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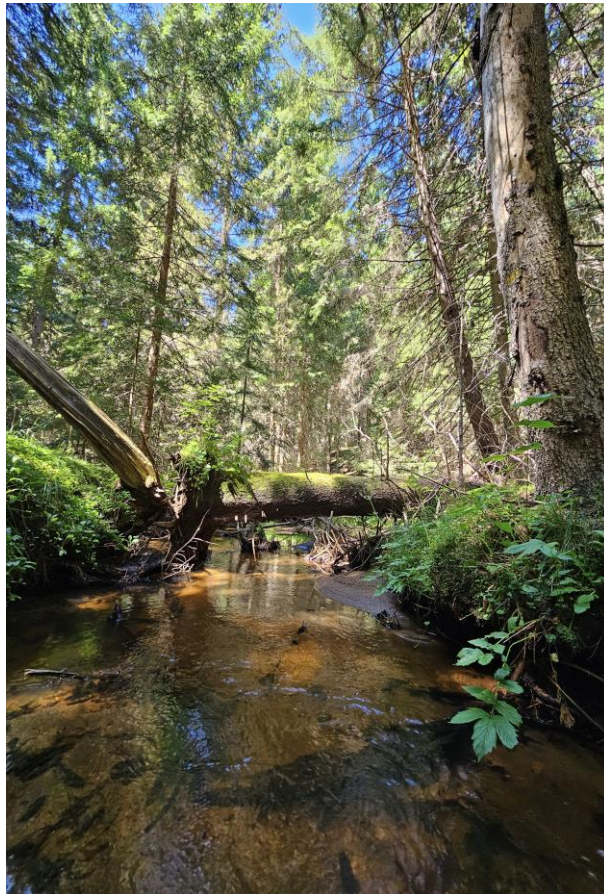
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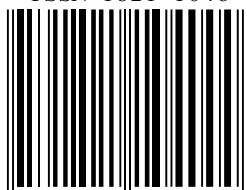
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Original scientific paper

THE IMPORTANCE OF APPLYING THE CIRCULAR BIOECONOMY CONCEPT IN FORESTRY

Ljiljana BRAŠANAC-BOSANAC¹*, Nevena ČULE¹, Ilija ĐORĐEVIĆ¹,
Goran ČEŠLJAR¹, Aleksandar LUČIĆ¹, Predrag ŠUMARAC²,
Tatjana ĆIRKOVIĆ-MITROVIĆ¹

Abstract: *Over the past few years, EU countries have been intensively adopting strategic documents and policies that guide and promote processes towards a circular bioeconomy. One of them is the European Green Deal, which was presented in December 2019. It is a package of policy initiatives, which aims to transform the EU into a fair and prosperous society with a modern, competitive economy based on efficient resource consumption and the protection of the environment and human health. The ultimate goal is to reach climate neutrality by 2050.*

The concept of circular bioeconomy has been recognized as an important strategic concept for the green transition. In this context, the forest-based sector plays a key role in ensuring sustainable and balanced environmental, economic, and social development using bio-based resources. Application of the circular bioeconomy concept requires innovation in forestry. The end result will be healthier ecosystems that consume and waste fewer resources.

However, integrating the concept of circular bioeconomy into forestry is a challenge due to the numerous conflicts and interests in space. In the coming period, innovative methods in the use of forestry biomass should be more actively promoted in Serbia, including circular business models, by increasing the efficiency of scientific, technical and financial support for innovations in this area. The key solution is in the knowledge transfer.

Keywords: circularity, forest-based sector, sustainable development, environmental protection.

