore has strengthened others eco-tools such as the Eco-Management and Audit System (EMAS), the European Ecological Quality Label (EU Ecolabel), the Environmental Technology Verification Program (ETV), as well as the Product Environmental Footprint (PEF) standard to evaluate the environmental performances of a product throughout its life cycle.

For this reason, recently agri-food companies have increased their actions and strategies connected to the sustainability, moving from end-of-pipe[3] solutions to integrated strategies based on life cycle assessment (LCA) [6] of products and joining environmental management systems, with the final aim to achieve more circular production systems.

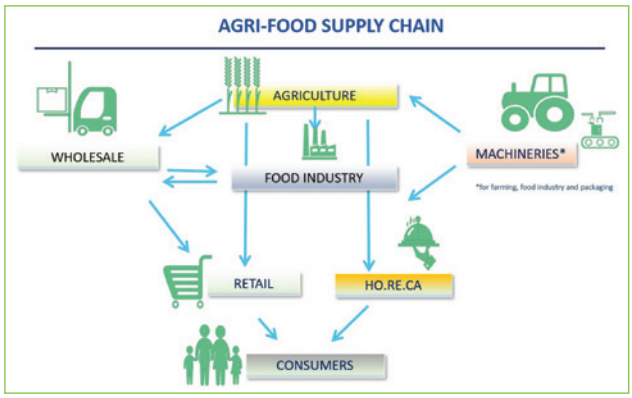
In this context **eco-innovation** represented an option to introduce more radical and systemic improvements regarding the environmental performances of the agri-food supply chain. The *Eco-innovation is* closely linked also to Circularity [7] notion because the development of circular solutions is possible thanks to the adoption of innovative technologies and sustainable processes [8].

Agro-industrial supply chains and Eco-innovations

Eco-innovations are therefore crucial for the transition of **agro-industrial supply** to a more circular model based on sustainable food production and processing [9] [10].

In the agri-food sector the supply chain are a sequence of interconnected phases and actors that determine different environmental impacts along the life cycle of the product. Significant differences can also occur between different supply chains as well as between specific phases of the same supply chain [Figure 2].

Figure 2. Scheme of Agro-industrial Supply chain



Source: Elaboration from Federalimentare data

The sustainability of the agri-food chains cannot be achieved without the contribution of all involved actors. Each of them plays a crucial role in the common goals of sustainable production and consumption. At this regard, the assessment of environmental impacts must concern all the phases of the agri-food chains according to the life cycle (LC) of the products, from agricultural

2 DECISION No 1386/2013/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013D1386

3 An approach to pollution control which concentrates upon effluent treatment or filtration prior to discharge into the environment, as opposed to making changes in the process giving rise to the wastes. (Source: European Environment Agency)

phase, to processing, packaging, distribution and consumption, up to the management of the resulting waste.
To overcome the most critical environmental aspects and to improve environmental sustainability of agro-industrial supply chains a series of ***Green or sustainable*** *Management or Technological actions* need to be implemented.
Green or sustainable practices and technologies [11],[12] are considered as drivers of eco-innovation. The result of their application is the reduction of environmental and ecological risks, so they have a strategic role to improve the overall environmental performances of products and processing. In most cases, objectives of satisfactory environmental sustainability in the short and medium term, are achieved through the correct implementation of the best environmental practices in specific phases of the supply chain [13].
For example, **best environmental practices** application such as the lightening of secondary and tertiary packaging and the use of packaging with a higher content of recycled material represent the most suitable strategy for reducing the environmental impact of packaging.
Horizontal or specific ***Green Technologies*** can be adopted to significantly reduce the environmental impacts associated with the consumption of resources (energy, water)
Regarding energy consumption, it represents one of the most critical aspects for several agro-industrial supply chains, such as dairy sector, which can have a high average impact on production costs. At this aim, different cross-cutting technologies, of low, medium or greater complexity, can be successfully implemented in order to improve energy efficiency. Some examples of the most common, effective and easily to carry out systems are shown in the following table:

Table 1. Some systems for energy efficiency

- **Heat loss recovery and reduction systems**
- **Photovoltaic Solar Panels**
- **Solar-Thermal Collectors**
- **LED lighting systems**

Concerning water resource, innovative technologies such as membrane processes (microfiltration, ultrafiltration and nanofiltration), for the extraction of useful compounds **allow to manage wastes and wastewaters** with a view to circular economy and industrial symbiosis and the creation of added value.
It is the application of the concept of **"Biorefinery"**: the use of waste/wastewater from the main production chain as secondary raw materials for obtaining co-products for food and non-food applications (food supplements, animal feed, fertilizers, cosmetics, pharmaceuticals, bioplastics and biofuels, and nutraceuticals). In this way, there is a double result: obtaining new products and reducing waste.
Below [Figure 3] is showed a picture of an ENEA plant with membrane technologies, for the recovery of biologically active principles, fractions and metabolites starting from agro-industry (such as wine, dairy products, tomato, oil industry) and bio-industry wastewaters.

