AMOCEAB

Network Strategy

Introduction

In March 2020 the new Circular Economy Action Plan (CEAP) provided a future-oriented agenda for systemic, deep and transformative transition to circular economy. The envisaged transformation should work for people, regions, and cities. To accelerate the transition, forerunner regions have started to: (1) align on circularity objectives and policy contexts, defining starting points, realistic ambitions and sector scopes; (2) map, assess, and prioritize intersectoral circular economy opportunities; (3) analyze economic implications; (4) understanding how regional differences could impact implementation of systemic models. The bio- and circular economies are two complementary policy strategies (EEA, 2018).The concept of "bioeconomy" has been defined as 'the production, utilization and conservation of biological resources, including related knowledge, science, technology, and innovation, to provide information, products, processes and services across all economic sectors aiming toward a sustainable economy' (International Advisory Council of the Global Bioeconomy Summit, 2018; Yang and Yang, 2022).The bioeconomy comprises any value chain that uses biomaterial and products from agricultural, aquatic or forestry sources as a starting point. Shifting from non-renewable resources to biomaterial is an important innovation aspect of the circular economy agenda (EEA, 2018), which aims at more regenerative resource production and consumption. The bioeconomy and the circular economy are thus conceptually linked.

A deep analysis of the state of the art has been carried out and twelve topics related to Circular Economy and Bioeconomy has been defined. All topics were studied in details by the related responsible partner by reporting its connection with Circular Economy and Bioeconomy and carrying out an analysis incuding Strengths, Weaknesses, Opportunities, and Threats, according to which priorities and relevances of the topic in each territory involved in the project were described.

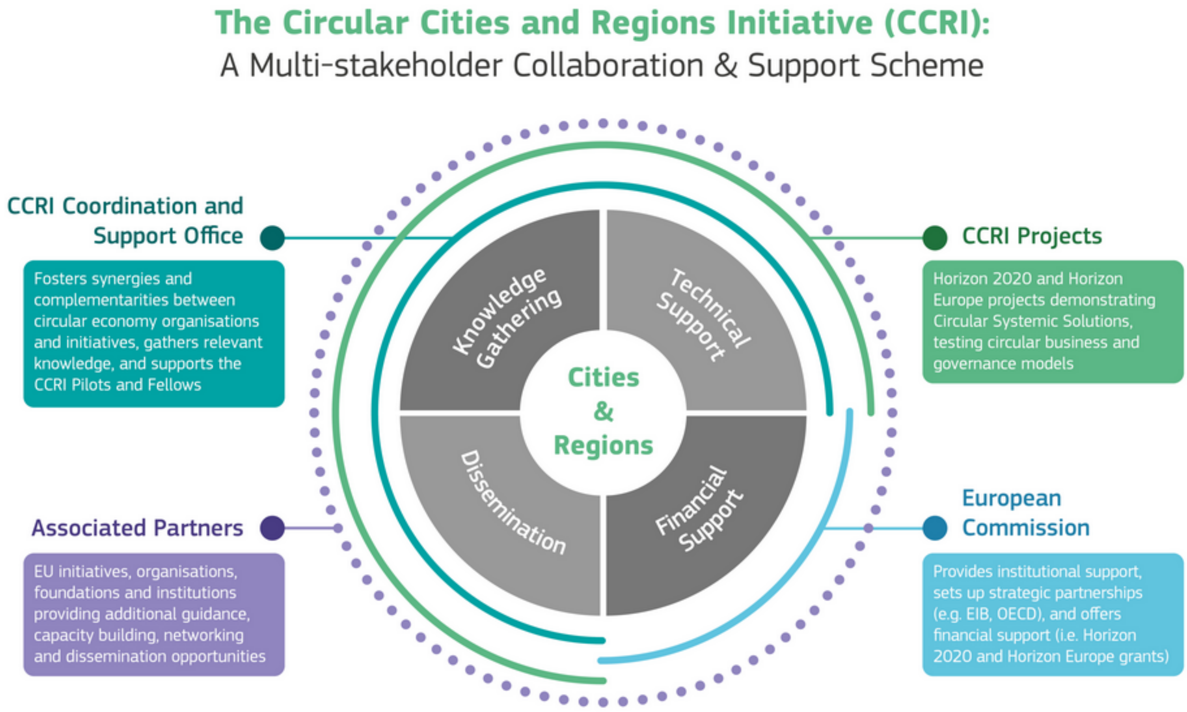
Identified twelve topics are listed below and singularly discussed, as follows:

- **Environmental Engineering and Biodiversity for Urban Circular Economy**;
- **Sustainable Business Model**;
- **Circular Economy is Smart Specialization Strategy**;
- **Industrial Biotechnologies and biobased value chains**;
- **Circular Value Chain and Digitalization**;
- **Social Impact and Social Acceptance**;
- **Circular Economy Policy**;
- **Energy Foot printing and Management in Circular Economy**;
- **Circular and Biobased Market Analysis**;
- **Food Biotechnology (Industrial Processes)**;
- **Circular Economy in Rural development (including aquaculture)**;
- **Industrial circular value chains and industrial symbiosis**.

Environmental Engineering and Biodiversity for Urban Circular Economy: Brief description of the topic and connection with Circular Economy and Bioeconomy

It is predicted that most of the population will live in cities in the future. In 2021, around 56% of the world population lived in urban areas and this number is predicted to rise to up to 70% in 2050 worldwide. According to the International Resource Panel (2018), cities are projected to consume around 90 billion tons of materials annually by 2050, following the current trend (compared to 40 billion tons annually in 2010). These statistics and trends suggest the necessity to consider cities as strategical points for the implementation and development of bioeconomy and circular economy models. In this context, the European Commission stated that 'cities should become major circular bioeconomy hubs, and circular urban development plans, which are often linked to the management of stocks and flows of organic materials, could translate into significant economic and environmental gains' (European Commission, 2018).

The initiative Circular Cities and Regions Initiative (CCRI) (https://circular-cities-and-regions.ec.europa.eu/) focuses on implementing the circular economy across Europe's cities and regions. It contributes to the policy objectives of the EU Green Deal, including the 2050 climate neutrality target, and the EU Bioeconomy Strategy, while including major Horizon2020 and HEU projects demonstrating Circular Systemic Solutions.



Literature studies (Yang and Yang, 2022) have identified three main components of the Urban bioeconomy and these include: a) Green Infrastructure (GI); b) Urban Farming; c) Biowaste managing and valorization.

Green Infrastructure is coined as 'a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation' (European Commission, 2020).Potential green infrastructure elements can be urban forests, stormwater retention systems, parks and lakes, green corridors, green walls, green rooftops, alternative concrete, dye-sensitive solar cells and more. Hence, GI can be introduced in an urban context to manage resources accordingly to Circular Economy principles, to improve the biodiversity status of the city and to provide many positive impacts ranging from economic, environmental to social and health benefits (Atanasova et al., 2021).For example, urban forests can support cities to reduce their fossil fuel consumption by generating local biomass and biofuels, and can purify the air and water, filter sunlight and provide shelter for humans and animals. In addition, some nature-based solutions can be realized by reusing demolition material as filter media (Atanasova et al., 2021; Pearlmutter et al., 2020).

Urban Farming, Urban agriculture, or urban gardening is the practice of cultivating, processing, and distributing food in or around urban areas. At present, bioproducts, most prominently food, are commonly produced outside urban boundaries through traditional agricultural activities. These products are often imported from distant and rural places to cities where they are consumed and degraded. To reduce the distance and directly produce food within cities, the concept of urban farming has become part of the city life over many years (Gehrke, 2012).Among urban farming practices, common or high potential plant production methods are organic cultivation, hydroponics, aeroponics, controlled-environment agriculture in forms like vertical farming, and agroforestry. For urban protein production, aquaculture, insect rearing, mollusk farming, algae farming, are potential practices (Yang and Yang, 2022).To save space, urban farming operations are increasingly organized in a vertical way by stapling different stacks.

Biowaste, which covers waste streams generated from biomass at production, processing or consumption stages, commonly originates from households, municipalities, commercial (e.g., catering) industrial (e.g., food processing) operations and agriculture. Within an urban environment, municipalities generally produce a great volume of green waste from gardens and parks. They also handle municipal wastewater facilities where wastewater is usually collected and treated, and sewage sludge is the produced biowaste. Regardless of their origin, biowaste is a source of energy and it is also rich in many biomolecules that can be valorized to products such as biopolymers, animal feed, essential oil, fertilizers, soil amendment and more (Yang and Yang, 2022). There are many opportunities arising from traditional and new biowaste valorization methods, which incentivize further technological development for generating high value bioproducts form biowastes produced in urban areas.

Waste management in the building sector is another strategical point for the implementation of bio-economy and circular economy within a city. Appropriate policies and initiatives in this sector may provide significant benefits to the environment. For example, in terms of CO_2 emissions, buildings are responsible for around 36% in Europe, therefore the reduction of energy consumption in this sector gives a significant improvement to reduce the whole energy dependency and greenhouse gas emissions. Since 65% of those CO_2 emissions are produced during the operational life of the building and 35% correspond to embodied carbon of building materials emitted during their manufacturing and transport, the right choice of building materials can significantly change the amount of energy embodied in a building structure. In particular, to satisfy the criteria of sustainable buildings during the entire service life, the new building envelope components, should: in the production phase, recycle/reuse by products/wastes with the benefit of valorizing them as resources and reducing the use of non-renewable raw materials; during the service life guarantee energy efficiency, durability to decrease repairing costs, and contribute for a comfortable and healthy indoor climate; at the end of service life, be able to be recycled to reduce the volume of waste to be disposed of in landfills. The use of renewable biomass resources/wastes in building materials, thanks to their zero-embodied energy, particular chemical/physical properties, as insulation ones, and low cost and availability, are particularly suited to meet these goals.

Tracking and organizing the flux of biomaterials produced by all the components of the urban bioeconomy, including needed treatments and transformation steps, results strategical for a successful implementation of this innovative organization of the economic and social city life. The concept of industrial symbiosis, which ‘engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products' (Chertow, 2000) is well-known in the field of industrial ecology. An urban symbiosis can be viewed as an extended version of industrial symbiosis applied on cities. An urban symbiosis can occur when resource flows that are located close to one another can be connected synergistically and thereby, brings about benefits for the environment and beyond (Geng et al., 2010). In an Urban Bio-Symbiosis, the waste and by-products of cities become feedstock for other bioproducts. On top of that, it does not only consider biowaste materials but also generally how other resources such as waste heat and used water can be utilized synergistically. Hence, the Urban Bio-Symbiosis includes (1) material and energy exchanges, (2) space sharing/reuse and (3) the use of multifunctional elements.

In this context, local utilities, which within an urban context handle with waste management and valorization, water reclamation and reuse, production of renewable energy, should play a pivotal role for the organization and functioning of the biomaterial fluxes produced by an urban bioeconomy. Particularly, these companies need to switch their business model from a "service provider" to a "solution partner", and they need to be able to acquire new technological skills and plants to be ready to produce new products from biowastes. Local utilities have generally a strict connection with citizens (i.e., users) and local administrations, and a great availability of data on urban infrastructures and interconnections, biomaterial generation and products demand. Hence, they are the perfect candidates for managing the implementation of an Urban Bio-Symbiosis System aimed at bioeconomy and circular economy models. In this way, new public-private partnership may be strategical to encourage local utilities towards new investments in innovative and sustainable technologies and to develop circular business models. For example, water utilities will have to invest in new technologies and processes that allow a sustainable recovery and reuse of water and need to be prepared to provide sufficient supply of treated water in remote and non-well-connected area. Furthermore, they need to valorize produced waste by transforming wastewater treatment plants in biorefinery able to generate biogas and fuels, to extract phosphorous, biopolymer and other valuable resources from sludge and wastewater (Preisner et al., 2022). Waste utilities need to invest in new technologies to treat wastes according to a market-driven approach, and they must become "producers" of raw materials, thus becoming part of the supply chain of manufacturing companies. A central role is demanded to an efficient organization of waste sorting, which will be strategical to facilitate the transformation of waste in resource. All local utilities may cooperate as an integrated partner able to manage waste, water, and energy according to a circular economy logic.

Role of city and of the management of urban services are paramount for the implementation of an urban bioeconomy and circular economy, and because of that the European Union has funded many research and innovation projects to encourage the creation of circular cities (European Commission, 2018).These research projects have been focused on increasing the technological readiness level of innovative and green technologies (e.g.; EMBRACED, URBIOFIN, RES URBIS and PERCAL project), on urban metabolism (e.g.; SCALIBUR, VALUEWASTE and WaysTUP! Projects), and on the implementation of Project Development Assistance (PDA).

The study on the city of Amsterdam is probably the most advanced vision of circular city, where a very interesting bioeconomy and circular business model has been proposed by analyzing fluxes of materials along the value chains of the building sector and of the bio-based industry (European Commission, 2022; Fabric.two and Gemeente Amsterdam, 2016). Results of the study showed that Amsterdam has the potential to greatly reduce greenhouse gas emissions and material consumption while, at the same time, realizing economic growth and stimulating employment opportunities if a bioeconomy and circular economy model will be implemented.

Cities are critically dependent on biodiversity for sustaining the social, economic and environmental well-being. The linear economic model relies on a continuous process of extraction and processing of natural resources is considered to be responsible for more than 90 percent of biodiversity loss (IRP, 2019), and according to the recent Global Assessment Report on Biodiversity and Ecosystem Services (IPBS, 2019), the current deterioration of biodiversity and ecosystem services is unprecedented. Recently, circular economy has received increasing interest as a necessary part of transformative change. Circular economy can have a positive impact on biodiversity when its solutions succeed in reducing the use of natural resources and pressures on different habitats, and the natural cycles in ecosystems are accounted for (Forslund et al., 2022). Biodiversity maintenance is crucial for urban areas and their residents. Healthy ecosystems provide with resources encompassing food, fuels, building materials and water. In addition, healthy local ecosystems offer a range of ecological functions and social co-benefits (Ruokamo et al., 2023).

Finally, green chemistry (GC) and the circular economy share the fundamental goals of shifting towards an economy that uses resources efficiently and safely, thereby reducing waste and protecting human health and the environment. GC helps optimize the use of raw materials by transforming waste and byproducts into new or secondary raw materials. In turn, these can be used for the production of new chemicals and new materials used in the design and manufacture of consumer products. They can allow for better recycling options and improve the overall efficiency of production processes. Concretely, GC is defined as the design of chemical products and processes that reduce or eliminate the generation of hazardous substances. It is based on the idea of eliminating the risk at source, as it is better not to pollute than to solve the problem deriving from the use of harmful chemicals. This principle has to be considered in designing new materials, since it is known that in many cases the presence of toxic pollutants (mainly in gaseous and liquid status) is much larger in flats than in other external areas. Some easy examples are represented by some "efficient" detergents largely used daily or solvents vapour slowly released by some wood and/or fabric furniture. Finally, as Chemistry surrounds us in many aspects of our daily life, we should not ignore that promoting sustainable chemistry it could be key in the development of circular economy.