ZNAČAJ PRIMENE KONCEPTA CIRKULARNE BIOEKONOMIJE U ŠUMARSTVU

Apstrakt: *Poslednjih godina, zemlje Evropske Unije intenzivno usvajaju strateške dokumente i direktive koje usmeravaju i podstiču procese ka cirkularnoj bioekonomiji. Jedan od njih je i Evropski zeleni dogovor, koji je predstavljen u decembru 2019. godine. Podrazumeva paket političkih inicijativa, sa ciljem transformacije EU u pravedno i prosperitetno društvo sa modernom, konkurentnom ekonomijom zasnovanom na efikasnoj potrošnji resursa i zaštiti životne sredine i zdravlja ljudi. Krajnji cilj je postizanje klimatske neutralnosti do 2050. godine.*

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Koncept cirkularne bioekonomije prepoznat je kao važan strateški koncept za zelenu tranziciju. U ovom kontekstu, sektor šumarstva ima ključnu ulogu u obezbeđivanju održivog i uravnoteženog ekološkog, ekonomskog i društvenog razvoja, korišćenjem bioloških resursa. Primena ovakvog koncepta zahteva inovacije u šumarstvu. Krajnji rezultat biće zdraviji ekosistemi sa niskim nivoom potrošnje resursa i rasipanja.

Treba naglasiti da je zbog mnogih sukoba i interesa u prostoru, uključivanje koncepta cirkularne bioekonomije u šumarstvo izazov. U narednom periodu u Srbiji bi trebalo aktivnije promovisati inovativne metode u korišćenju biomase iz šumarstva, uključujući i korišćenje cirkularnih poslovnih modela, povećanjem efikasnosti naučne, tehničke i finansijske podrške inovacijama u ovoj oblasti. Ključno rešenje je u transferu znanja.

Ključne reči: cirkularnost, sektor šumarstva, održivi razvoj, zaštita životne sredine.

1. INTRODUCTION

The bioeconomy is part of the green economy and can be defined in many ways, with different interpretations of the concept. Some countries around the world have a dedicated bioeconomy strategy or action plan. On the other hand, many countries do not have their strategy but have strategies or action plans that relate to the bioeconomy. Many of them relate to innovation and biotechnology in order to develop new products with added value or improve the productivity of biological resources and bioenergy. The role of forests and the forest sector is not always clearly recognized in the bioeconomy strategies or related strategies and action plans. However, forests and the forestry sector are important components of a sustainable circular bioeconomy. The production and consumption of wood-based materials and wood-based products is increasing. New products and technologies are emerging that aim to increase the added value of wood products, reduce the carbon and water footprint of products and processes, reduce pollution and waste generation and improve the circular economy.

While forest products can provide benefits compared to the use of non-renewable, greenhouse gas-intensive materials, there are also potential risks associated with the increased production and consumption of forest products. The production and extraction of raw materials needed to manufacture products has economic, social and environmental impacts.

Considering that the circular bioeconomy is focused on reducing the consumption of natural resources and the reuse of waste generated during the production cycle, this concept can provide an important guide for the development of a policy framework to promote innovation and investment in new technologies that reconcile the role of forests as a carbon sink. The increasing use of forest products raises concerns about increasing pressure on forests and forest-dependent populations, which could lead to forest degradation and ultimately to biodiversity loss and a reduction in carbon stocks and storage if unsustainable practices are adopted.

Sustainable, climate-smart forest management is needed to support biodiversity and other ecosystem services.

2. MATERIAL AND METHODS

The problem-oriented approach to the importance of the circular bioeconomy concept for sustainable development and the quality of the environment involved the use of numerous analytical tools to clearly identify opportunities, limitations and possible conflicts and to define measures to resolve them.

It is clear that we are facing strong negative impacts of climate change, which bring a new set of challenges. These challenges cannot be tackled independently in one area or sector (e.g. economy, industry, forestry, agriculture, environmental protection, etc.). The study was performed using the analysis method with descriptive, integral and participatory approaches. The importance of a circular bioeconomy, legislation, and approach to this problem is related to identifying the set of indicators suitable to monitor the performance of the forest-based sector by applying the analysis method with a descriptive approach.

The application of an integral approach meant the analyses of current laws, regulations, guidelines and recommendations on sustainable development and climate change adaptation as defined by various international, EU and national institutions. The introduction of new indicators and harmonization with European frameworks, policies and planning practices at all levels of decision-making was also applied.