Figure 3. Selective fractionation of agro-industry and bio-industry wastewaters by ENEA membrane technologies

Source: ENEA Division Biotechnologies and Agroindustry website (https://bioagro.sostenibilita.enea.it/)

Conclusions

Structural measures to promote eco-innovation include increased spending on research and development and investment in education; companies that have the capacity must encourage innovation by investing in their human resources and in research and development activities.
The use of innovative technologies, which require considerable investments, still represents a challenge (in financial terms and human resources) to many SMEs and micro-enterprises which represent almost all the agri-food companies in the EU.

What are the main critical issues to overcome?

- high fragmented context, with a high number of SMEs strongly linked to tradition leads to low capacity for experimentation and innovation.
- poor structural relationships between research institutions and SMEs
- low capacity of coordinated transfer of innovation by research institutions
- policies and regulatory instruments not fitting to the SMEs characteristics

Only by overcoming these hurdles, it will be possible to make eco-innovations economically sustainable and truly accessible to all business realities, "tailored to measure" for each of them.

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THE PACKAGING REVOLUTION TO DEAL WITH ENVIRONMENTAL GOALS

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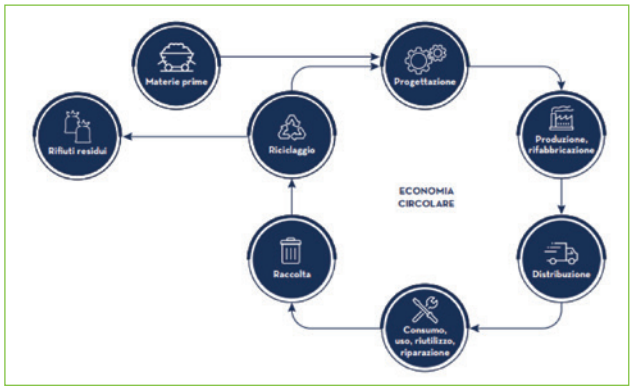
Keywords: ***Circular economy, sustainability, biodegradable, compostable***

The dispersion and accumulation of plastic materials in the environment is a global problem, by now sadly known to all. The presence of plastic microparticles has been ascertained in the most diverse ecosystems and in every corner of the planet, from Mount Everest to the Mariana Trench to the Arctic. Recently discovered is the introduction of microplastics into food chains, with consequences on animal health as well as on human health. Therefore, of crucial importance for the fight against pollution becomes the application of the principles of the circular economy to plastics, with an ever-decreasing number of wastes produced and, at the same time, an ever-increasing number of plastic waste recovered and subtracted to landfills or the environment.

Just over 60 percent of total plastic waste in Europe [1], is represented by packaging, defined, according to current Packaging and Packaging Waste Directive (PPWD – Directive 94/62/EC) as "products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer". The most critical environmental impact of packaging is still related to waste prevention. A this aim, a lot of investments on the research of innovative solutions were addressed to eco-design not and to communicate the system of values that revolve around it [2]. There are numerous projects for the management and valorization of waste in a circular key with a central role dedicated to the end of life with a view to zero waste at the end of the process [Figure 1] [3].

Figure 1. The role of the circular economy in waste management [4]



Source: CONAI Green Economy Report 2019

Also from the regulatory point of view several requirements were introduced and recommended such as increasingly stringent standards aimed at identifying information to be conveyed in relation to the product and the packaging itself, as well as establishing functionality and safety parameters and, secondly, environmental requirements, in order to promote additional criteria related to the potential impacts of the system, aimed primarily at the eco-design phase also by enabling a holistic vision of the phenomenon, it can act as a glue between all producers and consumers by creating a responsible balance between the various players in the supply chain.
An Action Plan was presented by the European Commission whose main objective was to encourage growth through the reduction of the Car-

bon Footprint and the introduction of models that will support the reuse of raw materials. And it is precisely following this direction that, in the context of the EU strategy on plastics, the Commission is going to define a reference framework for biobased, biodegradable and compostable plastics using part of the European Green Deal and the action plan for circular economy (CEAP).
In 2021, world production of plastics increased by 4% more than in previous years and after the post-Covid-19 pandemic period, reaching just over 390 million tons per year [Figure 2], demonstrating the strong and continuous demand for plastics. European Union's share, in the 2021, reached 57.2 million tons ([Figure 3], slightly more than the previous year and with an increase in bio-based/bio-attributed plastics [5].