Environmental Engineering and Biodiversity for Urban Circular Economy: topic contextualization

Recently, the national position paper "La Chimica Verde italiana: il ponte verso il futuro della bioeconomia alla luce del Green New Deal Europeo" (MiSE e Luiss Business School, 2020) has highlighted the food and beverage industries, and the water and waste management as the sectors that have mainly increased in relevance within the Italian Bioeconomy in the last decade. Bioeconomy results highly relevant for the Italian economy, and production of the Italian bioeconomy is one of the highest in Europe. Particularly, Germany has a production from the bioeconomy sector equal to €402.8 billions, France €357.7 billions, whereas Italy produces within the bioeconomy sector €328 billions. Lower production in bioeconomy has Spain (€220.6 billions) and United Kingdom (€189.8 billions).

In 2017 the Italian government promoted the development of a national Bioeconomy Strategy (BIT), and more recently updated it (BIT II) to interconnect more efficiently the pillars of the national bioeconomy: production of renewable biological resources, their conversion into valuable food/feed, bio-based products and bioenergy, and transformation and valorization of bio-waste streams. BIT II aims to improve coordination between Ministries and Italian regions in alignment of policies, regulations, R&I funding programs and infrastructures investment. The goal is a 15 % increase in turnover and employment in the Italian bioeconomy by 2030. Based on Italy's strategic geopolitical position in the Mediterranean basin, BIT II also includes actions to improve sustainable productivity, social cohesion and political stability through the implementation of bioeconomy strategies in this area (Presidenza del Consiglio dei Ministri, 2020).

Italy has put in place a formal bioeconomy cross-government working group involving the mobilization of key individuals in the Ministry of Agriculture, Food, Forestry; the Ministry of Universities and Research; the Ministry for Economic Development; and the Ministry for Environment, Land, Sea with the help of the respective Director-Generals. This group also involves other stakeholders such as Regional Authorities, National Agencies, and Institutes & Clusters. The coordination board is nominated by the Presidency of the Council of Ministers every four years providing a stable structure. It meets monthly led by a Scientific Coordinator. It focuses on monitoring and promoting the national bioeconomy action plan which has defined outcomes and scenarios including flagship and supporting actions.

Furthermore, according to the report on circular economy in Italy (2021), the national circularity performances in the production sector confirm to be better than the other four main EU economies. As per the resources productivity, Italy generates the highest economic value per material consumption unit: every kg of consumed resources generates 3.3€ in gross domestic product (GDP), as compared to the European average of 1.98€. Energy productivity is also good, generating a production of 8.1 € per kilogram of oil equivalent consumed (Circular Economy network, 2021).

Sustainable Business Models: brief description of the topic and connection with Circular Economy and Bioeconomy

During the last thirty years, a growing body of literature has been focusing on business model, which is a conceptual tool that helps to visualize and understand how firms do business by allowing performing analyses, comparisons and performance assessment, management, communication, and innovation (Osterwalder and Pigneur, 2005). Despite there is not a universally accepted definition about 'what a business model is', there is a large consensus that business models are platforms allowing organizations to represent and implement their strategy, and to identify how value is created and distributed (Richardson, 2008). A business model can be illustrated by nine main building blocks: value proposition, customer segments, customer relationships, channels, key activities, key resources, partners, cost structure and revenue model (Osterwalder, Pigneur, 2010). These components allow describing value creation, delivery and capture mechanisms i.e., how an organization creates value, delivers benefits to customers, and how it earns revenues from its products and services.

Recently, pressures for sustainability have brought to the fore the need for organizations to revise their business models, given that business as usual is no longer a solution for reaching sustainable development (Dyllick and Muff, 2015). Considering environmental, social and economic challenges, such as resource waste, climate change and population growth, organizations necessitate innovating their business models to embrace sustainability issues (Bocken et al., 2014; Massa et al., 2017; Tseng et al., 2015). Specifically, these challenges demand organizations to redesign their business model elements (Boons et al., 2013) to add social and environmental objectives to the economic ones (Bocken et al., 2019).

In this scenario, academics, practitioners and policy makers have been searching for innovative business models contributing to the sustainable development. In this regard, adopting a sustainable business model means for organizations creating positive impacts or reducing the negative ones for the natural environment, economy, and the society, hence contributing to solve societal problems and providing superior customer value while creating profit (Boons and Lüdeke-Freund, 2013; Dentchev et al., 2018; Stubbs and Cocklin, 2008).

Therefore, sustainable business models help describe, analyse, manage and communicate the sustainable value proposition of a company, thus embedding sustainability into every aspect of business (Evans et al., 2017). Schaltegger et al. (2016, p. 6) state that a business model for sustainability “helps describing, analyzing, managing, and communicating (i) a company’s sustainable value proposition to its customers, and all other stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social, and economic capital beyond its organizational boundaries”.

Despite literature on sustainable business model is fragmented (Lüdeke-Freund and Dembek, 2017), efforts have been devoted to providing classifications and archetypes of the different sustainable business models (Bocken et al., 2014; Lüdeke-Freund et al., 2018), which partially overlap. With the aim to capture emerging practices in the field, some scholars have proposed a sort of taxonomy of sustainable business models. For example, Bocken et al. (2014) propose a classification of eight archetypes linking the concept of business model innovation to the transformation mechanisms emerging for delivering industrial sustainability. The eight archetypes developed are the following ones: I) Maximise material and energy efficiency; II) Create value from 'waste'; II) Substitute with renewables and natural processes; IV) Deliver functionality, rather than ownership; V) Adopt a stewardship role; VI) Encourage sufficiency; VII) Re-purpose the business for society/environment; VIII) Develop scale-up solutions. Similarly, Lüdeke-Freund et al., (2018) propose 45 patterns to support sustainable business model design and sustainability-oriented business model innovation such as pricing and revenue patterns, eco design patterns, supply chain patterns or social mission patterns.

Sustainable business models have received substantial attention by researchers and industries. Supply chain management, entrepreneurship, strategic planning and quality management are just some examples of the research areas that have borrowed the concept of sustainable business models (Nosratabadi et al., 2019; Vetroni Barros et al., 2021). In a similar vein, sustainable business models have been employed in several industries such as fashion, healthcare, energy, agrifood, construction in order to achieve economic, social and environmental goals (Nosratabadi et al., 2019).

Literature frequently refers to sustainable business models along with the concept of circular economy to the point that a growing strand of studies addressing circular business models is emerging. Circular economy is one of the most powerful concepts in the sustainability domain (Lewandowski et al., 2016) and is defined as "a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" (Geissdoerfer et al. 2017, p. 759).

Circular economy means switching from a linear model to a circular one to reduce the negative impacts on environment and society. At a macro-level perspective, moving towards a circular economy depends on policy makers' decisions of, while at a micro-level perspective, on rethinking supply chains and designing circular business models.

According to Linder and Williander (2017 p. 183) a circular business model may be defined as "a business model in which the conceptual logic for value creation is based on utilizing economic value retained in products after use in the production of new offerings. […] The term circular business model therefore overlaps with the concept of closed-loop supply chains, and always involves recycling, remanufacturing, reuse or one of their sibling activities (e.g., refurbishment, renovation, repair)".

A circular business model entails other fundamental elements (e.g., Lewandoski, 2016; Lüdeke-Freund et al., 2018; Vetroni Barros et al., 2021). First, switching from a linear model to a circular one requires material and product design, eco-design, green building prototypes. Furthermore, a circular business model adopts a life cycle perspective which involves the assessment and evaluations of environmental impacts across the whole life cycle of products and services (Zhang et al., 2018). As a consequence, designing a circular business model demands a coherent supply chain management in order to establish closed-loop supply chains (Lüdeke-Freund et al., 2018). These aspects are accompanied by green marketing initiatives and actions devoted to motivate consumers to sustainable consumption.

Sustainable Business Models: topic contextualization

A business model for sustainability can be defined as supporting voluntary, or mainly voluntary, activities which solve or moderate social and/or environmental problems. By doing so, it creates positive business effects which can be measured or at least argued for. A business model for sustainability is actively managed in order to create customer and social value by integrating social, environmental, and business activities (Schaltegger et al., 2012)[1]. The Business Model Canvas is an efficient tool to describe, visualize, assess and change business models; also, it forces project holders to focus on the most strategically important elements of the innovation, product or service. Cost-Benefit Analysis (CBA) enables a comprehensive evaluation of the justification of project implementation not only from the point of view of the project holder, but also considering the benefit for the entire society (e.g., country, region). As we can see, the definition of SBM is very clear because defines the characteristics that an activity should embrace to be considered as such, but in reality, could be very difficult to identify a company that adopts an SBM just based on the information available on-line. For this reason, considering that the scope of this work is to evaluate and describe the relevance of the "Sustainable Business Models Topic", we decided to proceed in different steps. First, we evaluated the presence of international or national projects aimed at developing circular economy models in the countries or projects aimed to develop some specific sectors from which sustainable business models could emerge. As we will show in the following sections, in the countries analysed there are many different projects and initiatives aimed to improve three different fields: sustainable tourism, sustainable agriculture and sustainable infrastructures (through the transformation of cities into circular economy models). Through the analyses carried out, we can state that the countries give different relevance to the topic, for example, Croatia and Slovenia have many national initiatives aimed to make their cities and infrastructures green and resilient, so we can assume that is given a great relevance to the environmental aspects. On the other hand, other countries, like Greece, Albania, Bosnia, Serbia and Italy, have many national programs and initiatives aimed to develop and improve sustainable tourism and sustainable agriculture, to support local communities, and small businesses and to relaunch areas that suffered from difficult contexts (like wars or poverty). Therefore, we can assume that there is a high economic relevance. Then, we considered the number of university courses that are aimed to form managerial figures capable of running or creating a sustainable business, and in this case, Italy and Slovenia have the biggest number of such courses.

Circular Economy is Smart Specialization Strategies: brief description of the topic and connection with Circular Economy and Bioeconomy

- Definitions of CE

When implementing a circular cycle in the life cycle of a product, the concept of the end of a product's life is overcome and the focus is on the efficient use of limited resources, ensuring that they are reused or recycled for as long as possible (Yadav B., 2021).

The European Commission (2015) has adopted the Circular Economy Package, an Action Plan consisting of 54 concrete measures to support EU companies in the transition to circular business models through so-called R-strategies.

The literature defines several systems of circular strategies: the 3Rs system (reduce, reuse, recycle) (Wichai-utcha N., Chavalparit O., 2019), the 4Rs system (reduce, repair, recycle, remanufacture) (Barreiro-Gen, M, Lozano, R., 2020) and the 5Rs system (reduce, reprocess, reuse, recycle and recover) (Tony, M.A., 2022) .

The measures in the Circular Economy Action Plan cover the entire cycle and set the timetable for the completion of actions.

In the vision of the CE model, the main actors – companies, society, and governments – must meet their needs, which can be traced to three dimensions: economic benefits, environmental impact, and resource scarcity (Banaite. D, et al, 2016).

The expected benefits of EU adoption of the Circular Economy Package range from saving EU businesses €600 billion, or 8 per cent of their annual turnover, to creating 580,000 jobs in innovative design and reducing EU carbon emissions by 450 million tons by 2030 through reduced environmental impact (Athena, 2020).

- Definitions of S3

To assess regional competitiveness and identify opportunities for growth and sustainable development of regions, a place-based approach is the Smart Specialization Strategy (S3).

Thus, the S3 takes the form of a policy measure to overcome the disorganization and weakness of activities in EU countries and to offer support to those areas that have research, technological and production capacities to carry out particular activities. It also follows the socioeconomic situation of countries and their integrated technological, institutional, and business processes. The idea behind S3 is to concentrate resources in certain areas of expertise according to the needs and available resources of each region and to ensure the most effective results through rational and strategic spending of public capital (Stanojev. J, et al, 2021).

Moreover, each region benefits from different approaches in the S3 dynamics, as diverse regions will benefit from institutional integration, while integrated ones benefit from increasing diversity (Grillitsch M., 2015).

- Correlations between CE and S3

Due to the lack of CE priorities embedded in the strategies themselves and the different requirements of funding instruments in the past, circular economy projects have not been able to fully benefit from S3. The circular economy needs to be horizontally integrated into the S3 to stimulate all aspects of the circular economy (Athena, 2020).

The goal of S3 is to improve the relevant sectors and transform existing economic structures with the support of research, development, and innovation. To support CE in the regions, regional cluster strategies should be combined more efficiently and innovatively with S3 to minimize the situation where regions are dispersing their efforts too widely, with partly overlapping strategies in addressing the same problem (Vanhamäki S., et al., 2021).

Meeting the climate targets by transitioning towards climate neutrality and sustainable practices it is achievable with preventive and active policies. They need to be coordinated and mission-driven strategies aimed at the transformation of Europe in a sustainable, circular and industrial value creator system, with high employment, quality of work and security (Berger C. et al., 2022).

Moreover, S3 can be used as an enabler of the green and digital transition, especially in a moment where a response to COVID-19 is needed, in order not to leave behind anyone in Europe, as mentioned in the workshop "Smart Specialisation 4 Blue Growth Cooperation" by (Rodriguez Coronil L., 2020).