Complex conditions and a multitude of conflicting interests and factors characterize forestry. To gain a deeper insight and assess the feasibility of the planned solutions, we therefore had to apply a participatory approach. This approach was achieved by analysing the legal and planning provisions on different aspects and sectors of forestry at the national level.

Different scientific methods were applied in the study following the needs and objectives of the research. Concerning specific scientific methods, the analytical method was used (Miljević, 2007) to study strategic and legislative frameworks of circular bioeconomy. To study the content of documents, content analysis was applied as a kind of partial analysis (Milosavljević & Radosavljević, 2008). Some authors (Bulmer, 1977; Neumann, 2014) classify content analysis into a group of nonreactive methods since it does not involve direct collection of data from the research subjects. This research also included review analysis (Wunder et al., 2008; Keča & Marković, 2019) of the elements in the field of circular bioeconomy.

The results and discussion presented in the paper are based on different international declarations, legal regulations and acts. The conclusions were based on collected literature data and knowledge transfer of researchers engaged in the CEE2ACT project.

3. RESULTS AND DISCUSSION

3.1. Meaning of the circular bioeconomy concept

The 2030 Agenda for Sustainable Development (UN, 2015), which includes a set of 17 Sustainable Development Goals supported by 169 targets, ranging from 5 to 12 targets per goal, was adopted by the international political community in September 2015. According to Miola and Schiltz (2019), the Goals

emphasize the integration of the three pillars of sustainability - environmental, economic, social and the harmonious relationship between humanity and nature.

Developed countries of the European Union understand the circular bioeconomy as the economy that uses renewable biological resources to sustainably produce food, bio-based materials, feed, products, fuels and bioenergy, and in which waste products are kept within the system. Their policies of development and Strategies of Bioeconomy are focused on the sustainable conversion of biomass and bio-based resources into marketable products and place biomass production and processing in a single system while underscoring the role of technology in biological resources to create added value and encourage new business models. The legislative of EU countries recognized the importance of circular bioeconomy as a new techno-socio-economic paradigm of production and consumption. In Figure 1, a concept of circular bioeconomy is shown.

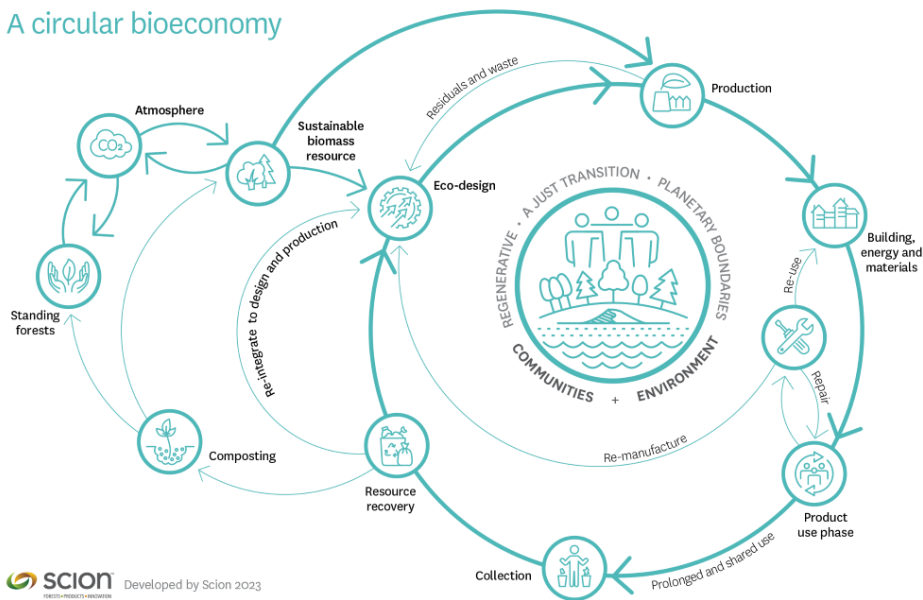


Figure 1. A circular bioeconomy concept

Source: SCION (<https://www.scionresearch.com/about-us/the-forest-industry-and-bioeconomy/the-circular-bioeconomy>)

According to D'Amato et al. (2019), the bioeconomy concept emphasizes the importance of technological innovations to complement or substitute non-renewable resources with bio-based alternatives. The circular bioeconomy is characterized by shifting from a fossil fuel-based economy to one based on renewable resources and then improving resource use efficiency and recovering/recycling waste generated in the production cycle.