Figure 2. World plastics production evolution

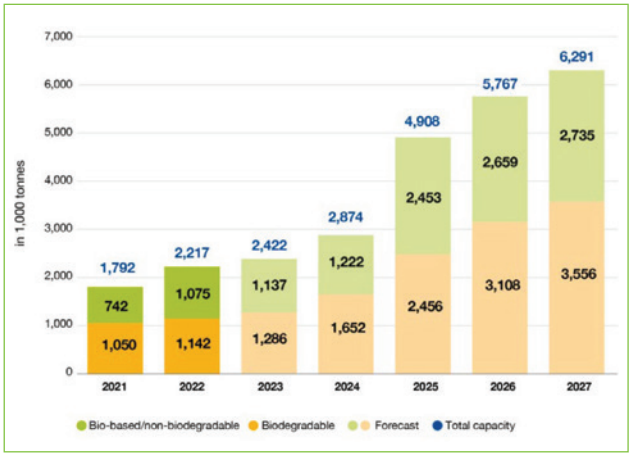
Sources: Conversio Market & Strategy GmbH and nova-Institute. The above data are rounded estimations - nova-Institute 2022; data for bio-based structural polymers, preliminary estimations for 2021 in the world

Figure 3. European plastics production evolution

Sources: Conversio Market & Strategy GmbH, nova-Institute, Polyglobe database by Kunststoff Information Verlagsgesellschaft mbH, Eurostat (European Statistical Office) 2018-2020 production quantities have been calculated based on the development of Eurostat production indices – nova Institute 2022; data for bio-based structural polymers, preliminary estimations

To this end, the European Commission produced in November 2022 after public consultation a communication in which it defines the EU policy framework on biobased, biodegradable and compostable plastics [6].
According to the latest market data compiled by European Bioplastics in collaboration with the nova-Institute, global bioplastics production capacities are expected to increase from around 2.2 million tonnes in 2022 to around 6.3 million tonnes in 2027 [7] [Figure 4].

Figure 4. Global production capacities of bioplastics



Source: European Bioplastics, nova-Institute (2022)

Currently, biodegradable plastics overall, including PLA, PHA, starch blends and others, account for more than 51% (over 1.1 million tons) of global bioplastics production capacities. The production of biodegradable plastics is expected to increase to more than 3.5 million in 2027 thanks to a strong development of polymers, such as polylactic acids (PLA) and PHAs (polyhydroxyalkanoates).
In the frame of the above-mentioned regulatory framework the is still the risk to confuse some terms that apparently seem to indicate the same thing. As stated by the CEN document EN 17228:2019 [8], the terms "biopolymers" and "bioplastics" are commonly used to identify polymers and plastics that are bio-based, biodegradable or have both properties. However, while these definitions are quite widespread and used by the industry, it is recognized that they are susceptible to misunderstanding and therefore inadequate for standardization purposes. When associated with plastics, the prefix "bio" can be perceived by consumers as an indication of biodegradability or full natural origin. This is a cause for concern as it

can lead to misleading information and confusion throughout the supply chain and especially for end consumers. Therefore, the CEN document EN 17228:2019 recommends that, when referring to the origin of the raw material, the terms polymer/plastic/bio-based plastic product should be used instead of biopolymers/bioplastics/bioplastic products. The European standard EN 16575:2014 [9] (Bio-based products - Vocabulary) specifies that the term "biobased" means "derived from biomass" and that bio-based products (e.g. bottles, solvents, chemical intermediates, composite materials, etc.) are products derived wholly or in part from biomass. It is essential to characterize the amount of biomass contained in the product, for example, by its content of biological origin or the carbon content of biological origin. There are certifications on the bio-based content that refer to the European standard EN 16785-1 [10], Bio-based products - Bio-based content - Part 1: Determination of the bio-based content by radiocarbon analysis and elemental analysis which specifies a method for determining bio-based content in products, based on radiocarbon analysis and elemental analysis. [Figure 5] This European Standard is applicable to any solid, liquid and gaseous product containing the element of carbon, provided that a statement is available indicating the composition and origin of the product. This method is not necessary for the determination of the bio-based content in natural products entirely derived from biomass.