Industrial Biotechnologies and biobased value chains (focus on food sector): brief description of the topic and connection with Circular Economy and Bioeconomy

Globally, it was estimated that food loss and wastes exceeded 1 trillion United States dollars (FAO, 2015; Bhat, 2021). Annually ~20% of food produced in the European Union (EU) is wasted, costing about 143 billion Euros (De Schutter et al., 2019). The occurrence of wastes can be from agricultural fields (postharvest feedstock or biomass), food processing industries (wastes/by-products such as pomace, waste water), distribution (mainly during transportation), and consumption (at the household level). These values also promote the social iniquity. In fact, nearly 1 billion people suffer from chronic undernourishment globally, while global food demand is projected to increase between 70% and 110% by 2050. According to FAO (2015), the annual contribution to food loss and wastes by fruits, vegetables, and root crops amounts to~45%, ~35% by the fish industry, ~30% by cereals, and ~20% by oilseeds, meat, and dairy products. Food waste are of different kind: liquid, solid, and semi-solid, such as wastewater, fats, used oil, toxic household materials, and others. These wastes are known to possess potentially destructive consequences to environment and human's health. Liquid waste derives mainly by the water used for cleaning, sanitation, cooking, and transportation. Solid wastes are compressed with lignin, cellulose, amylose, and monosaccharides, expressing nutrients in contaminated shape. If on the one hand food waste should be minimized, also in accordance to the "Sustainable Development Goals" of the United Nations (FAO, 2015), on the other hand, agrifood waste and by-products need to be valorised (Cecilia et al., 2019). Sustainable recovery of valuable resources in the form of bioactive compounds, industrially valued chemicals, enzymes, natural pigments, aroma compounds, acids, biopolymers, but also proteins and microbial biomasses from agri-food industrial wastes and/or by-products represents a fundamental step in the current global scenario, respecting the bio-economy/circular economy concepts. All these added value compound/ingredients can be applied in the food, nutraceuticals, cosmetics, cosmeceuticals, and pharmaceutical sectors. The applications of anaerobic digestion, combustion, fermentation, gasification, liquefaction, pyrolysis, and torrefaction are some of the commonly adopted technologies for efficient valorisation. Biotechnological approaches can be seen as the most sustainable and green ones. From one hand they can promote the release of compounds already present in the matrix but not available. For example, microbial fermentation can increase the concentration of health-promoting compounds such as polyphenols, flavonoids, tannin, dietary fiber, pigments, and peptides starting from apple and wine pomace, grape skin and seeds, peels of banana, mango, orange, papaya, pomegranate, lemon, potato, and tomato (Cantatore et al., 2019, Durante et al., 2019, Godard et al., 2018, Pontonio et al., 2019, Pontonio et al., 2017, Madrera et al., 2017, Ricci et al., 2019). At the same time, waste and by-products can be used as substrates to produce completely new ingredients or compounds. For instance, bran (from rice, oats, and wheat), corncobs, and straw can be a potential low-cost eco-friendly substrate to produce enzymes. Industrially useful enzymes like acetyl glycosaminidase, alkaline phosphatase, lipase, protease, chitinase, hyaluronidase, and transglutaminase have been also obtained from fishery and fruit wastes (Patidar et al., 2018; Venugopal, 2016). Microbial biomass can be also used as source of protein (single-cell proteins) with potential usage as poultry and cattle feed (Gervasi et al., 2018, Spalvins et al., 2018). Microbial metabolism can then produce flavoring compounds with potential revenue. For instance, olive mill wastes have been used to produce flavor compounds by using *Rhizopus oryzae* and *Candida tropicalis* (Guneser et al., 2017). dos Reis et al. (2018) obtained value-added aroma compound fermenting vinasse with yeasts, such as *Saccharomyces cerevisiae*, *Candida parapsilosis*, and *Pichia anomala*. Eventually, lactic acid bacteria, commonly used to produce traditional foods, can be selected to ferment residues from plant materials. Valorization strategies using LAB include the production of lactic acid that may be reintegrated in the food chain as well as enhancing protein digestibility and sensorial properties of these vegetable by-products that could be used as food ingredients.

Industrial Biotechnologies and biobased value chains (focus on food sector): topic contextualization

The **Italian bioeconomy**, that wants to facilitate the achievement of the European Green Deal, **relies on all major sectors of primary production**, such as agriculture, forestry, fisheries and aquaculture, but also those processing biological resources (food and drink, wood and pulp and paper industries), the biorefineries, and parts of the chemical, biotechnological, energy, marine and maritime industries. It is currently making **about EUR 330 billion/y of turnover and 2 million**

jobs. In 2015, the **Italian food industry**, with a turnover of EUR 132 billion, 54,400 businesses and 385,000 employees, **is the second largest manufacturing sector in Italy, and the third in Europe**. The industry sector relies mostly on Small and medium-sized enterprises (SMEs) which have been proved to be a resilient sector, capable of growing also during the economic crisis. The Food Industry can provide huge opportunities for innovation and growth in the Bioeconomy sector. The Roadmap drawn by the National Agrifood Technology Cluster (CL.A.N.), a multi-stakeholder network of the key national players of the agrifood chain, from companies to research centers, microbe collections and institutions, is based on the following points: 1) **Obtaining new foods and/or fodders** for zootechnical purposes, innovative ingredients and/or bioactive compounds for developing health-giving foods with a high nutritional value obtained from by-products generated by the agrifood processing industries; 2) Adopting **innovative processes to exploit by-products** left over from agroindustry processing, to be placed on the market as new products for the food, fodder and agricultural sector; 3) **Reducing disposal costs** and finding new economic returns from agrifood by-products; 4) Analysing **techniques to recover low cost by-products** and their functional components, with a low environmental impact (BIT, 2017). In 2017 the Italian government promoted the development of a national Bioeconomy Strategy (BIT), recently updated (**BIT II**) to interconnect more efficiently the pillars of the national bioeconomy. The priorities of the Italian bioeconomy are focused on: sustainable agriculture and forestry; sustainable and competitive agri-food sector for a safe and healthy diet; bio-based industries; aquatic living resources and marine and maritime bioeconomy. More related or connected to the food sector, the goals are: to **improve healthy diets and people's health**; to **improve food safety, security, defense, and integrity**; to **boost sustainable, competitive, and innovative food manufacture**; to **boost food policies**, **supply chains, markets, and communities**; to **boost the production of biobased products and biofuels** in the framework of a circular economy; to boost the **sustainable exploiting of marine resources**; to **protect and valorize marine environment** (Fava et al., 2021). The Agrifood sector is also a priority in the strategic plans of all the regions, reflecting the value and importance of the sector linked to the quality and strong identity of the products. All the regions approved **Smart Specialisation Strategies (S3)**, strategic frameworks to design and implement research, technological development, and innovation policy interventions. Emilia-Romagna focused its S3 on two main objectives: 1) strengthening of the international competitiveness of its productions through a strong capacity of technological and organizational innovation, in order to mitigate the pressure on production costs, especially wages, and the improvement of its attractiveness for investments and skills; 2) capability to develop new markets and its socio-economic model towards systems that incorporate the knowledge economy, the information society and sustainable development. Overall, the strategy is based for on five methodological elements: 1) **Structural strengthening** by increasing investments and employment, strengthening research efficiency and technological innovation, strengthening the value chains and the organization of post-production services, diversification; 2) **Technological foresight** by identifying medium-term trajectories towards which ER will focus its research and innovation in order to anticipate and intercept socio-economic and technological trends; 3) **Entrepreneurial discovery and cross-fertilisation** by intercepting, mapping and promoting evident and hidden excellences and specializations, to overcome isolation and increase the opportunity for innovation; 4) **Aware and participatory governance** by constantly confronting policy makers with stakeholders to share objectives and bring together public and private actions; 5) **Greater integration with national and European policies** (RIS3ER, 2016)

Circular Value Chain and Digitalization: brief description of the topic and connection with Circular Economy and Bioeconomy

Circular, sustainable, and innovative value chains are assuredly connected with sustainable growth, as outlined in the recently updated European Circular Economy Action Plan, a fundamental component of the Europe's agenda for sustainability and resiliency, the European Green Deal. Under this scope, the overall life cycle of products, starting from designing and manufacturing procedures, and going further to energy consumption, reuse and recycling, is being reanalysed to switch from the linear pattern of "take-make-use-dispose", to a more efficient and climate-neutral approach, aiming to close the loop, for achieving circularity.

The green transition, as being reinforced by circularity, is called to accompany the digital transition towards climate neutrality, a target that has been underlined as a key requirement in EU's green agenda (Green Digital Europe). Digital solutions, in relevance to carbon emissions, have a bifold character; they may provide a vast potential to minimize emissions and enhance sustainable growth by exploiting powerful tools such as artificial intelligence, digital twins, and others, but they can also create a significant environmental burden since their manufacturing and operation demands a significant amount of resources. To this end, the inseparable connection of green and digital transition can lead to a win-win situation, by overcoming challenges in relevance to energy and resources consumption and efficient management.

The green and digital transition aims to strengthen social and economic growth and resilience, acting always under the umbrella of climate neutrality. To this end, the three pillars of sustainability are enclosed in this approach (environment, economy, society), as underline the European Growth Model, which focuses on shaping a smart circular economy, through the contribution of digitalisation to the green and sustainable goals (European Commission, 2022).

Recently, many industries worldwide embrace the new business models for disrupting the linear settings in value chains by adopting a pattern based in circularity, sustainability and efficiency. The circular economy paradigm encourages the shift towards waste reduction, reuse, recycle, based on the effective resources' valorisation (Carraresi, Broning, 2021), empowering the concept of secondary raw materials and highlighting their exploitation potential within an industrial value chain. Specifically, for the Balkan and Mediterranean territories, considerable progress has been made over the last years regarding the level of circularity in the industrial symbiosis and waste management field, but they are still lagging behind of the EU countries, indicating the need for extensive efforts towards circularity (Angelis-Dimakis et al., 2022)

Secondary raw materials (SRMs) are a product of recycling, and they can replace (fully or partially) the virgin raw materials in manufacturing processes. As the JRC reports, the SRMs can be technically identified as materials able to being recycled and return into the process and financial activities as new raw materials (EU Science Hub, 2016).The importance of SRMs in supporting the circular economy in each step of the value chain (production, consumption, repair and manufacturing, waste management, etc.) has been defined since 2015 through the Action Plan for Circular Economy, although the EC has outlined a strategy to ensure the sufficient access to raw materials on three pillars; *access to raw materials on world markets at undistorted conditions, foster sustainable supply of raw materials from European sources* and *reduce the EU's consumption of primary raw materials* (COM/2008/0699).

On the other hand, Europe foresees to a achieve both green transition and digital transition during the Digital Decade, focusing mainly in high energy-consuming industrial facilities towards a net-zero industries concept. Digitalisation has the capacity to empower the sustainable circular economy by providing and assessing critical information on the availability, location and condition of the products. Digitalisation can boost the efficiency in industrial processes, minimise the waste, energy consumption and costs. A combination of available systems and tools can provide major opportunities towards sustainable industrial value, such as the cyber physical systems, Big Data,

data analytics, Internet of Things. Traceability and transparency of a product throughout its lifetime, can be supported and enhanced by the use of artificial intelligence or blockchain technology (Antikainen et al., 2018).

The emerging needs of the SRMs re-injection in the manufacturing, industrial and financial processes across the Europe, led the Joint Research Centre to the set up and development of a tailored information system, the Raw Materials Information System (RMIS), which serves as an integrated information centre for SRMs including general information, policies, economics and trade, RM profiles. Among others, RMIS includes the Raw Materials Scoreboard, a cornerstone of the European Union Raw Materials Knowledge Base (EURMKB). The scoreboard aims to provide reliable monitoring information about materials to every interested stakeholder; governments, authorities, industries, etc. Currently, the third edition of the RM scoreboard is available, presenting 27 indicators grouped into six main thematic clusters; 1. Raw materials supply in EU, 2. Raw materials in the global context, 3. Circular economy and recycling, 4. Competitiveness and Innovation, 5. Environmental dimension, and 6. Social dimension (European Commission, JRC, 2023).

Circular value chain and digitalization: topic contextualization

Priority and relevance of digitalisation in circular economy in Greece

In December 2018, Greece presented the new Circular Economy National Strategy and the relevant Action Plan, to update it two years later after the introduction of the new EU Circular Economy Action Plan March 2020. This new updated action plan of Greece about circular economy, has been built on five main pillars;

1. the sustainable production and industrial policy, including the environmental certifications, ecological designing, industrial symbiosis

2. the sustainable consumption, including the promotion of green public procurements, reuse, and remanufacturing

3. the waste reduction

4. horizontal activities, such as a national observatory, monitoring indicators, etc.

5. specification and prioritisation in selected products' categories such as plastics, vehicles, batteries.

The activities of the five pillars target to enclose the overall value chain, in accordance with the EU Initiatives for 2021-2025.

The Greek Ministry of Environment and Energy foresees to increase the recycling and reuse of products, and the reduction of wastes, also to establish a secondary raw materials market and encourage their use as production resources, aiming to empower the circularity in industrial processes (Greek Ministry of Environment and Energy, 2021), (New Action Plan of Greece for Circular Economy)

The new action plan outlines the horizontal initiatives regarding governmental issues, regulatory framework, organisation and implementation, and underlines the targeted activities for industries and citizens by exploiting new and used innovative digital models.

The manufacturing industries present a high interesting since they currently consume about 40% of materials, while the closed loop models can improve their financial efficiency, providing stable prices and avoiding a risky price fluctuation. Innovative models, based on the closest consumer-producer relationship, the adaption to the consumers' needs, sharing economy principles, are empowered by digital technologies such as Internet of Things, the bid data, the artificial intelligence, to encourage the financial circularity and simplicity, reducing the dependency from raw materials.

For achieving the national targets about circular economy, Greece brings in the frontline the research and development, in accompany with the digitalisation, forming therefore the three main pillars for the transition into the circular economy model for advancing the industries and consumers, but also the overall national economy.

Moreover, the National Strategy for Research and Technology Development is one of the cornerstones of the national strategy for the shift into an environmental and financial sustainable development model, building on the knowledge and innovation exploitation through the added value products and services (New Action Plan of Greece for Circular Economy).