The literature review concludes that the key principle of the circular bioeconomy is the 4Rs framework (Reduce, Reuse, Recycle, Recover), in which the hierarchy between the Rs is a fundamental aspect. The first R (Reduce) is considered to take precedence over the second R (Reuse) and so on. This hierarchical

relationship is closely linked to the “cascade” principle”, which envisages the use of raw materials according to a priority based on potential added value (Ciccarese et al., 2014; Proskurina et al., 2016; Paletto et al., 2019).

3.2. The intersection of the circular bioeconomy with forestry

Forests are a renewable resource, providing wood, non-timber products and many ecosystem goods and services (Deng et al., 2024). Beyond timber, forests provide various ecosystem services such as biodiversity conservation, climate regulation, water regulation and flood protection, soil protection and nutrient supply, pest control and pollination, etc. (Figure 2).

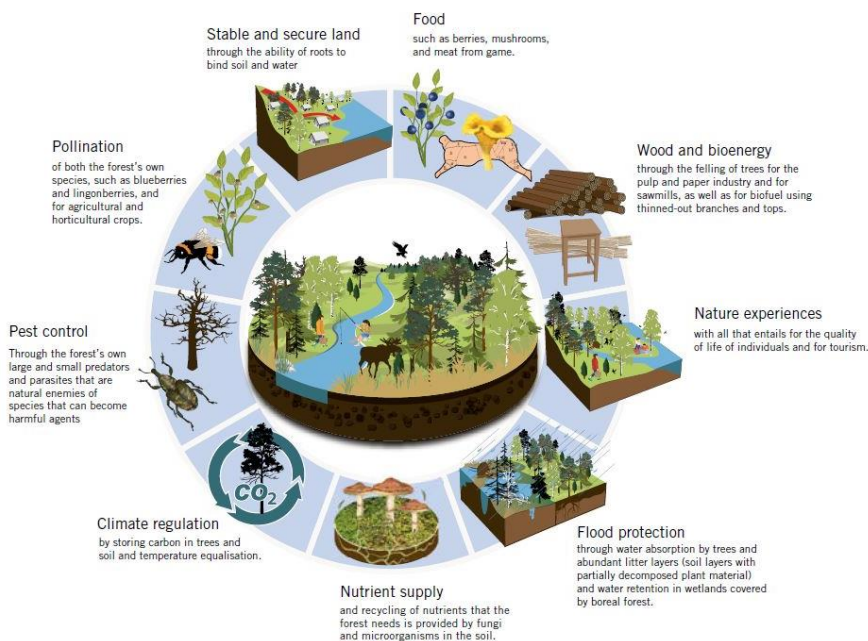


Figure 2. Examples of ecosystem goods and services provided by forests

Source: <https://forestbiofacts.com/introduction-to-forest-based-bioeconomy/the-forest-sector-and-the-idea-of-circular-bioeconomy/>

The **forest-based sector** is one of the most important sectors for developing a bioeconomy. It has a fundamental role in the pursuit of the following choices and objectives (Bracco et al., 2019; Linser & Leier, 2020):

- ✓ the sustainable management of natural resources and the supply of ecosystem goods and services useful for human well-being;
- ✓ enables sustainable patterns of production and consumption because wood is a renewable resource, a versatile raw material used to produce high added value products;
- ✓ improving the efficient use of resources;
- ✓ reduce waste production and promote secondary raw material market;
- ✓ boost sustainable farming and forestry throughout the production and supply chain.