Figure 5. BIO-BASED CONTENT – ecolabel [11]

Source: InnProBio, Forum for Bio-Based Innovation in Public Procurement

While the EN 16760:2015 [12] standard – Bio-based products – Life Cycle Assessment, provides the specific indications and requirements necessary to carry out an LCA study on products derived from renewable sources and evaluate the impact on the life cycle of bio-based products with particular attention to how to manage the specificities of the bio-based part of the product, based on the ISO 14040 and ISO 14044 standards.

Packaging and sustainability

At this regard, and in connection with the other initiatives carried out by the European Commission, the Plastic Strategy, envisaged in the Community Action Plan, although not binding, is functional to indicate the political direction for future actions on the matter. In particular, the Commission's willingness to ensure that by 2030 all plastic packaging placed on the EU market is reusable or recyclable according to cost-effective criteria [13].

For this reason, the European Commission, on 30th November 2022, has decided to review the former Directive 94/62/EC27 to strengthen the mandatory requirements that packaging must meet in order to be placed on the EU market. By this revision, the Commission aims to:

- Have fully recyclable and sustainable packaging;
- Reduce packaging waste (also due to excessive packaging);
- Promote a "sustainable" eco-design that meets recyclability and reuse requirements;
- Fix ambitious targets on recycled content of packaging;
- Simplify the composition of the packaging itself.

In Italy, to further strengthen these concepts, on 14 January 2022 Legislative Decree 8 November 2021, n. 196 [14], transposing Directive (EU) 2019/904 (so-called SUP Directive), on the reduction of the impact of certain plastic products on the environment, by prohibiting the placing on the market of disposable plastic products listed in Part B of the Annex (including plastic cutlery, plates and straws) and oxo-degradable plastic products and also specifying that products made of biodegradable and compostable material, certified compliant with UNI EN 13432 or UNI EN 14995, with percentages of renewable raw materials equal to or greater than 40% and from 1 January 2024 greater than at least 60%.

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CONSUMER'S AWARENESS: TOWARDS A SUSTAINABLE APPROACH

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Keywords: ***consumer's awareness, environmental labels, companies***

In the last decades food waste has generated, and it's still doing, significant inequity [1], poverty and important loss for the environment. For these reasons consumer's awareness for responsible production and consumption is increasing and it's important to continue in this way to achieve a long-term sustainability. On the other side, companies and sellers are led, by this trend, to reduce food waste and to increase their responsibility for the best sake of our planet. Following this perspective, consumers are increasingly demanding:

- More product choices
- Additional variations
- Faster availability
- Reliability and traceability of the products

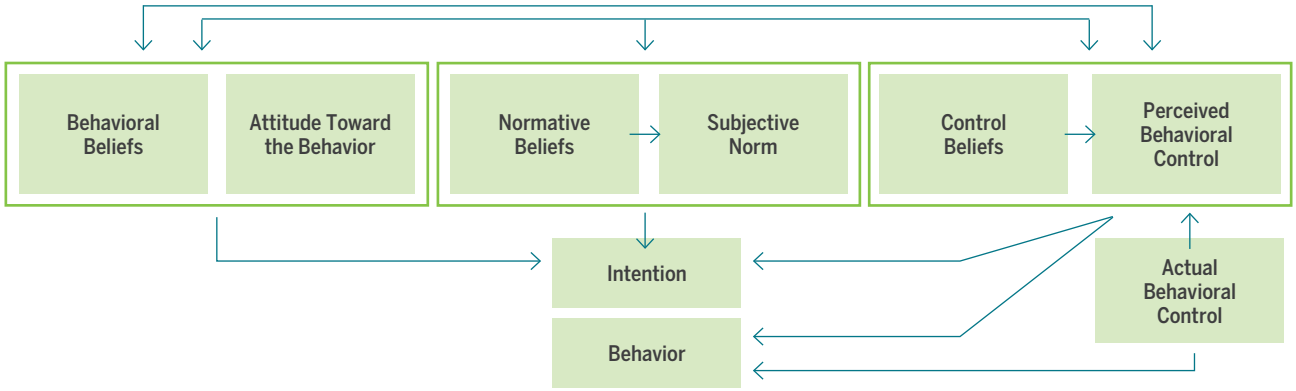
People want to know where their food was grown, harvested, processed, distributed and sold, before it reaches their tables. Transparency [2] and clearness are the key-words to create a new system of consumption and the industry is trying, not only to provide information, but also to create conditions that allow customers to evaluate such information, increasing their level of knowledge/understanding. It will permit to consumers to feel involved in their purchaising [3] activities and informed and educated about the expectations and features of services. This approach could create a collaboration from the "bottom" towards service providers and service performance, giving origin to an interactive and transversal system. In this way consumer education became a process through which customers can improve their perceived value, allow them to obtain information/advice, learn how to make rational and efficient future choices, and protect their rights. Furthemore a digital transformation is taking place in the food industry and the manufacturing models are changing through the use of smart technologies, likewise consumer's [4] attitude. This networking approach emphasizes the interdependencies of actors, resources and activities as a key component for a major change in the industry. These aspects are highlighted also by the food processing operations that have benefitted from this new kind of net-industry, by improving traceability, monitoring, control of food quality, automation and training to predict consumer preferences, reducing loss and waste at the same time. On a social level, there are some elements that can guide consumers towards sustainable choices:

- Availability of "green" product information
- Knowledge of environmental issues
- "Biospheric altruism"
- Collettivism

Focusing on the last two points, we can say that their impact on the society should not be underestimated, because when someone know, perfectly, what kind of harmful consequences his actions can generate on other people, is more inclined to make sustainable and altruistic choices [5]. The PCE (Perceived Consumer Effectiveness) play a decisive role in influencing people behavior on ecological purchases, but to make these effects real, the agri-food system must work alongside with "the bottom". A solution could be improving the effectiveness of the ecolabelling (environmen-

tally friendly product): a system usefull to fill the gap between sailers and consumers, giving them informations on product's quality, recyclability, sustainability and availability. In fact, often occurs that consumer attitudes toward enviromental issues might not match perfectly with pro-enviromental behaviors. This happens because consumers are often submerged by too many products available on the market and this leads to a disparity between consumers' purchase attitude (choosing the right product/pro-enviromental) and their behaviour (purchasing the product that they desire). This frame of mind can be explained with the theory of planned behavior [Figure 1]: fulfilling some pre-conditions, make it easier for attitudes to be correctly translated into behavior, such as actually purchasing ethically/sustainable.

Figure 1. Limitations of the Theory of Planned Behavior



Source: https://sphweb.bumc.bu.edu/otlt/mphmodules/sb/behavioralchangetheories/BehavioralChangeTheories3.html

The TPB (theory of planned behavior) states that behavioral achievement depends on both motivation (intention) and ability (behavioral control). It distinguishes between three types of beliefs: behavioral, normative, and control. A person's actual control over the behavior is divided in six constructs: [6]

- attitude: This refers to the degree to which a person has a favorable or unfavorable evaluation of the behavior of interest
- behavioral intention: This refers to the motivational factors that influence a given behavior where the stronger the intention to perform the behavior, the more likely the behavior will be performed.
- subjective norms: This refers to the belief about whether most people approve or disapprove of the behavior
- social norms: This refers to the customary codes of behavior in a group or people or larger cultural context
- perceived power: This refers to the perceived presence of factors that may facilitate or impede performance of a behavior
- perceived behavioral control: This refers to a person's perception of the ease or difficulty of performing the behavior of interest.

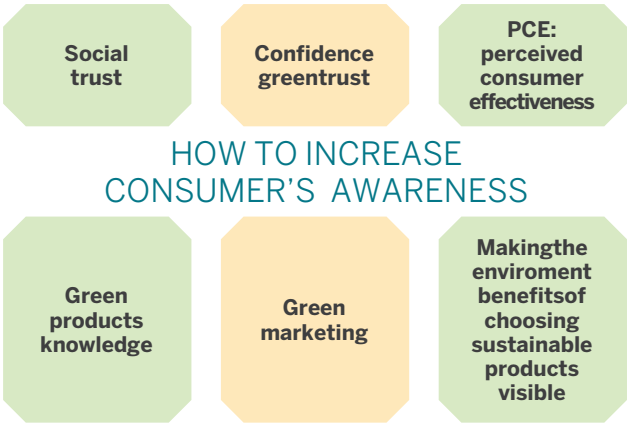
Furthermore, the influence of perceived consumer effectiveness on green food consumption is different depending on the people: [7]

1. people who hold a high level of social trust may think if they purchase environmentally friendly foods, their behavior will create goodwill for the society [8]
2. people who hold a low level of social trust are usually pessimistic and lack of confidence, hence they don't believe in their capacity to enhance social and environmental issue.