According to the planning of Greek General Secretariat for Research and Innovation for the programming period 2021-2027, the eight topics of priority are:

- Materials, construction and manufacturing
- Transport and logistics
- Agri-food sector
- Digital technologies
- Bioscience, healthcare and pharmaceuticals
- Tourism, culture, and creative industries
- Sustainable energy
- Environment and circular economy (GSRI, 2021)

In the Environment and circular economy sector, 10 areas of interventions are defined, including the **Industrial Symbiosis/Secondary Raw Materials** with the priority of *using residues from secondary raw material production to manufacture high added-value products*, and the **Interdisciplinary interventions** with the priority of *transition to a climate-neutral, sustainable and digital industry based on the principles of circular economy.* (GSRI, 2021 - Final sector priorities)

In the Materials, construction and manufacturing sector, among the 11 areas of interventions are included the **Reconfigurable Manufacturing Systems & Added-Value Chains** defining the priority of *Digital twin applications in industrial production and/or manufacturing processes*, and **the Materials, Processes, Devices and Production Systems for Circular Economy & Industrial Symbiosis**, defining the priority of *Clustering/Strengthening value chain clusters of materials, technologies and applications.* (GSRI, 2021 - Final sector priorities)

Social Impact and Social Acceptance: brief description of the topic and connection with CE and Bioeconomy

Social impact Circular Economy (hereinafter CE): Throughout the past decade, social impact and acceptance of CE (CE) in the global market have been progressively attempting to stay up with environmental regulations and European Union (EU) directives, resulting in the effective handling of primary resources through waste reuse in the realm of the CE. The influence of ambitious EU environmental policies and financial assistance from the European Commission (EC) assisted social actors in recognizing the CE's ecological, economic, and social benefits. For years, responsible development and the secure supply of raw resources have been high priorities on the EU's political agenda. Companies must demonstrate that raw materials are used properly and that social efforts have a beneficial impact on the community to assure resource efficiency and acquire in (also in Slovenia). This is especially true in industries with a high environmental effect, such as the extractive industry, where the openness of payment information to governments may minimize unfavorable social attitudes, boost confidence, and allow for future expansion. The extractive sector is critical at the start of the supply chain for many goods' CE models. As a result, the most recent EU policy considers upstream operations holistically. Together with an ambitious program of initiatives to stimulate investment and deepen economic integration, the European Commission works to address the need for social fairness and economic prosperity through fair and effective tax coordination. The EU needs a tax system that matches the demands of the contemporary economy while also supporting the Union's greater political ambitions. The European Commission and the European Union's member states are aiming to make tax systems more transparent, responsible, and effective in all sectors (Nowaczek, Kulczycka, Dziobek, & Kalnina, 2021). Transparency in the EU, for European firms and governments, can lead to a better knowledge of the industry's constraints and activities regarding local populations and the environment. It may also promote social impact and public trust in mining activities, as well as assist a more sustainable approach. What matters most is that businesses recognize the importance of innovative collaboration with communities to their performance and social license to operate, and communities increasingly expect it, given their positive relationship to environmental and social performance, transparency, and accountability (Nowaczek et al., 2021). Sustainability reporting is an essential tool for mining firms to communicate information to their stakeholders.

The societal approval of CE operations may be strengthened by making tax systems more open, responsible, and effective in all sectors. The EU and individual Member States are working on it to promote European aims and include new business standards (Nowaczek et al., 2021).

Concerning the single aspects, **employment** has the highest frequency in the reviewed studies, tied at the second level of occurrence are quality and well-being, social networks, and the local community. Some other factors are highlighted such as participation and local democracy, social cohesion, and occupational health and safety are increasingly used to assess the social dimension within CE (Padilla-Rivera, Russo-Garrido, & Merveille, 2020). **Social equity** has also a high frequency. Employment was the most often mentioned social element in literature, since CE can offer job possibilities, directly addressing regional unemployment inequalities and vocational mismatch (Padilla-Rivera et al., 2020). The necessity of supporting circularity-based economies illustrates that it is vital that governments get involved by proposing new policies and rewarding their advances to create more jobs. Pociovălișteanu et al. investigated the link between the environment and jobs by determining the jobs produced as a result of environmental legislation. Their findings imply that initiatives to promote green jobs in the context of sustainability should focus on the establishment of educational programs and training, as well as encouraging the use of greener technology by various stakeholders. It was also discovered that green infrastructure investment should encourage a green economy on a societal level. In this view, employment in the CE plays a vital role in solving socioeconomic issues, since it allows the CE to create new jobs, whether small or transformational, and battle unemployment and social unfairness for an exponentially rising population in a dynamic economy (Pociovălișteanu, Novo-Corti, Aceleanu, Șerban, & Grecu, 2015).

(Social) equity is one of the most frequent social aspects in CE as equitable distribution of system benefits, to improve social benefits for poverty alleviation or improving human rights and **social justice** (Padilla-Rivera et al., 2020) This demonstrates the interconnectedness of the notion of social fairness within an interpretation of sustainable development aimed at meeting the requirements of both current and future generations. **Sharing economy** and its goal is to share goods/services or other resources by a group of individuals. The sharing economy is based on the notion of maximizing the value of advantages provided by technology through lending, renting, and trading to promote the integration of user and consumption perspectives into design processes to integrate them into CE solutions. There are three key assets of sharing economy: more efficient and resilient use of cash resources (economic), more efficient use of natural resources (environmental), and deeper social relationships between individuals (social) (Cherry & Pidgeon, 2018). **Participation and local democracy** may function as local change mechanisms to educate people, provide information about a bureau's work, and allow people to participate in decision-making and social acceptance and cohesion by local actors, particularly residents and local authorities. CE affects some **health and safety** impacts as disease issues, for example, as well as enhancing people-centered health systems and public health competence, as well as fostering supportive settings and resilient communities (see World Health Organization (WHO) initiatives) (Pociovălișteanu et al., 2015). **Social aspects** are relevant in CE - they can provide an overview of how social strategies and actions impact or benefit society within CE; social aspects can help with CE monitoring. The most often stated socioeconomic components of CE in this literature review were those relating to employment, health and safety, and participation; however, there were additional social concerns that were significant but were not addressed in the research examined. These problems were poverty eradication, food security, and gender fairness. These social concerns are significant to us because they may aid in comprehending the negative externalities caused by the transition to a CE. In terms of tools and measurements for the social component of CE, we discovered that Social Life Cycle assessment may be utilized to integrate social characteristics of products and services within a life cycle perspective, complementing the environmental and economic dimensions of CE. These social dimensions, which are inextricably intertwined with CE goods and services, must be considered while developing technical tools and should not be overlooked. Nevertheless, education, engagement, and legislative backing from the literature overview emerged as critical levers for the transition to a sustainable CE (Mies & Gold, 2021).

While the CE is viewed as a paradigm based on natural evolution, the result is that people must be seen as the primary players since they are constantly touched by any change or evolutionary adoption (Tavera Romero, Castro, Ortiz, Khalaf, & Vargas, 2021). A prevailing notion is well captured by Kirchherr et al. (Kirchherr, Reike, & Hekkert, 2017), according to which CE notion is associated with "… end-of-life concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), to accomplish sustainable development, which implies creating environmental quality, economic prosperity, and social equity, to the benefit of current and future generations" (Kirchherr et al. 2020, pp. 224–22; Corvellec, Stowell, & Johansson, 2022). If one looks at the EU, one will notice that circular economic practices have been formed without any clear debate or consideration of system boundary constraints (Inigo & Blok, 2019; Korhonen, Nuur, Feldmann, & Birkie, 2018). The EU's strategy, for example, conveys clear material aspirations, whilst its ambitions in terms of social justice and environmental preservation remain more ambiguous (Flynn & Hacking, 2019; Kovacic, Strand, & Völker, 2019; Schröder, Lemille, & Desmond, 2020).Murray states that it "is unclear how the concept of the CE will lead to greater social equality, in terms of inter- and intra-generational equity, gender, racial and religious equality and other diversity, financial equality, or in terms of equality of social opportunity. These are important moral and ethical issues that are missing from the construct" (Murray, Skene, & Haynes, 2017). The CE may offer wealth and a social good impact, but it can also make life more difficult for many. It is critical to ensure that the real and perceived societal advantages are balanced; otherwise, there is an overwhelming risk that priorities will neglect social concerns (Corvellec et al., 2022). Slovenia has been actively promoting the CE model as a way to reduce waste, improve resource efficiency, and create new economic opportunities. The CE has the potential to generate significant social and environmental benefits in Slovenia, including reducing greenhouse gas emissions, creating jobs, and promoting sustainable consumption and production patterns. Social impact and social acceptance of the CE in Slovenia: Circular Business Models, Waste Reduction, Job Creation, Social Cohesion, Education and Awareness-Raising, Regulation. Slovenia has actively promoted the CE model, with significant social impact and social acceptance. Slovenia can create a more sustainable and equitable future for all by continuing to adopt circular models, methods, tools, best practices, and technologies ("Roadmap towards a CE in Slovenia 2018," 2018). The Adrion region has been actively promoting the CE as a way to reduce waste, improve resource efficiency, and create new economic opportunities. The CE has the potential to generate significant social and environmental benefits in the region, including reducing greenhouse gas emissions, creating jobs, and promoting sustainable consumption and production patterns (IPPC, 2014).

The notions of social effect and social acceptability are linked because the bioeconomy's social impact may affect the social acceptance (Bezama, Ingrao, O'Keeffe, & Thrän, 2019). For example, if the bioeconomy produces jobs and economic prospects in rural regions, this might boost rural populations' societal acceptance of the bioeconomy. Nevertheless, if the bioeconomy has severe environmental or social consequences, such as deforestation or relocation of residents, social approval of the bioeconomy may suffer (Philp & Winickoff, 2018; Ramcilovic-Suominen, 2022). The readiness of people and communities in the Adrion region to embrace and promote Bioeconomy activities is referred to as social acceptability. Cultural standards, economic incentives, and political will can all have an impact on social acceptability. People may be less inclined to embrace or adopt Bioeconomy activities if they regard the Bioeconomy as a danger to their way of life, or if they do not recognize the economic or environmental advantages (Bell et al., 2018). But, if the bioeconomy has a positive social impact and is not socially accepted, it may not be sustainable in the long term. Similarly, if the Bioeconomy is socially accepted but has negative social impacts, it may not be desirable or ethical. It is critical to involve stakeholders at all levels and to clearly and persuasively convey the benefits of Bioeconomy practices. This might involve educating communities on the economic, environmental, and social benefits of the bioeconomy, as well as collaborating with lawmakers to develop policies that encourage sustainable Bioeconomy activities. The Adrion region's bioeconomy may contribute to long-term economic development, environmental conservation, and social well-being by increasing societal acceptability and addressing social impact (van Langen et al., 2021). The bioeconomy idea has the potential to have a substantial societal impact on Slovenia by fostering sustainable economic growth, lowering pollution and greenhouse gas emissions, and enhancing food security (Cingiz, Gonzalez-Hermoso, Heijman, & Wesseler, 2021; Dolge et al., 2022; Szarka & Kittler, 2022).

Social Impact and Social Acceptance: topic contestualization

Croatia: The circular economy is critical for Croatia's economic development, particularly in light of the country's upcoming EU membership. Circular approaches have tremendous potential in Croatia, particularly in tourism and agriculture. Croatia could adjust, not only to a new financial resource obtained via EU membership, but also to appropriately accept new norms and goals required by the EU for sustainable growth. Yet, Croatia continues to suffer major problems with the absorption of ESI funding. Croatia is therefore marginally "better" than Italy, which got 44% of total EU funds over the same year, at the bottom of the EU member states ranking (Kovačić, Kerčević, & Burić, 2021). In terms of societal impact and acceptance, the circular economy has the potential to improve the quality of life for Croatian inhabitants. It has the potential to encourage more sustainable lifestyles, create green jobs, and improve community health and well-being. Furthermore, the circular economy may promote social inclusion by giving opportunities for underserved populations such as long-term jobless, migrants, and persons with impairments.

Among other environmental issues, the bioeconomy has the potential to help reduce greenhouse gas emissions, soil erosion, and water pollution. The sustainable use of natural resources, like forestry and agriculture, can help to preserve Croatia's distinctive biodiversity, scenery, and cultural heritage. The expansion of the bioeconomy has the potential to offer new jobs and income opportunities, particularly in rural areas where employment alternatives are few. Additionally, the bioeconomy has the potential to regenerate rural regions and reduce socioeconomic disparities. To fully realize the bioeconomy's promise, it is necessary to ensure consumer, stakeholder, and policymaker approval of bio-based products and services. Increasing trust and awareness of the benefits and drawbacks of the bioeconomy can help (Papadopoulou, Loizou, & Chatzitheodoridis, 2022).

Greece: Because of the country's economic troubles and the need to transition to a more sustainable and resilient economy, the circular economy is becoming more relevant in Greece. In the energy and waste management sectors, circular processes are very important. The Greek government has set implementation of circular economy objectives in practice, through a Circular Transition Business Plan of Greece, as one of its key cross-sectoral priorities. The National Action Plan on Circular Economy (NAPCE), was developed as Greece's response to the EU Action Plan for the Circular Economy-priorities: (1) removing regulatory and legislative barriers to a circular economy through 10 plus regulatory and legislative interventions, such as incorporating circular economy considerations and criteria into the Environmental Impact Assessment and Strategic Impact Assessment requirements for sites and projects, as well as in the environmental permitting process, or developing new legal definitions for wastes, by-products, and re-fuse materials after first use intended for re-use, waste declassification, and waste quality standards; (2) Directing current money to the above-mentioned actions and funding demonstration projects; (3)Expanding knowledge, comprehension, education, awareness, and communication; (4) Strengthening governance mechanisms by establishing an inter-ministerial Executive Secretariat for the Circular Economy to supervise the implementation and an associated Observatory to track progress (Kalogiannidis, Kalfas, Loizou, & Chatzitheodoridis, 2022; Martinidis, Dyjakon, Minta, & Ramut, 2022).

Greece has considerable natural resources, including agricultural land, forests, and marine resources, which may be used to promote the growth of the bioeconomy in a sustainable manner. The social impact of the bioeconomy is also essential, since it may help communities become more sustainable and egalitarian. The bioeconomy, for example, may help rural development by offering new economic possibilities and encouraging the use of local resources. It can also help to build more sustainable and resilient food systems, which are critical for improving food security and decreasing food waste (Kalogiannidis et al., 2022). To guarantee that the bioeconomy is socially acceptable and fulfills the interests and concerns of all stakeholders, it will be critical to ensure its success in Greece. This will necessitate community involvement, careful evaluation of the environmental consequences of bioeconomy operations, and the creation of legislation and regulations (Graikioti, Sdrali, & Klimi Kaminari, 2022).

Italy: Italy, for instance, has the largest proportion of total waste recycling of any European country, at 79.4%, well ahead of the EU average (49%) and all other larger European countries combined. Most of the detailed cases address more than one of the Five Pillars: (1) Circular input - production starts with renewable materials or goods or those derived from previous life cycles; (2) Product useful life is extended in a variety of ways, including modular design and making products easier to repair; (3) Product as a service: a business model in which the client purchases a limited-time service while the product remains the property of the company, which then reuses it efficiently; (4) Shared management systems for multiple users of a product, good, or skill ("Italy, a Circular Economy Champion," 2023).

The Italian bioeconomy policy aims to increase turnover and jobs by 15% between 2017 and 2030, as well as to promote the sustainable valorization and regeneration of national biodiversity (both terrestrial and marine), ecosystem services, and marginal/abandoned areas or industrial sites (Fava et al., 2021). Italy is aiming to a) shift from areas to systems by effectively interlinking the core principals of the bioeconomy through the utilizing of deeply rooted traditional industries as well as local public and private stakeholders; b) adding value from local biodiversity and circularity while respecting natural crop production cycles; c) quickly and effectively aligning regional, national, and EU initiatives and helping to promote a cohesive dedication to the implementation of the Bioeconomy; and d) promoting the bioeconomy in Mediterranean area (Fava et al., 2021).