The circular bioeconomy and forestry intersect through their shared sustainability goals, resource efficiency, and climate action. If we look back and analyse the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007), we can see that even then, the importance of a sustainable forest management strategy for mitigating CO₂ emissions was highlighted, and the IPCC strategy aims to conserve forest carbon stocks while achieving a sustainable annual yield of fibre for energy and material extraction. Circular bioeconomy strategies promote the same goal - „Sustainable forest management practices that maintain forests' ecological, economic, and social functions” (Toppinen et al., 2020). This includes selective logging, afforestation, reforestation and revegetation, and promoting biodiversity to ensure forests serve as carbon sinks and habitats while supplying raw materials. The circular bioeconomy emphasizes protecting and enhancing these services by adopting practices that maintain or restore natural ecosystems, ensuring long-term sustainability. Also, it promotes forest practices that prioritise biodiversity, such as mixed species planting and reducing monocultures (Piplani & Smith-Hall, 2021). This makes forests more resilient to pests, diseases, and climate change and enhances their ecological function.

Biomass helps diversify Europe’s energy supply, create growth and jobs, and lower GHG emissions (Jarre et al., 2020). For example, high-quality wood can be used for construction, and lower-grade materials can be used for paper, bioenergy, or bio-based products. Maximising the value extracted from each part of the tree reduces waste and improves resource efficiency. Residues, such as branches, bark, and sawdust, are transformed into valuable products like bioenergy (e.g., pellets), biochemicals, or bioplastics, contributing to a closed-loop system that minimises environmental impact (Arâmburu et al., 2022).

Forests are also crucial to achieving carbon neutrality as they can sequester carbon from the atmosphere (Nunes et al., 2020). They store carbon and support the circular economy by being renewable, recyclable and energy efficient, but they also contribute to climate change mitigation by reducing CO₂ levels in the atmosphere. In addition, forests provide raw materials for innovative bioproducts such as bioplastics, biofuels and biochemicals that replace fossil materials.

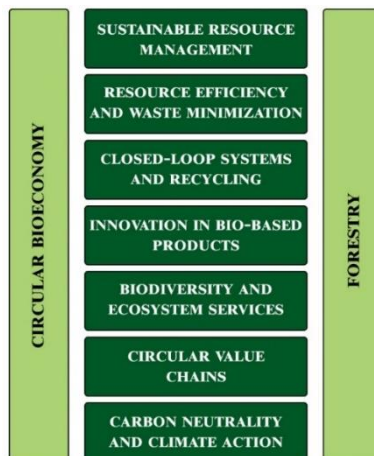


Figure 3. *The intersection of the circular bioeconomy with forestry*

According to the latest available data from the European Commission (Joint Research Centre, Biomass flows), the total biomass supply in 2022 in EU27 added up to 1 billion tons of dry matter. The forestry sector is a producer of 31% biomass. Around 60% of the biomass in the EU is used for food and feed, with 24% of identified biomass used for energy and 16% for biomaterials (Gurria et al., 2022).

The wood industry in Serbia, which relies heavily on forestry, presents substantial potential for circular bioeconomy practices. By maximising the efficient use of raw materials throughout all processing stages, waste can be reduced and value increased across the supply chain. The forest-based sector is recognised in Serbia's Industrial Policy Strategy for 2021-2030 (Official Gazette, 2022) as having great potential for circular economy integration.

4. CONCLUSION

The circular bioeconomy helps transform forestry into a key contributor to a more sustainable and resilient economy by promoting sustainable forest management, waste minimization, closed-loop systems, and bio-based innovation. The circular bioeconomy concept is developed on the principle: „We borrow from nature and give new products back by creating a closed-loop system in which there is no waste”. Promotes the cascading use of forest biomass, where wood and its by-products are used through multiple stages of value creation.

Applying the circular bioeconomy principles to forestry aims to create circular value chains where materials are reduced, reused, recycled and recovered at the end of their life cycles. This reduces pressure on forests by minimising the need for continuous extraction of raw materials, thus creating more sustainable forestry-based industries. Additionally, by promoting the local processing of forest products, the circular bioeconomy strengthens regional economies, reduces transportation emissions, and fosters more sustainable use of local forest resources. Local communities also benefit through job creation and the development of sustainable forestry practices.