Ultimately consumer's level of PCE affects their likelihood [9] of performing ecologically conscious consumer behaviors such as the purchase of eco-friendly products, recycling efforts and participation in environmental groups.
But how can we increase these characteristics among consumers? Surely a starting point could be to strengthen consumer's knowledge [10] about environmental protection and impacts of green products on it. In fact, many studies consider "knowledge" [11] as a precondition for green purchase intention: it can be considered as

an information stockpiled in consumers' memory which affects their assessment of information and preferences, as well as their purchasing behavior of green products [Figure 2].

Figure 2. How to increase consumer's awareness



Source: ENEA

Consequently, the more knowledge consumers can store, about green products, the more they understand the environmental protection relevance and green product's description, attributes, functions, and utility. This leads to more confidence in the judgment of green products. Vice versa from market perspective, enterprises must change their business model and management, implementing green trust and perceived consumer effectiveness in their market choices. Furthermore, they need also to enhance the environmental protection function of green products alongside with a renewal of their brands in a pro-environment perspective, increasing consumer's confidence in them. This will result in an increment in their green buying intentions and perhaps even behaviors. To encourage this change is necessary that companies provide clear and transparent information on their labels, with specific environmental data [Figure 3],

Figure 3. ISO14020 classification of environmental labels

EU Ecolabel www.ecolabel.eu — www .ecolabel.eu	ISO 14024 Environmental labels and declarations {Type I environmental labelling)
www.recycte-more.co.uk	ISO 14021 Self-declared environmental claims (Type II environmental labelling)
EPD® www.env1rondec.com	ISO 14025 Environmental labels and declarations (Type III environmental declarations)

Source ISO14020 SO 14020 standard (2000) classifies Environmental labels according to the three groups shown in Figure 3:

(1) Type I labels can be awarded to products which are consistent with environmental criteria released by a third party organisation. An example is the European Ecolabel whose award criteria are issued on the results of a LCA application under the supervision of the Ecolabel Committee. As a clearly recognizable guarantee of environmental excellence, the EU Ecolabel can become a key marketing tool addressed to environmentally conscious consumers.

(2) Type II labels are constituted by self-declaration of producers, based on environmental performances of their products, for example the recyclability at end of life.

(3) Type III labels consist in a quantified declaration of the environmental performance of products throughout their life cycle. The purpose of an Environmental Product Declaration (EPD) is to provide transparent information relevant to the environmental performances of products and services for comparison purposes. Such environmental performances listed in the EPD can be verified by a third party organization.

such as resources saved, and carbon emissions reduced. The consumer must feel that he or she is a part of environmental protection process thanks to their purchaising choices, only in this way consumers could feel involved and inspired to make the right decision about environment. In this context, however, there is a major problem that is the one concerning the too large number of green labels on products [Figure 4].

Figure 4. Example of ecolabels

Source: the Committee on Sustanaibility Assessment (COSA)

In fact, there are a wide range of labels, and it isn't always easy to tell which are trustworthy and which aren't, especially for consumers, as the Associate Professor Sukhbir Sandhu from the University of South Australia says: "Currently there are so many accreditations, so many certifications floating about, that almost any firm can make an environmental claim, and for consumers, even if they want to do the right thing, it's not easy". The problem is also that many labelling and certifications are run by companies themselves or by independent non-government organisations and, in some cases, by governments. In a recent survey by The Guardian[1] reveals that many multinational companies of the food distribution system have stormed the world of the labels that certify the eco-sustainability and this is undermining the very control of the "guaranteed" supply chains.

These companies have lost interest in this system, because it no longer seems to generate too many benefits, the demand for sustainable products continues to grow and use green labels approved by third parties with a supervisory function often blocks production if you do not meet certain quality and social standards. This effect is called greenwashing which is the practice of many companies trying to build a misleadingly positive self-image in terms of environmental impact, in order to divert people attention from the negative effects on the environment caused by their activities or products. In many cases this phenomenon is manifested through the creation, by companies, of their own labels, logos and other merchandising with information of sustainability and equity established by the companies themselves, without there being a third subject with the authority to regulate and verify the authenticity of their statements, without therefore defining accurate quality standards. The downside of the process is obviously clear, with hundreds of slogans and colorful logos the consumer thinks to make a choice "green", but in reality, it's absolutely not so.

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10 CHAPTER

CONSUMER'S TOWARD CARBON FOOTPRINT LABELS ON FOOD IN CROATIA

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Keywords: ***carbon footprint; consumer attitudes; Croatia; extra virgin olive oil; CO_2 labels***

Abstract

In the last few decades we are witnessing sustainability issues gaining weight in consumers' value systems. Unfortunately, consumers' favorable attitudes toward environmental issues are not reflected, actually, in their purchase behavior. According to the FAO, agriculture and agricultural industry is responsible for approximately 14% of global greenhouse gas emissions. To enable consumers to act understanding the scheme of green choices and environmental sustainability, the implementation of eco-labeling schemes is necessary.