Slovenia: offers opportunities for innovation and competitiveness, particularly in the manufacturing sector within CE. Slovenia has also implemented several circular policies and initiatives, including the adoption of a National Circular Economy Roadmap ("Roadmap towards a Circular Economy in Slovenia 2018," 2018). Slovenian communities, organizations, businesses, research centers, and renewable sources agencies encourage sustainable ways of life and energy efficiency programs to raise public awareness about eco-food, waste management, and traffic emissions.

The bioeconomy encompasses various sectors such as agriculture, forestry, fisheries, and biotechnology, and is considered a key component in achieving the Sustainable Development Goals (United Nations, 2023). In Slovenia, policymakers, stakeholders, and citizens are all concerned about the social impact of the bioeconomy. The bioeconomy has the potential to generate new job opportunities, particularly in rural areas, and to aid in the development of local communities. It can also promote social inclusion and equality by improving living standards and increasing access to basic services. Furthermore, the bioeconomy can help to preserve cultural heritage and traditions while also promoting sustainable lifestyles and environmental education. The bioeconomy's acceptance in Slovenia is critical to its success. Public awareness, participation, and engagement are critical for developing and implementing policies and strategies that promote growth that is equitable and environmentally friendly. The bioeconomy should be viewed as a collaborative effort involving various actors including the government, private sector, civil society, and academia. Local communities and stakeholders must also be involved to ensure that their needs and priorities are considered in the decision-making process (Association of Chemical Industries of Slovenia at the Chamber of Commerce and Industry of Slovenia (CCIS-ACIS), 2020; Hetemäki et al., 2017; Rogelja et al., 2023).

Albania: The circular economy is a new concept in Albania, but it has the potential to promote long-term economic growth while reducing environmental impact. Agriculture, construction, and waste management are key sectors for circular practices in Albania. Albanian companies are recognizing their responsibility to reduce their environmental impact (PINARI & ÇELA, 2022). Albania and BiH in particular obtain a low ranking when looking at performance in the entrepreneurial ecosystem.

A positive social impact is showing in the generation of new revenue streams which can be used to subsidize support social facilities and initiatives; the strengthening of social capital and cohesiveness within the community, bioeconomy initiatives supported by its income, new social linkages and strengthens pre-existing relationships in a community; facilitating attitudinal and behavior change within the wider community.

Bosnia and Herzegovina: In Bosnia and Herzegovina, the circular economy is still in its infancy, but there is growing recognition of its potential to promote sustainable economic development and reduce environmental impact. Waste management, agriculture, and construction are key sectors for circular practices in Bosnia and Herzegovina. Agriculture remains one of the most important sectors of the national economies in the WB countries, contributing significantly to economic and social stability. However, its role in economic development is limited because it serves as a social amortization during the region's economic crisis (Hukic, 2017).

Montenegro: Montenegro prioritizes the circular economy, particularly in light of its EU accession process. Circular practices have opportunities in the tourism and agriculture sectors. In Montenegro, the social impact of the bioeconomy refers to the effects of bioeconomic activities on society as a whole. This includes the environmental, public health, and community impacts. It is critical to ensure that the benefits of bioeconomy initiatives are distributed evenly across society and minimize any negative consequences. In terms of social acceptance, it is critical to ensure that the general public understands and supports the bioeconomy's development. This can be accomplished by engaging citizens and encouraging their participation in bioeconomic activities through communication and outreach efforts. Given Montenegro's small population and the importance of long-term development to the country's prosperity, the social impact and social acceptance of the bioeconomy are both critical and should be prioritized. Ensuring that bioeconomic initiatives are socially responsible and widely accepted will not only support sustainable development but will also contribute to Montenegro's long-term economic success (The United Nations Development Programme (UNDP) in Montenegro, 2022).

Serbia: The circular economy is a priority for Serbia, particularly in the context of its EU accession process. By implementing the circular economy concept, the domestic economy has a chance to grow, and society and citizens benefit from improved environmental protection, particularly in the area of waste reduction, as well as new jobs created in the waste processing sector. It is believed that a nation's social capital is an investment without which there is no future. According to estimates, the circulatory economy concept can create approximately 30,000 jobs in Serbia (Bakator, Đorđević, & Đorđević, 2019). The bioeconomy sector is still in its early stages of development, especially in rural areas where agriculture and forestry are significant economic activities. Small farmers can benefit from the bioeconomy by diversifying their income streams and improving their livelihoods. It can also help to address rural depopulation by creating new jobs and promoting long-term development and including awareness-raising, education, and stakeholder engagement. Local communities, farmers, and other stakeholders must be involved in the development of bioeconomy projects to ensure that their needs and concerns are addressed. It is also critical to communicate the potential benefits of the bioeconomy and to address any misunderstandings or concerns that may arise (Dobrijević et al., 2019).

Circular Economy Policy: brief description of the topic and connection with Circular Economy and Bioeconomy

According to World Wildlife Fund (De Angelis 2018), presently we live in an economy emptying natural capital: 'by 2012, the bio-capacity equal of 1.6 quantities of the earth was needed to produce the natural resources and services humankind consumed in that year'. Ellen MacArthur Foundation and McKinsey (2013 in de Angelis 2018; Fric, 2019) continue to believe that a capital-restoring and regenerative circular economy and bioeconomy would benefit mankind. But there are three critical questions to address: (1) what does such an economy look like, and why do we need it, (2) who are the essential participants in developing and maintaining a circular economy, and (3) what adjustments would they need to make for such an economy to flourish (ibid.). The Ellen MacArthur Foundation's (De Angelis 2018) notion identifies the circular economy model as a reaction to the challenges of a rising economy, the use of limited resources, and overall environmental capacity. Following that, we use combining critical semiotic analysis with an evolutionary and institutional approach to political economy offering one interesting way to achieve this goal (Jessop and Oosterlynck 2008) transformation from linear to a circular economy where an evolutionary and institutional approach to semiosis allows us to recognize the semiotic dimensions of political economy (ibid.). We focus on the influence of ambitious EU environmental policy and the European Commission's financial assistance, which allowed social actors to see not only the ecological but also the economic and social benefits of CE (European Commission 2023).

According to a World Economic Forum report, the circular economy concept and terminology gained traction following the 2012 World Economic Forum, where this report, prepared in collaboration with the Ellen MacArthur Foundation and McKinsey & Company, demonstrated for the first time its utility and potential to drive new economic development (Fric, 2019; World Economic Forum in Barbero 2017, 9). “However, popularity frequently has downsides or risks, such as becoming merely a catchphrase - some people believe the fundamental essence of circular economy is lost in translation and is misinterpreted,” says Barbero (2017, 9). “There are many misconceptions of the circular economy such as that it is just another way of describing recycling, or that it encourages people to re-use and keep products for a longer time, therefore it decreases sales since it might be an opportunity for some people, but on the long term will have a negative impact on manufacturers, and so on”, also explains Barbero (2017, 9).

As one of the EU's most established concepts, the circular economy symbolizes the EU's approach to coping with the constraints of rising economies and consumption of limited resources and environmental capabilities (Ellen MacArthur Foundation 2016, 2017). The transition to a circular economy is thus built on the reuse, modification, and processing of existing resources and products (ibid.). To reduce waste generation, it also allows for the use of more renewable energy sources, the discontinuation of hazardous chemicals, the reduction of raw materials, and the redesign of product design to make it more recyclable while retaining its added value for as long as feasible (ibid.). Products in a circular economy remain in the environment long after they have reached the end of their useful life (ibid.). To summarize, the circular economy can be defined from different aspects (ibid.). In its essence, it represents a global model of sustainable economic development in which resources are used moderately and reasonably (ibid.). From a resource point-of-view, the model discriminates between biological and technical materials and results in prolonging the useful lifespan of both as much as possible (ibid.). In the pre-manufacturing phase, the circular economy model requires that products are designed effectively and efficiently so as to enable their circular flow (ibid.; Fric, 2019). In terms of economic potential, it encourages creative approaches to all phases of the life cycle, and by delivering all of the above, it lays the ground for a new sustainable system (ibid.). Of course, the circular economy as we found from the available literature is treated as existing in the form of such as an industrial and economic model for the sustainability of society; as a new sustainable paradigm; as a concept and practice; a challenge - really a new paradigm, or just a new designation/renaming; origin and its evolution; transformation of business models and their integration into practice: impacts on the economy (positive and negative); effects on the economy; limitation.

If the circular economy attempts to reduce reliance on (new) natural resource extraction, it can be supplemented by the bioeconomy, a concept that encompasses economic activities related to the invention, development, production, and use of biological products and processes for energy, materials, and chemicals (Biofuture Platform, 2018). The resultant junction is known as the "circular economy." Although it has the potential to steer a transition to more sustainable production and consumption, the notion is still in its infancy, with many problems and research concerns left. Notably, companies and scholars describe the notion differently, which causes misunderstanding and makes successful implementation of the framework challenging. Furthermore, the phrases "circular bioeconomy" and "sustainability" are frequently and inexactly interchanged in academics, business, and politicians.

The bioeconomy, like the circular economy, is a developing area with ambiguous definitions and meanings (Aguilar et al., 2019; Giampietro, 2019). The European Commission, for example, defines the bioeconomy as "the sectors of the economy that use renewable biological resources to create food, materials, and energy." (European Commission Research Innovation Bioeconomy (ECRIB), 2019). Similarly, the German Bioeconomy Council defines the bioeconomy as all industrial and economic sectors, as well as the services that support them, that generate or process biomass or employ biological resources in any form (Efken et al., 2016). Meanwhile, the Biomass Research and Development Board in the United States uses Golden and Handfield's (IPPC, 2014) definition of the bioeconomy for its bioeconomy initiative [Biomass Research Development Board (BRDB), 2018, which characterizes the bioeconomy as the global industrial transition of sustainably utilizing renewable aquatic and terrestrial biomass resources in energy, intermediate, and final products for economic, environmental, social, and national security. The bioeconomy is implied in these definitions as the utilization of renewable biological resources such as biomass to create renewable biofuels, bioproducts, and biopower for economic, environmental, and social advantages. There is no doubt that bio-based goods are deemed renewable and may have lower environmental implications than petroleum-derived rivals (Adom et al., 2014). Bio-based goods replace fossil carbon with biogenic carbon derived from biomass, and their end-of-life carbon dioxide ($CO2$) emissions are biogenic $CO2$, which is deemed carbon-neutral (IPPPC, 2014). Furthermore, when employed as an energy source, biofuels and biopower are renewable energy that may substitute fossil fuels and power to help ease the depletion of fossil resources (Government Printing Office, 2012).

However, there is an ongoing debate on the sustainability aspect of the bioeconomy. According to certain definitions, the bioeconomy is not innately sustainable just because it is built on renewable resources (Pfau et al., 2014; Gawel et al., 2019). Indeed, a non-sustainable bioeconomy can lead to a variety of sustainability issues. An increase in biofuel demand, for example, will result in an increase in biomass demand, which will result in competition for arable land use (i.e., land-grabbing for biomass feedstock production), freshwater consumption, and even food production (i.e., food vs. fuel), resulting in social unrest or social sustainability concerns. On the environmental sustainability front, increased land demand for biomass production will have severe environmental consequences, including increased greenhouse gas emissions (responsible for global warming) as a result of indirect land-use changes (e.g., deforestation for growing energy crops (Plevin et al., 2010). Another example is recent research that found bio-based products do not always perform well in all environmental aspects (Vendries et al., 2020). When comparing petroleum- versus bio-based packaging and food service ware, the latter has a lower global warming potential and uses less fossil energy, but has negative environmental implications in numerous areas, including ozone depletion, acidification, water consumption, and eutrophication.

To tackle sustainability issues, it must be a sustainable bioeconomy, not just a bioeconomy. The present bioeconomy continues to rely heavily on nonrenewable energy and fossil-based raw materials such as nitrogen fertilizers, organic compounds, and polymers sourced mostly from petroleum oil and gas. The sustainable bioeconomy will involve sustainable biomass feedstock production, biomass conversion processes, and products, in addition to substituting fossil resources with renewable resources. Furthermore, a sustainable bioeconomy may be realized by combining it with other multidisciplinary fields, such as the circular economy.

Most stakeholders would consider the bioeconomy to be the junction of the two growing ideas of the circular economy and the bioeconomy. However, the link between the circular economy and the bioeconomy is complicated and a source of contention. The circular bioeconomy is interpreted by the European Commission's bioeconomy strategy as a framework for reducing reliance on natural resources, transforming manufacturing, promoting sustainable production of renewable resources from land, fisheries, and aquaculture, and promoting their conversion into various bio-based products and bioenergy while creating new jobs and industries (European Commission, 2023). A circular bioeconomy is also defined as an approach to promote developed economies' economic growth by combining a desired "what" (circular economy) with a practicable, sustainable, and desirable "how" (bioeconomy) (Giampietro, 2019). A circular bioeconomy may also be defined as more effective resource management of bio-based renewable resources through the incorporation of circular economy concepts into the bioeconomy (D'Amato et al., 2018). The debate over the relationship between circular economy and bioeconomy can also be broken down into five categories: (1) the circular economy and bioeconomy as separate but reinforcing concepts, (2) both concepts as completely integrated, (3) both concepts as partially antagonistic, (4) the bioeconomy as a prerequisite for a circular economy, or (5) the circular economy as a tool for transitioning from a fossil economy to a bioeconomy (Leipold and Petit-Boix, 2018).

Furthermore, some would argue that the bioeconomy is already fundamentally "circular by nature," as it is based on the regenerative and circular nature of the planet's ecosystems (Leipold and Petit-Boix, 2018). Bio-based goods, for example, created from renewable biological carbon (the major component of biological substances like biomass), are recycled and reused throughout the biosphere (i.e., carbon cycle). However, if the bioeconomy is based on EMAF's butterfly circular economy system diagram, it is not truly circular (Ellen MacArthur Foundation, 2019; 2023a; 2023b). The butterfly diagram depicts the circular economy as including both biological and technological processes. Only the biological cycle is related to the bioeconomy, in which materials are manufactured from biological nutrients (i.e., bio-based goods) that may be safely returned to the biosphere.