By integrating circular bioeconomy practices such as recycling, renewable energy use, and forest regeneration, forestry can play a key role in mitigating climate change. Sustainable forest management can enhance the carbon sink capacity of forests, while bio-based products offer alternatives to fossil-based ones, reducing overall greenhouse gas emissions. Biomass from forestry belongs to solid biomass, which includes firewood, plant mass of fast-growing plants, branches, wood waste from forests, sawdust, bark, and wood residue from the wood-processing industry.

The forest-based bioeconomy contributes to climate change mitigation in different ways: through the carbon stored in forests and the carbon stored in products made from wood and by using wood to substitute fossil fuels and other, more carbon-intensive materials. Forests and harvested wood products currently sequester the equivalent of circa 10% of the EU's greenhouse gas emissions. However, the carbon sink of forests is declining due to many factors. Reversing this trend requires sustainable forest management practices and afforestation. A shift towards greater use of wood products with longer service lives and substitution benefits can also increase the benefit of climate change mitigation. A “system-perspective” analysis

helps to understand the trade-offs and synergies amongst the different options and optimise the contribution of the forest-based bioeconomy to Europe's climate goals.

To apply the circular bioeconomy concept in forestry, it is necessary to:

- ✓ rethinking forestry development orientations;
- ✓ taking advantage of innovative technological solutions;
- ✓ economic support;
- ✓ strengthening political and institutional support;
- ✓ ensuring policy coherence across objectives, instruments and practices and
- ✓ involving relevant stakeholders in forest policy design processes.

Circular bioeconomy principles align with forestry in promoting practices that reduce emissions across the entire value chain, from sustainable harvesting to producing low-carbon bio-based products. Applying the principles of the circular bioeconomy in forestry promotes competitiveness, innovation, and protection of the environment and space while contributing to economic growth. It has the potential to create many new jobs while conserving valuable and increasingly scarce natural resources and adding new value to waste materials.

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THE IMPORTANCE OF APPLYING THE CIRCULAR BIOECONOMY CONCEPT IN FORESTRY

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Goran ČEŠLJAR, Aleksandar LUČIĆ, Predrag ŠUMARAC,
Tatjana ĆIRKOVIĆ-MITROVIĆ*

Summary

The circular bioeconomy is a complex and dynamic system which requires new strategies and tools to steer and govern this complex system towards the desired outcomes. The importance of applying a circular bioeconomy concept is in the potential to contribute to climate change mitigation, socio-economic development and environmental protection by maintaining the value of bio-based products, materials and resources in the economy for as long as possible. Applying the principles of the circular bioeconomy in the economy prioritizes the use of renewable biological resources in bio-based materials, feed, products, fuels and bioenergy, keeping waste products in the system and transforming them into value-added products. Dissemination of examples of good practices from EU countries, profitable business successes and innovative business models can be a valuable tool for attracting the attention of small and medium-sized enterprises and entrepreneurs in Serbia to the circular bioeconomy, especially in the forestry sector.

ZNAČAJ PRIMENE KONCEPTA CIRKULARNE BIOEKONOMIJE U ŠUMARSTVU

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Rezime

Cirkularna bioekonomija je složen i dinamičan sistem koji zahteva nove strategije, mape puta i alate za usmeravanje i upravljanje ovim složenim sistemom ka željenim ishodima. Važnost primene koncepta cirkularne bioekonomije je u potencijalu da doprinese ublažavanju klimatskih promena, društveno-ekonomskom razvoju i zaštiti životne sredine, održavanjem vrednosti proizvoda, materijala i resursa na bazi biomase u privredi dugo vremena. Primena principa cirkularne bioekonomije u privredi daje prioritet korišćenju obnovljivih bioloških resursa u bio-materijalima, stočnoj hrani, proizvodima, gorivima i bioenergiji, zadržavanju otpadnih proizvoda u sistemu i pretvaranju u proizvode sa dodatom vrednošću. Širenje primera dobre prakse iz zemalja EU, profitabilnih poslovnih uspeha i inovativnih poslovnih modela može biti koristan alat za privlačenje pažnje malih i srednjih preduzeća i preduzetnika u Srbiji na cirkularnu bioekonomiju, posebno u sektoru šumarstva.

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