This study reveals Croatian consumers' preferences towards carbon footprint labels for olive oil products as well the effect of carbon footprint information on WTP behavior, and knowledge about carbon footprint, the author accompanied an online survey.

Results of this survey showed that Croatian consumers perceived food production as highly responsible for tackling climate change. Most of interviewed participants are generally concerned and dispose of generic knowledge about climate change. The study found a general interest among Croatians in carbon labels and in climate-friendly products. The analysis showed that consumers perceived also the production method as one of the triggers for the intensification of climate change.

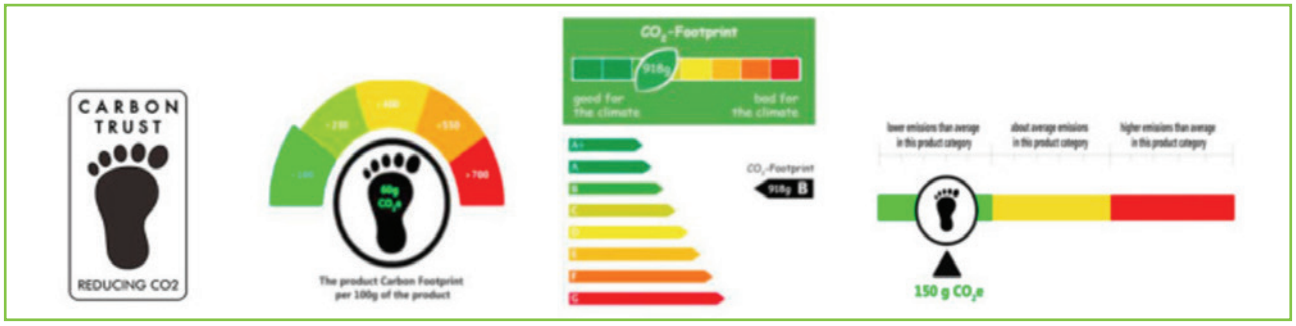
Introduction

In the last few decades sustainability matters have become a priority issue in consumer value systems. This increase in consumers' value system is reflected to a certain degree in their food purchase decisions [1]. From one point of view, these are good news when aiming at increasing the sustainability of food consumption [2].

Talking about market shares numerous studies have found that the favorable attitudes of consumers towards environmental issues are not actually reflected in their purchase behavior [3, 4, 5]. Many studies have found that the phenomenon of consumers' favorable attitudes towards environmental issues is not reflected, actually, in their purchase behavior, often referring to the attitude-behaviour gap. This gap could be due to budgetary constraints, information overload and limited knowledge about sustainability issues [4, 6]. Feucht and Zander [2] concluded that there might be a need to better inform consumers concerning that their limited knowledge seems to be particularly relevant regarding the sustainability of food consumption. Another constraint of sustainability in food consumption is supposed to be the low degree of trust in labeling and other communication means and limited perceived relevance of own behavior [7].

According to the FAO, agriculture and agricultural industry is responsible for approximately 14% of global greenhouse gas emissions. Following the forecasts for 2050, the population will grow to reach 10 billion individuals. Many countries recognize this and push the importance of promoting and developing sustainable activities [Figure 1].

Figure 1: Innovations in the agrifood sector to reduce food products environmental footprint



Source: Rondoni A. and Grasso S. 2021. Consumers behaviour towards carbon footprint labels on food: A review of the literature and discussion of industry implications. Journal of Cleaner Production 301. https://doi.org/10.1016/j.jclepro.2021.127031

To enable consumers to act understanding the scheme of green choices and environmental sustainability, the implementation of eco-labeling schemes is necessary [2]. This strategy is also used to foster climate-friendly behavior by the introduction of Carbon Footprint labeling (CFP) labeling schemes (also called carbon labels or CO_2-label) on the markets [8]. Examples of carbon footprint labels are shown in Table 1. Different barriers for the success of these schemes have been identified in the information level provided by carbon labels, in fact they are often not readily comprehended by consumers.