The Western Balkans (including Non-EU Partner States Albania, Bosnia and Herzegovina, Montenegro, and Serbia) is one of Europe's most strongly hit regions by the effects of climate change. Most of its countries have vowed to take steps to reduce emissions and ensure sustainability, and the area is now striving to make substantial advances in the circular economy strategy. Instead of focusing on single-point solutions like as recycling rates and trash management, which have historically been the region's top priorities, the circular economy approach considers the entire system. The circular economy idea is still relatively new in this region, and incentives for businesses to shift to green and circular practices are limited. Nonetheless, recent advances in the legislative and administrative environment, as well as external circumstances, may have the potential to expedite the adoption of CE principles across the corporate sector and regional economies.

Circular Economy Policy: topic contestualization

Croatia: could adjust not only to a new financial resource obtained by EU membership but also to appropriately accept new norms and goals required by the EU for sustainable growth. Nonetheless, Croatia continues to confront major problems in terms of ESI fund absorption; according to the European Commission, Croatia received 4,058,542,188 EUR in total EU payments until January 2021, which is barely 45% of the overall allocation for the seven years. Nonetheless, despite adequate resources, Croatia suffers a lack of execution, even though the potential of the Circular Economy and the relevance of green investments in Croatia may provide a considerable boost to the Croatian economy. As seen, the Republic of Croatia suffers both legislation and operational shortcomings in terms of waste disposal, usage, and resource reuse, but this may be a significant motivation for adopting waste management to construct a circular economy. Croatia dedicated a lot to priority to separate collection of paper, plastic and glass, electrical and electronic equipment, waste batteries and accumulators, end-of-life vehicles, waste tires, waste oil, waste textiles, and medical waste. Croatia is developing a CE monitoring framework.

Greece: Greece's Governmental Economic Policy Council endorsed a National Action Plan on Circular Economy in early 2018 to set the country on a path towards the long-term adoption of circular economy principles. This further supports Greece's economic strategy in its key quest to "Green" the economy in a way that creates jobs, especially for women and youth and supports long-term equitable and inclusive growth based on resource efficiency, promotion of SMEs, innovation and investment in new technologies, and strengthening of the "social economy" potential. Greece has few natural resources. Its only substantial mineral deposits are of nonferrous metals, notably bauxite. The country also has small deposits of silver ore and marble, which are mined. Greece is also facing new development priorities from fostering digitalization, improving entrepreneurial and business ecosystems, and addressing environmental challenges. At the same time, these new priorities must also tackle existing social challenges and mitigate rising inequalities.

Italy: Since the Ronchi Decree (*Legislative Decree n. 22 of 5 February 1997)*, Italy has started to implement the required changes to build a circular economy. Italy has a very advanced level of recovery and recycling in 2016, particularly for municipal garbage, and a European level of excellence for industrial and commercial waste. It is also required to homogenize the performances of the North and the Center-South of the Country to further enhance the levels of recovery and recycling and to fulfil the criteria of the European law, which is changing. The new "National strategy for the circular economy," which focuses on eco-design and eco-efficiency, aims to help achieve climate neutrality goals by defining: new administrative and fiscal tools to strengthen the secondary raw materials market, expanded producer and consumer responsibility, dissemination of sharing and "product as a service" practices, and a roadmap of actions and measurable targets between now and 2040. The new approach will also have an impact on the following intervention areas: eco-design and product innovation, bioeconomy, blue economy, critical raw resources, and critical raw materials. Furthermore, the new traceability system will be part of the national policy, allowing control bodies and law enforcement authorities to be supported in prevention and repression (italiadomani 2023).

Slovenia: Slovenia's strategic development goals include the circular economy. It is strongly linked to the SDGs and is incorporated in important national papers such as "A Vision for Slovenia in 2050," "Slovenian Development Strategy 2030," and "Slovenia's Smart Specialisation Strategy." The strategy's primary objective is to improve everyone's quality of life. The food system, forest-based value, manufacturing, and mobility are priority topics within the broader framework of natural resources (Godina Kosir 2018). The consumption of resources per inhabitant in Slovenia is equal to the EU average. However, Slovenia lies below the EU average in terms of the efficiency of consumption of resources and energy, and we are also progressing too slowly in terms of the productivity of carbon consumption. The transition to a low-carbon circular economy is, therefore, a priority development orientation for the entire economy. Slovenia has the main goals to achieve by 2030: a) Breaking the link between economic development and increases in resource consumption and GHG emissions, which will be achievable via education and the participation of numerous stakeholders in the transition to a circular economy; b) promoting innovation, the use of design, and information and communication technologies to develop new business models and products that use raw materials and energy more efficiently, as well as through climate change adaptation; c) replacing fossil fuels through the promotion of EE and the use of RES in all areas of energy use, while harmonizing interests in cross-cutting areas: water - food - energy - ecosystems; d) ensuring that transportation infrastructure and energy use support the transition to a low-carbon circular economy and allow for sustainable mobility, including through the introduction of new mobility concepts and increasing the share of public passenger transportation; e) using infrastructure projects to design nodes for the low-carbon circular development and economic growth solutions at the regional and local levels. Slovenia was one of the first CEE nations to use a circular economy narrative to encourage the transition to a sustainable production and consumption model. Slovenia's Ministry of Environmental and Spatial Planning and Circular Change released its Roadmap to a Circular Economy in May 2018. Recommendations for key stakeholders have been provided based on the Circular Triangle concept (the Circular Economy, Circular Culture, and Circular Change). The Food System, Mobility, Manufacturing Industry, and Forest-Based Value Chains have been identified as key categories for circular transformation. As a result, the Circular Change Institute has been working hard as a network governing authority in Slovenia and throughout the world, notably in the Western Balkans area. It is a worldwide forerunner involved in transition promotion, reaching out to various regional frontrunners and stakeholders. Slovenia's EU presidency emphasized the necessity of regional interconnectedness in the transition to a circular economy. The special lifestyle newspaper "Circular Insider" features stories from Slovenian and international circular economy practitioners (by Circular Change). Circular Change also collaborates with the Holland Circular Hotspot Network and other worldwide circular networks (Roadmap Towards the Circular Economy in Montenegro 2022).

Bioeconomy is not the central topic of any specific Slovenian framework or policy. There are, however, several national and EU frameworks that touch on the topic of bioeconomy: Slovenian Smart Specialization Strategy (S4) (it focuses on sustainability and fosters SRIP partnerships amongst various stakeholders from the entire value chain), Transition signpost towards a green economy (emphasizes the opportunities Slovenia has to transition into a circular economy, mostly about agriculture and forest-wood chains) and the Rural Development Program (mentions the conventional use of agricultural and forest biomass, as well as energy production). There are also some far more general support frameworks for bioeconomy: the Research and Innovation Strategy of Slovenia, the Slovenian Industry Policy, Sustainable urban strategies of municipalities and the Government framework program for the transition to a green economy. In Slovenia, the „Technologies for sustainable biomass transformation and new bio-based materials“ are a part of the „Networks for the transition to a circular economy“. „Networks for the transition to a circular economy“ are 1 of 9 (Slovenia’s Smart Specialization Strategy) Priority Areas. The Priority Area is coordinated by a national cluster-like entity, Strategic Research and Innovation Partnership (SRIP) Networks for the transition into the circular economy (National Bioeconomy Dossier: Slovenia 2020).

Albania: In the Republic of Albania, the notion of a "circular economy" is still in its early stages. The notion of circular economy was previously mentioned in the January 2018 draft Strategy on Integrated Waste Management. The revised Integrated Waste Management Strategy is based on the vision or perception of the concept of "zero waste," in which waste is collected and treated as raw materials, and management is carried out through the use of circulatory systems, which serve the criterion of use and preservation of raw material resources. The waste power structure is the most important waste management principle (prevention, reuse, recycling, recovery and disposal) (Regional Circular Economy Status Report Written Contribution from Western Balkans and Turkey, 2021)

Bosnia and Herzegovina: Circular Economy (CE) has been established in Bosnia and Herzegovina in recent years. Because of its pre-accession interest in becoming an EU member, BiH has begun to move in that direction since the European Green Deal and Green Agenda for Western Balkans were unveiled. Rather than the recycling itself offered in recent decades, the CE is acknowledged as a concept that encourages sustainable development. After being presented by LIR through the ENV.net project, and by many professionals previously dealing with waste management concerns, the notion became "more alive" in Bosnia and Herzegovina (Regional Circular Economy Status Report Written Contribution from Western Balkans and Turkey, 2021).

Montenegro: the concept of CE in Montenegro is far away. The first analysis of CE was in 2014 within the document: Resource efficiency and sustainable human development (UNDP_Resource efficiency and sustainable development, 2014). CE and the efficient use of resources have not been directly integrated into Montenegrin policies and regulations, however, constructive developments are underway, such as the stimulation of innovation and productivity, the mitigating of the effects of economic expansion, the sustainable use of natural resources, and the enhancement of governance National Sustainable Development Strategy 2007 – 2012. The start of industrialization and the transition to a market-based economy introduced an unsustainable model of economic growth to Montenegro, which is similar to that of many other developing countries: "take, produce, consume, and discard"; it is a linear model based on the assumption that quantities of materials extracted from nature are infinite (Regional Circular Economy Status Report Written Contribution from Western Balkans and Turkey, 2021; Roadmap Towards the Circular Economy in Montenegro 2022).

Serbia: Serbia has made some progress in terms of environmental and climate change preparedness. Overall, Serbia made modest progress in the previous year, focusing mostly on strategic planning and should significantly increase its objectives for a green transformation. In Serbia, the circular economy idea is still in its infancy where the phrase "CE" is not included in the 2020 European Commission Report. Serbia is adopting various circular economy projects. Because is within the Negotiation stance for EU membership, it is also planned how and when Serbia would fulfil all EU member nations' commitments through a series of Directive Specific Implementation Plans (Circular Economy Action Plan). Serbia is demanding a transition phase for waste management (where circular economy aims for waste management are stated) (Regional Circular Economy Status Report Written Contribution from Western Balkans and Turkey, 2021).

Energy Foot printing and Management in Circular Economy and Bioeconomy: brief description of the topic and connection with Circular Economy and Bioeconomy

Besides carbon footprint and water footprint, the measurement of energy footprint is crucial for many industries. The energy footprint is one of the indicators of energy consumption. In literature, different definitions of the energy footprint can be found. According to Jordán (2012), the energy footprint is one of the ecological footprints and represents the measure of land which is needed to absorb the CO_2 emissions. This approach focuses on the outcome of energy use, which is CO_2 emissions, to highlight the problem and the way for corrective action to take corrective measures. Wackernagel and Rees (1996) defined the energy footprint as the land or the amount of forest area needed to absorb the CO_2 emissions from burning of fossil fuels, absorb the radiation from nuclear fuels and build dams to produce hydroelectricity. According to the Global Footprint Network (GFN) (2009), the energy footprint is a measure of land required to absorb the CO_2 emissions from the consumption of non-food and non-feed energy. The energy footprint can be classified into different categories such as the energy footprint from using fossil fuels, the energy footprint from using hydroelectricity and the nuclear energy footprint. The measure of the energy footprint is based on the area and can be global hectares or local hectares with a specific carbon sequestration estimate (Walsh et al., 2010). Often, the energy footprint is the largest share of the overall environmental footprint (Kitzes et al., 2009). Energy footprint considers only CO_2 emissions, which differs from the carbon footprint which takes into account the total amount of greenhouse gases, which are much higher than CO_2 emissions. According to Fang et al. (2014), from a methodological perspective, the energy footprint takes a further step in translating the amount of CO_2 emissions into the amount of biologically productive land and water required to absorb these emissions than does the carbon footprint. The energy footprint is very useful since it can establish a connection between atmospheric carbon emissions and terrestrial carbon sinks, however, the methodology for determining the energy footprint is not yet as standardized and scientifically robust as for the other ecological footprints (Fang et al., 2014). Energy footprints consist of different “sub-footprints” such as fossil energy footprint, nuclear energy footprint, solar energy footprint, renewable energy footprint and others (Čuček et al., 2012).

The energy footprint can be reduced through efficiency measurement and appropriate energy management. The concepts of circular economy and bioeconomy can be one of the vital steps in which energy consumption and footprint can be reduced. Compared with the linear economy, the circular economy is a more sustainable economy and has less carbon emission and it tends to minimize energy usage (reduce the energy footprint). One of the aims of the bioeconomy is to decrease reliance on fossil fuels, which will reduce greenhouse gas emissions and the energy footprint. By using the bioeconomy, which highlights sustainability and ecological processes, it is possible to optimize the use of energy (Bugge et al., 2016). A circular bioeconomy is a term when a circular economy is complemented with a bioeconomy. The circular bioeconomy tends towards the use of renewable energy and non-toxic materials and requires the usage of low-carbon energy and sustainable supply chains (Tan and Lammers, 2021). One of the advantages of the usage of the concept of circular economy and bioeconomy can be in reducing greenhouse gas emissions. One of the principles of the circular economy is to design and reuse waste, which includes CO_2 and other greenhouse emissions. For example, the principle of circular carbon economy can be used as a framework to reduce, reuse, recycle and remove CO_2. Different studies have shown that the concept of a circular economy and bioeconomy combined with the different climate action plans can reduce greenhouse gas emissions, which will reduce the energy footprint. According to the Ellen MacArthur Foundation (2019), the decarbonization of energy systems can only eradicate up to 55% of global greenhouse emissions, while the remaining 45 % of the emissions which are related to the production of goods and materials, can be reduced by using the concept of the circular economy when applied to the industry and food systems and can reduce around 9.3 GT of CO_2 emissions in 2050. Circular bioeconomy is considered a low-carbon economy and tends to create a sustainable and greener environment, protect the environment, sustain energy–environment nexus, increase food security, promote sustainable and economical manner of waste disposal (Leong et al.,2021). At present, most of the materials flows are not part of a circular economy but potentially can become part of a circular economy. Since fossil fuels are mainly used for energy purposes, they will never be a full part of the circular economy (Carus and Dammer, 2018). Renewable energy should be preferential as an energy source to achieve a sustainable circular economy, which is a challenge that requires alignment between the circular economy and energy transitions (European Environment Agency, 2018). The energy management and energy industry are very important in making a sustainable economic system and enabling a circular economy in the industry. Energy plays a key role when producing recycled material. Circular economy and the optimization of resources or energy management are one of the ways to improve the energy self-sufficiency of the countries (Deloitte, 2018).

The circular economy is a vital part of the energy transition and strategies such as recycling material will support the energy transition from fossil to renewable energy sources. To achieve better sustainability and minimize energy demand the circular economy should be complemented with a bioeconomy and recycling and recovery of the products should have minimum energy requirements.