Methods

In this study, to assess consumers' preferences towards carbon footprint labels for olive oil products and to evaluate, as well, the effect of carbon footprint information on WTP behavior, and knowledge about carbon footprint, the author accompanied an online survey. Online questionnaires were conducted with 407 consumers in the coastal part of Croatia. The chosen part of Croatia represents the Mediterranean part of the country where consumers use olive oil on a daily basis as part of the Mediterranean diet. The data were analyzed with mixed logit models and with descriptive statistical methods and SPSS software. The questionnaire followed a semi-structured guideline and was conducted in June 2022. Participants for this research were recruited online. All questionnaires were self-administered by the participants. A limitation was set for age (18+) according to the fact that adults earn money and make purchase decisions in their households. Another restriction to participating, to ensure that the results are relevant for the market, is that participants had to be at least partially responsible for the food purchase in their household. People working in the olive oil production sector were excluded from the study, in order to avoid distorted results due to their expert knowledge.

In order to test potential designs for carbon footprint labels, the author created three hypothetical claims on labels for the carbon footprint measures: 1. Claim organically produced (method); 2. Claim locally produced in your county (transportation); 3. Claim climate-friendly (climate-friendly). The design of the labels was based on findings from previous scientific studies [9, 10]. Scales had been found to be preferred by consumers since they allow for comparison thanks to the relative rankings making the labels more meaningful to consumers [11, 12, 13].

The questionnaire comprised 25 questions (closed and open-ended) and took around 5 to 7 minutes on average to be completed. At the beginning of the questionnaire, the participants were asked to rank the importance of 5 product attributes in their purchase decision, regarding the Lickert scale.

Results

The demographics sample were included in the online questionnaire. Sample characteristics are summarized in Table 1. The average age of respondents in this survey was 41. The higher share of interviewed students among our respondents could explain the lower average age. The percentage of women and men in this survey is almost equal, with 53% being men. Almost half of the participants (48.9%) in this survey had a

University degree, 39.5% finished high school and 11.6% finished elementary school. The majority of households (47.1%) had an income above 1,500€ per month, 32.0% had an income between 1.000€ and 1.500€, and 20.9% below 1.000€/monthly.
In our sample, 40.4% of participants were formally employed, 31.3% were students, 7.8% were retired, 7.3% were self-employed and 13.2% participants were farmers who did not produce olives or olive oil.

Table 1. Sample demographic (N=407)

Variable	Categories	
	Mean	St. Dev.
Age (years)	41.00	11.42
Gender	%	
0= Male	53.0	
1= Female	47.0	
Education	%	
Elementary school	11.6	
High school	39.5	
University	48.9	
Household income (€ /month)		%
Low income= less than 1.000€	20.9	
Mid income= between 1.000€ and 1.500€	32.0	
High income= more than 1.500€ 47.1	47.1	

The large majority of participants in this research knew about the carbon footprint on food (74.6%). Participants (65,9%) heard/read about carbon footprint from media (TV, radio, Internet, newspaper), 17.9% read in books about carbon footprint, 9.4% heard/read at the school/university and 6.8% participants from other sources heard/read about carbon footprint.
In order to test potential designs for carbon footprint labels, the author created three hypothetical claims on labels for the carbon footprint measures: 1. Claim organically produced (method); 2. Claim locally produced in your county (transportation); 3. Claim climate-friendly (climate-friendly). Results revealed that Croatian consumers' have the highest trust in the claim that carbon footprint is related to mitigating climate change (71.5%), then in the claim that carbon footprint is related to the method of production (organically produced), 15.0%, and the lowest concern in carbon footprint among Croatian consumers (13,5%) was about the distance of transportation of produced food. A large majority of interviewed participants (91.4%) are willing to pay higher prices for food products that have a lower carbon footprint and are "eco-friendly". The majority of 58% of participants are willing to pay 15% higher prices for those products, 20% are willing to pay 10% higher, 8,7% are willing to pay 5% higher prices while 1,3% of participants are not willing to pay higher prices for food products with a lower carbon footprint.

Discussion and conclusions

According to this online survey among Croatian consumers' of extra virgin olive oils, consumers perceived food production as highly responsible for tackling climate change. Results of this study showed that most Croatian consumers' are generally concerned and dispose of generic knowledge about climate change. The study found a general interest among Croatians in carbon labels and in climate-friendly products. The analysis of the interviews showed that indeed consumers perceived also the method of production as one of the responsible ways for the intensification of climate change. The large majority of participants in this research knew about the carbon footprint on food and heard/read about carbon footprint in the highest share from media (TV, radio, Internet, newspaper). Concerning the relatively high share of students in this research, the low share of consumers who heard in the school/university is worrying. A large majority of Croatian consumers' are willing to pay higher prices for food products that have a lower carbon footprint and are "eco-friendly".

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