Energy Foot printing and Management in Circular Economy and Bioeconomy: topic contestualization

Bosnia and Herzegovina applied for EU membership in February 2016 and was granted EU candidate status in December 2022, on the condition that the country take the recommended steps to strengthen the rule of law, the fight against corruption and organised crime, migration management and fundamental rights. The candidate status will further motivate the country administration to speed up institutional and legal reforms. During the last decade, Bosnia and Herzegovina has set up a legal framework for policy instruments to contribute to sustainable and environmentally sound waste management. BiH transposed to a certain level several waste package directives to EPR schemes for WEEE and packaging waste, waste oils, waste tyres, batteries and accumulators and waste batteries and accumulators, end-of-life vehicles.

Declaration on the Green Agenda (i.e. Sofia Declaration) that aligns with EU Green Deal, was endorsed by the Western Balkans leaders during the WB Sofia Summit (10th November 2020). The Action Plan for implementation of the WB Green Agenda (adopted in October 2021 during Brdo kod Kranja Summit) covers period 2021 to 2030 and is structured to reflects the seven components of the Sofia Declaration (i.e. Climate Action, Energy, Transport, Circular Economy, Pollution, Sustainable Agriculture and Nature and Biodiversity Protection), grouped into five pillars:

i. Decarbonisation,
ii. Circular economy,
iii. Depollution,
iv. Sustainable agriculture, and
v. Protection of nature and biodiversity.

This should be further deepened with harmonisation with the new circular economy action plan (CEAP) adopted by the European Commission in March 2020. It is one of the main building blocks of the European Green Deal, Europe's new agenda for sustainable growth. It is expected that transition to a circular economy will reduce pressure on natural resources and will create sustainable growth and jobs.

The new Environmental Strategy and Action Plan – BiH ESAP 2030+ takes into account both the EU Green Deal and the Green Agenda for the Western Balkans as key documents. In addition, the United Nations Development Programme (UNDP) in BiH supported preparation the "Roadmap for the circular economy of Bosnia and Herzegovina. National Energy and Climate Plan of Bosnia and

Herzegovina (BiH) for the period 2021-2030 has been recently drafted. The NECP has its five dimension which will simultaneously ensure a secure energy supply and economic development:

- Security of supply
- Energy market
- Energy efficiency
- Decarbonisation
- Research, innovation and competitiveness.

The political and institutional reforms that have been made in the last 5 years are a strong driver of changes that will support the transition to the circular economy and bioeconomy. The industry's interest for improvement of their resource efficiency of the production is increasing, there are more and more industries that are looking for consulting services in this area and that are active participants in the green transition program.

Circular and Biobased Market Analysis: brief description of the topic and connection with Circular Economy and Bioeconomy

The challenges we face, in an international context that is demonstrating all its fragility, are numerous and demanding. The data make it clear that we need to find quick and concrete solutions on environmental sustainability, to prevent and limit risks and damages at a social and economy. We need to invest to use less energy, fewer resources and regenerate our soils, bringing back organic matter and closing the carbon cycle, put in place the necessary tools to produce according to a true circular economy approach.

In this context, the Bioeconomy is a pillar of the ecological transition because of its ability to contribute to the implementation of all 8 policy initiative areas in which the Green New Deal is articulated, representing its key element to decarbonize the economy, decrease the use of nonrenewable resources and maximize the efficiency and sustainability of renewable resources.

The Bioeconomy can be a powerful tool of European strategies and policies to generate a change of course that passes through a cultural change in society expressible by "doing more with less."

Italy, today, can boast leadership precisely in the field of the Circular Bioeconomy, which has been achieved through the integration of green chemistry and agriculture, with the construction of an integrated supply chain for bioplastics and biochemicals. Despite these firsts, and the tangible evolutionary and regenerative potential, the Bioeconomy is not yet fully considered a strategic sector. It requires the utmost attention, at the national and European level, and constant involvement, so that the Circular Bioeconomy sector is properly framed.

In 2019, the new "European BioEconomy Strategy" strongly emphasized the need to move all productive sectors toward circularity and environmental sustainability. In Europe, in 2021, the BioEconomy generated an output of about 1.5 trillion euros, employing more than 7 million people.

In absolute terms, Germany remains the leader with an estimated value of Bioeconomy output of 463.6 billion euros, followed by France with a value of 379.4 billion. Italy ranks third, with an output of 364.3 billion euros, ahead of Spain (251.5 billion). In terms of employment, the Bioeconomy records values between Spain's 1.5 million employees and Germany's 2.3 million. Italy, with just over 2 million employed, ranks second immediately after Germany, ahead of France (1.8 million) and Spain (1.5 million).

A separate discussion deserves the bio-based component of chemical and energy production: the increases in oil prices will not end in the short term, given the tensions between supply and demand and the difficulties in finding a diplomatic path out of the current crisis. This translates into a competitive advantage for bio-based production that will depend on many factors, including the prices of alternative commodities to oil, such as agricultural commodities, which in turn are experiencing high tensions, not only due to the emergence of the Russian/Ukrainian conflict but also, increasingly, due to climate change.

An analysis of the diffusion of some of these strategies in the Bioeconomy sectors, carried out on the 2018 data from ISTAT's Permanent Census, shows a good positioning of the Bioeconomy sectors, but also points to a huge untapped potential in many sectors.

In 2021, all Bioeconomy-related activities in Italy generated an output of 364.3 billion euros, employing just over two million people.

After ending 2020 with a 2.6 percent decline in the value of output, the Bioeconomy rebounded in 2021 with a 10.6 percent rebound in output, fully recovering lost ground and positioning itself at levels higher than pre-pandemic (2019) by about 26 billion euros. Employment was more stable, at levels of just over 2 million throughout the period under consideration (2019-2021).

The evolution observed in 2021 brings the Italian Bioeconomy to weigh 11.4 percent of total output, up from the previous two years. Employment in the Bioeconomy as a percentage of the national total is 8.2 percent.

The year 2021 closed with growth for all sectors pertaining to the Bioeconomy, showing for most sectors a full recovery of the ground lost in 2020. However, sectoral performances are quite diversified: the sectors that had marked the largest declines in 2020 record, in fact, a significant rebound in 2021 by recovering the ground lost in the previous year. Other sectors, on the other hand, show less pronounced dynamics both in 2020, when the decline was modest, and in 2021, with positive but limited changes. Finally, other sectors show significant acceleration in 2021 against very moderate trends in 2020.

The agribusiness supply chain, which accounts for about 60 percent of the value of the Bioeconomy, with an output of €216 billion (of which €153 billion is generated by the food, beverage, and tobacco industry), after showing substantial resilience in 2020, closed 2021 on an upward trend, positioning itself about €12 billion higher than in 2019. Year 2021 ended on a positive note for both the agriculture supply chain and the downstream processing industry. The latter in particular showed a good development trend thanks to the results achieved both on the domestic front and in foreign markets. The most significant contribution to growth came precisely from the domestic market, thanks to internal purchases and the significant rebound in out-of-home consumption, which rebounded significantly in the spring months. Positive signs were also observed in international markets, driven by demand from European countries. Moreover, in terms of employment, the agribusiness supply chain is the most significant sector of the bioeconomy: in 2021, employment in this sector (928,000 in agriculture and 468,000 in the food industry) amounted to 46.1 percent and 23.2 percent of the total national Bioeconomy, respectively. (Source: Intesa Sanpaolo elaborations on various sources).

Circular economy data in the European Union show a modest number of materials put back into the economy. The circular materials utilization rate measures the share of materials recycled and fed back into the economy, saving the extraction of primary raw materials in the overall use of materials. The circular material use, also known as circularity rate, is defined as the ratio of the circular use of materials to the overall material use. The overall material use is measured by summing up the aggregate domestic material consumption (DMC) and the circular use of materials.

According to data for the year 2021 circular material used in European Union is 11,7%. Highest rate is in Netherlands (33,8%). High rates are also in Belgium (20,5%), France (19,8%) and Italy

(18,4%). Lowest rates are in countries like Ireland (2,0%), Romania (1,4%) and Finland (2,0%). According to the same source, circular materials used rate increased from 8,8% in 2005 to 11,7% in 2021 which justifies needs for accelerating switch from linear to circular economy. One would expect more rapid increase of this rate that usually serves as a primary circular economy indicator.

Above chart represents value added in economy in circular economy sectors. Data shows that 0,99% of GDP was gross value added to circular economy sectors in European Union in 2019. High numbers of value added to these sectors are in Croatia (1,74%), Lithuania (1,24%), Bulgaria (1,15%), Italy (1,14%) and Poland (1,06%). Lowest value added in these sectors are in Greece (0,40%). On the European Union level we can observe very low gross value added to circular economy sectors which also shows urgent need to stimulate these sectors through holistic approach.

Food Biotechnology (Industrial Processes): topic contextualization

The needs and priorities of the Republic of Croatia include challenges related to climate change (e.g. droughts and floods), health (e.g. the COVID-19 pandemic) and geopolitical events (e.g. supply chain disruptions and other crisis situations). In doing so, first of all ethical principles should be followed, and then other frameworks, such as the priorities of the European Commission: (1) European Green Plan, (2) Europe ready for the digital age, (3) Economy in the interest of citizens, (4) A stronger Europe in the world, (5) Promotion of the European way of life, and (6) New impetus to European democracy [1]; as well as the Bioeconomy Strategy of the Republic of Croatia (this Strategy should be available predictably in May 2023) and, of course, legal reference system.

Croatia is involved in global value chains (GVC), especially in the field of Food Biotechnology (FB) and Pharmaceutical Biotechnology (PB) (both - FB and PB as Industrial Processes), as well as Information and Communications Technologies (ICT), and all three fields are of utmost importance for Croatia's sustainable economic growth. Term value chains (VC) involve the complete set of activities, such as design, production, marketing, distribution and support to the final consumer, and term global (G) emphasizes interconnectedness among countries (De Backer & Miroudot, 2014). Croatia's major trading partners are Austria, Bosnia and Herzegovina, Italy, Germany, Hungary, Serbia, Slovenia, and Montenegro, and in 2014 intermediate and final goods and services were mainly exported from Croatia to those countries (Peruško et al., 2018).

Seven (7) thematic areas could be identified as essential for establishment of Croatia's circular economy and bioeconomy, as follows: (1) Agroecology, (2) Food production and supply systems, (3) Forest value added chains, (4) Management of freshwater and marine and coastal resources, (5) Bioenergy, (6) Advanced Biochemicals, Pharmaceuticals and Biomaterials, and (7) Education in the field of Biotechnology with special focus on Circular Economy and Bioeconomy.

In order to achieve the established goal, it is necessary to:

1. Improve infrastructure in research and innovation, application of research and innovation results in biotechnological production, and closer cooperation between the academic community and producers of biotechnological products and services.

2. Increasing the utilization of biomass and entire added value chains by applying innovative technologies and other solutions, but also investment and business models with an emphasis on the establishment and development of small and medium-sized biotechnology companies (SMEs).

3. Reorganization of the multidisciplinary concept of bioeconomy in terms of integration of sector-oriented policies. As the bioeconomy unites agriculture, forestry, fishing, then the production of food, energy and all the so-called bioproducts, then the integration of all policies related to these sectors is assumed here, which is in line with the EU bioeconomy strategy [2].

4. Increasing visibility and involving all stakeholders: primary producers and the processing industry, the so-called brand owners, consumers, small and medium-sized companies, research and technology centers and universities, and especially civil society, in the creation and implementation of the Applied Genomics Strategy in the field of Biotechnology.

5. Availability of funding sources and establishment of a public-private partnership for research and development in the propulsive field of Biotechnology.

6. Reorganization of the educational system with an emphasis on the selection of gifted individuals and the engagement of teachers in order to reduce the volume (quantity) of classical forms of teaching and increase the representation of the project approach to teaching, as well as the introduction of continuous (lifelong) learning.

7. Depolitization of the bioeconomy concept and definition of real (real) problems and challenges, as well as the independence of distinguished and proven experts in order to act outside the framework of defined policies.

Industrial circular value chains and industrial symbiosis: brief description of the topic and connection with Circular Economy and Bioeconomy

The 21th century, the era of abundance that is present in most of **industrialized world** represents the two-way road. One direction is continuous fast technological growth in all aspects of life while the other direction that is often neglected or forgotten is even faster waste generation especial in **developing and third-world countries**. The major cause of **waste accumulation and mismanagement** is without a doubt a human negligence and superficial mindset without thoughts of the future with only goal of achievement short-term benefits. The primary **European Union's challenge to be climate-neutral by 2050** – an economy with net-zero GHG emissions, may be obtained by replacing non-renewable fossil resources with waste and sustainably sourced biomass to produce industrial applicable technologies (EU Green Deal, 2019).

An innovative concept of **generating, valorization and upcycling the waste streams into new-added materials** will support the Green Deal initiative for sustainable environment by addressing the systematic problem (EU Green Deal, 2019). This circular value chains have to be consolidated in term of **developing and optimizing technologies for more efficient and cost-effective waste processing.** The EU strategy of transforming the Union into modern, resource-efficient, and competitive economy, decouple the economic growth from resource depletion, and include everyone into sustainable **circular economy and bioeconomy concept** (Circular Economy Action Plan, 2020). The holistic multidisciplinary nature of **industrial symbiosis** supported by technology and knowledge transfer between researchers, industry and stakeholder, will greatly contribute to overall socio-economic impact and strengthen dissemination and exploitation of innovative technological solutions.

Supporting the **waste free policies** (Zero Waste Europe, 2019), the by-products/waste generated during extraction of raw materials, will be used as source matrices for new-material production (e.g., polymers, sensors, sorbents, among others). New sustainable bio-materials, will be upscaled and tested in industrial environment on real samples and further optimized to satisfy **high industrial standards**. The implementation of **„green procedures"** in every aspect of (pre)treatment and bioconversion processes of raw materials is nowadays imperative of **chemical engineering practice. Green chemistry** has gained significant interest among chemists, stressing the role of analytical chemists in environmentally friendly practices 41 namely, through reducing the sample volume, the corresponding amount of energy, reagents, and waste generation is also significantly lessened as well as the time needed. The optimization and subsequent validation of process modification and improvements of current as well as new "green" technologies will serve as foundation for future clean, cost and energy efficient **scale-up (upcycling techniques)**. To comply not only with changing design objectives of the industry (a real application of scaling up in complex engineering systems), but increasingly stringent environmental quality regulations as well (Alrabghi et al., 2016), a **novel simulation-based framework (optimization models)** have to be developed. The process synthesis and design of (bio)chemical reactors requires accurate modeling and full-scale simulation, prior to real application in waste/water treatment plants. Through supporting the optimization of process synthesis and the design of reactors, new systematic model-based methodologies will be applied (Emenike et al., 2018). A number of **innovative technologies** are developed to accentuate, expedite, and augment conversion of **waste streams** and byproducts to **value-added materials**.

The development of advanced materials (e.g., highly porous bio-adsorbents, bio-sensors) ensures that application (most commonly – treatment and monitoring) may be carried out more efficiently and thoroughly, (Karić et al., 2022). **Designing novel, selective and biodegradable materials** for waste/water monitoring and treatment, predominantly functionalized by non-harmful chemical agents, is paramount to environmental protection (Hokkanen et al., 2016). This approach fully utilizes the principles of waste minimization, ensuring a 'new added value' and practical implementation to this waste material (i.e**., a closed loop of material flow in industrial value chain**). These approaches may be especially reflected in less developed or developing countries, offering a simple, low cost and pragmatic solution for waste/water treatment (Đolić et al., 2019), including potential **resource recovery**.

Knowledge and information exchange within the scientific community and policy-makers as an essential step towards effective policies on environmental quality improvement, especially in less developed countries such as the Republic of Serbia and Bosnia and Hercegovina. Therefore, a more comprehensive (holistic) approach of circular value chains and industrial symbiosis would reflect onto: 1) **strengthening national environmental regulations and legislations, and their enforcement**; 2) **better monitoring of environmental media quality including the environmental impact assessment**; 3) **improved training and knowledge of innovative technologies (processing, design);** and 4) **expanded capacity building to address recourse recovery potential.**

Industrial Circular Value Chains And Industrial Symbiosis: Topic Contextualization

The industrial sector in the Republic of Serbia, which has a major and direct impact on the exploatation of raw materials and the way they are used, is still in the early stages of transition from a linear to a circular economy and bioeconomy. The implementation of circular economy principles in the process of production has the aim to 'close the loop' among three impetuses: industrial waste, process and material (as a new-added value of waste processing). Industrial waste encompasses materials that do not have any practical application after a given fabrication process. There are many sectors of industrial manufacturing that produce and valorize disparate types of waste in Republic of Serbia, including: electric power plants (e.g., coal-combustion products) (Đolić et al., 2022), pulp and paper industry (e.g., cellulose-based derivates) (Gane et al., 2020; Kostić et al., 2022), chemical plants and petroleum refineries (e.g., solid and liquid waste) (Ivaniš et al., 2016), building industry (e.g., composite materials) (Omran et al., 2022), food and wood processing (e.g., bio-waste, organic residues) (Popović et al., 2022). The waste valorization process presents the transformation of waste into a new product of potential engineering application (Karić et al., 2021). The primer goal of industrial waste valorization is to promote sustainable production and consumption, as a societally responsible behavior that directly reflects into the environmental benefits (climate change, water/air/soil pollution, depletion resources, and food security, among others) (Cvetković et al., 2022). Elimination of tremendous amounts of underused waste by circular high-value approach will eliminate problems with their uncontrolled decomposition, and disposal and management, simultaneously providing economic benefit and lowering environmental impact. The importance of permanent education (i.e., training schools, workshops, peer – learning study), directed to profesionals, and laypersons as well (Josipović, 2020), is especially reflected in the era of green and digital transition. Disparate professional and scientific publications on waste valorization may enchance the real-scale application in various engineering fields: chemical, bio-chemical, textile, civil and environmental engineering), including material science, as one of the most multidisciplinary sector in the last 15 years (Kokeza et al., 2021). The application of the circular economy and bioeconomy model on national and global level represents the inevitable perspective of all economic systems.

The following **joint master degree mission statement** has been defined in agreement with the **AMOCEAB** objectives reported in the proposal and with project documents, which have been defined and agreed in the framework of the project activities (*e.g.*, Deliverables T1.1.2, "Definition of Network Governance and membership"; T1.1.5, "MEMORANDUM OF UNDERSTANDING for the implementation of the Interreg V-B Adriatic Ionian – ADRION1313 AMOCEAB – Adrion Master On Circular Economy And Bioeconomy").
Accordingly, main project aims, *i.e.*, a) the creation of a Transnational Network within the Adrion region and b) the creation of a Master Course in Circular Economy and Bioeconomy, will be pursued by the following overall strategic targets:

- *Creation of a transnational network of universities and business supporting organizations able to cooperate, discuss and prepare joint measures - in particular study courses - to disseminate knowledge and create experts in Circular Economy and Bioeconomy.*
- *Organization of a mutual learning path on techniques and methods through which a Master Course in Circular Economy and Bioeconomy can be concretely developed for the stated objectives.*
- *Implementation of a collaborative educational, instructional and cultural network within the ADRION region.*
- *Exchange of research information within the ADRION Region Promotion of activities, cooperation and educational goals.*

The **mission** of the joint master degree is the high level academic formation of novel expert professional figures to be employed in engineering and economic sectors mainly, dealing with bioeconomy and circular economy aspects. This overall aim matches with recommendations from the ADRION programme, which consider the sustainable growth of the Adriactic-Ionian region of strategic relevance, by specifically defining target marine/maritime and environmental and social innovation topics, namely:

- *Blue Economy;*
- *Social Innovation;*
- *Renewable Energy;*
- *Circular Economy*.

The joint master degree aims at preparing advanced professional experts, who will help regional industrial actors to:

- *Enlarge portfolios of entrepreneurial opportunities dealing with a higher exploitation of resources, with particular attention to the possibility of valorizing underexploited organic residues;*
- *Responde to new regulamentation requirements about industrial sustainability;*
- *Promote (transnational) networks including all type of partners dealing with the development of industrial value chains in the framework of the bioeconomy and circular economy (e.g., feedstock providers, industries, public and private utilities, local administrations, policy makers, business support organisations, citizen associations);*
- *Contribute to develop sustainable and virtuous regional areas, capable of maximizing the exploitation of local resources and of capturing public/private funding opportunities.*

In order to pursue the mentioned overall aims, **the joint master degree statement** will be defined in the final grant agreement document signed by all partners and, accordingly, the master degree program will respect the following statements:

- *The Program will provide students with knowledge and skills regarding bioeconomy and circular economy;*
- *The Program will have a duration of two academic years with 120 ECTS and it will consist of mandatory mobility amongst the Partner Institutions and Associated Partner Institutions. It offers different tracks to the students from the different Full Partner Institutions;*
- *The Program is divided into four semesters, where:*
  - *The first semester is provided by Università Politecnica delle Marche.*
  - *The second semester is provided by Università Politecnica delle Marche.*
  - *The third semester is provided by at least one of the Degree Awarding Full Partner Universities as one of two tracks.*
  - *The fourth semester is mainly dedicated to the master thesis preparation at any of the Degree Awarding Full Partner Universities.*
  - *The final thesis discussion will be held at one of the Degree Awarding Full Partner Universities.*
- *The program structure is defined by the Executive Board following the academic structures in place.*
- *The current program structure is to be made publicly available on the AMOCEAB website*

In agreement with this purpose, master participants will gain skills on the twelve target master topics stated in the Deliverable T1.2.4 "Definition of key contents of the Joint Master Course".

Two programs (Engineering program" and "Business program") will be proposed. Specializations will be offered during the second program year of the "Engineering program", namely:

- Circular services and technologies for sustainable cities and regions;
- Circular food chain and industrial biotechs;
- Green industrial production, symbiosis and cyber-physical systems.

Programs were drafted considering the following conditions:

- Total courses: 16
- Mandatory courses: 13
- Elective courses: 3
- Period abroad: minimum 6 months
- Internship: 6 ECTS
- Thesis: 18 ECTS

The period abroad can be accomplished by students during the third semester and/or during the internship/thesis period.

The **joint master implementation strategy** has been assessed following a deep discussion about each partner national regulations on master courses. In fact, Italy is the only nation among those of the transnational network that recognize **postgraduate specialization courses** (1st and 2nd level degrees), mentioned as "masters", providing practical professional and specialist skills for the placement in the job market. In particular, the minimum requirements for attending 1st and 2nd level specialization courses are a Bachelor's and a Master's degree Diplomas, respectively. Partners belonging to all other countries implied that a **Second Cycle degree programme** (Master's degree) would have been proposed as the result of the AMOCAB activites, in agreement with own regulations.

Certificates obtained by successfully participating into such Italian postgraduate programmes are only recognized in Italy. However, ECTS obtained by passing specific examinations can be recognized by each university belonging to the transnational partnership, by same modalities assessed in the framework of university Erasmus programmes.

In Italy, the procedure for the accreditation of a Joint Master degree is long and complicated. It is much easier to organize a professional master (postgraduate specialization course). On the other hands, professional masters are not supported by the ERASMUS mobility program.

All this considered, the following implementation strategy has been proposed (further details will be stated by the **Consortium Agreement**, which will outline the terms and joint procedures for the preparation and provision of the master):

- For the first accreditation year an Italian 1st level degree postgraduate specialization course (Master Universitario di Primo Livello) with duration of 2 years will be provided according to the regulations reported in the Consortium Agreement for the Joint Master Degree Program (Action Plan signed by all Partners). During the first 2 years of Master di Primo livello, each Partner University will assess the specific accreditation process in order to release an additional diploma in compliance with each specific national legislation. The national accreditation release is not mandatory for all the partners; the partners that do not provide accreditation will contribute with teaching and mobility activities; this will allow a) overcoming Italian long accreditation procedures and b) verifying and optimizing the capability of attracting students, as well as participant satisfaction and course effectiveness in terms of industrial interest and involvement. In fact, the JS of Interreg-Adrion program stated that accreditation of future transnational university master must be done as soon as possible both to ensure the effective link with the implemented summer courses and to meet the programme schedule with regard to the launch of future calls and programme financial performance (ideally, by the end of 2023).

- The academic program, providing students with knowledge and skills regarding bioeconomy and circular economy, will have a duration of two academic years with 120 ECTS and consists of mandatory mobility amongst the Partner Institutions and Associated Partner Institutions. The Program will be divided into four semesters, where the first and second semesters will be provided by Università Politecnica delle Marche and the third semester will be provided by at least one of the Degree Awarding Full Partner Universities as one of two tracks. The fourth semester will be mainly dedicated to the master thesis preparation at any of the Degree Awarding Full Partner Universities.

- In order to disseminate the master course, the program structure will be published and updated on the AMOCEAB website as well as by those of project partners. In general, the marketing and raising of awareness surrounding the master program will be the joint responsibility of all Institutions. The Consortium will market, advertise, and promote the Program to ensure its worldwide visibility. A strong focus will be on social media. Interaction with European and national agencies for higher education, cultural services and diplomatic representations of the Institution countries and the European Union, scientific and professional bodies and organizations and international scientific conferences, will also be used.

- The Program website will be a single, comprehensive, integrated website containing information related to the Program, including, but not limited to, the description of the Program,

- In spite of the fact that no specific constrains are required for students' mobility, mandatory **mobility** amongst the Partner Institutions and Associated Partner Institutions will be proposed. To this aim, the course will offer different tracks to the students from the different Full Partner Institutions. All partners consider this course feature very important, in the perspective of enlarging the portfolio of international experiences of master participants.
- Partners will seek to obtain **funds** under the Programs intended for the financing of joint study programs and/or through third parties, in order to support participant expenses, among which those related to the mentioned mobility; in case of funding the master study by the donor Program, the donor Program rules and guidelines will apply on financial management. In the opposite case that no external funding will be obtained, the students' participation in the AMOCEAB program will be subject to the payment of fees.
- Specific **boards** will be defined for all administrative and scientific managements. In particular, beside the *Coordinating Institution* that will take overall responsibility for the implementation of the Program, one *Executive Board* (EB) will represent the managerial body of the Consortium and will consist of eleven members (Executive Board Members) – one representing each Full Partner and two representing the Coordinating Institution. Furthermore, one *Academic Board* (ACB) including one representative per partner will be appointed by the EB within the first three months of the Program and it will be responsible for proposing to the EB the content of the Master program, ensuring consistency and academic knowledge of the Master program and defining the admission criteria to the Master Course. Administrative staffs will be managed by one Administrative Board (AB), which also will be appointed by the EB within the first three months of the Program and it will include the Principal Coordinator at Università Politecnica delle Marche (Chair person) together with local Administrative Coordinators at each Full Partner Institution. Among issues that the AB will take care of according to the Consortium Agreement, full support to applicants and participants (application procedures, selection and admission, student administration) will be assured.
- Further committees, which will be assessed in order to facilitate the activitiy of mentioned boards, will be appointed and dismissed by the EB for each student intake, and in particular:
    - one *Student Selection Committee* (SSC) will consist of nine members, one representing each Full Partner Institution and two representing the Coordinating Institution. SSC will guarantee the admission process, prepare the call for applications and process the submitted applications.
    - one *Student Counselling Committee* (SCC) will consist of nine members, one representing each Full Partner Institution and two representing the Coordinating Institution. SCC members will be the main student advisors in their respective universities, consulting students in academic and not academic matters. SCC will be in charge to the reallocation of the students into their respective specialization tracks in the third semester; additionally, the SCC will provide career advice to the AMOCEAB students. In general, the SCC will represent the students' interests towards the EB.
- The course examinations will follow the conditions of each Degree Awarding Full Partner Institution where the course is carried out, which will use its grading system defined in national legislation. However, the Consortium will define a conversion system to standardize students' grades following the European Credit Transfer and Accumulation System (ECTS). In this framework, the The Master Thesis will represent a compulsory part of the Program and will have to comply with the requirements of the Program and with the rules of the Degree Awarding Full Partner Institutions. Each Master Thesis will be supervised by at least one supervisor from Degree Awarding Full Partners Institutions and will be graded by an examination committee composed according to national requirements.

- Supporting services for students will represent important tools for helping applicants and participants with orientative, administrative and logistic staffs. All Degree Awarding Full Partner Institutions will support the students participating in the Program in the application for all services offered by them in their own programs, including assistance in obtaining visa, access to appropriate library, ICT and learning facilities, language courses, accommodation, student cards, and other student and administrative support services. The Consortium will issue a Student Handbook to provide further information on such services and the applicable conditions before the enrolment of the first cohort of students.

The Action Plan is embedded within the Network Strategy because it contains the main academic, financial, executive and administrative aspects for the Master realization. The strategic vision of the network and its practical implementation are aligned with the Action Plan according to art. 8 where the main academic structure is reported also referring to the current program organization (art. 8.5) publicly available on the AMOCEAB website (https://amoceab.adrioninterreg.eu/). In this sense, the signatures signify partners' commitment and operationalization both of the strategy and action plan.