Circular economy business models as sustainable solutions for forestry biomass recovery in the Baltic Sea Region

P. Marcinek[1], J. Osiadacz[1], D. Włóka[2], M. Smol[1]

[1]Division of Biogenic Raw Materials, Mineral and Energy Economy Research Institute, Polish Academy of Sciences, Cracow, 31-261, Poland
[2]GreenBack Ltd., Katowice, 40-600, Poland
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Presenting author email: marcinek@meeri.pl

The Baltic Sea Region (BSR) contains substantial quantities of underutilised forestry biomass residues, including bark, needles, cones, and other organic materials (Muizniece and Blumberga 2015). While these resources are widely available, their utilisation varies considerably among countries in the region, reflecting differences in technological advancement and development stages. In many cases, these residues are predominantly employed in lower-value applications, such as bioenergy production (Rytter et al. 2016). Nevertheless, they hold significant potential for the extraction of high-value compounds with diverse industrial applications.

The key challenge lies in transitioning from conventional, low-value applications to innovative approaches that fully harness the potential of these resources, thereby promoting a more sustainable and circular economy (CE) (Kacprzak 2023). The project "Innovation in Forestry Biomass Residue Processing: Towards Circular Forestry with Added-Value Products" (acronym: CEforestry) seeks to address this issue by developing and implementing novel CE concepts, converting forestry side streams into high-value products, and enhancing cross-sector collaboration within the BSR. The CEforestry project primarily aims to develop and implement innovative practices and CE concepts within the forestry sector to enhance the utilisation of biomass side streams in the BSR. This objective will be accomplished by fostering collaboration among various stakeholders, including researchers, small and medium-sized enterprises (SMEs), large corporations, and other relevant actors. The project will showcase the practical implementation of these solutions through pilot facilities. Additionally, a key goal is to design CE business models (BMs) specifically tailored to the recovery and utilisation of forestry biomass residues. These models will serve as long-term strategic frameworks, outlining how enterprises can secure financing, establish objectives, and optimise resource efficiency.

During the project, four CE BMs were developed. The first focuses on extracting antibacterial compounds for use in wastewater treatment and the paper industry. The second explores the use of natural antibacterial extracts as food preservatives, extending shelf life while ensuring safety. The third model proposes the development of plant-based meat alternatives through fermentation, addressing the growing demand for vegetarian products. The fourth model utilises antibacterial extracts in cosmetic production, offering a sustainable and natural alternative to synthetic agents, aligning with consumer preferences for eco-friendly products.

This paper focuses on the second business model that has been developed: antibacterial extracts for the food industry (food preservatives). The developed product is a natural biocide extracted from fresh spruce needles, intended for industrial use in the food and feed manufacturing sectors.

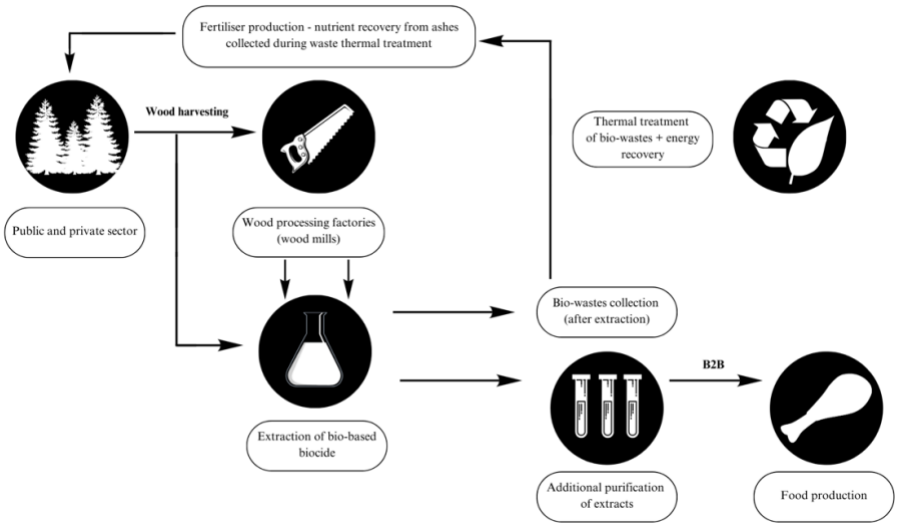

Figure 1. Process flow

By utilising the antibacterial properties of shikimic acid and polyphenols found in spruce needles, it serves as a sustainable and environmentally friendly alternative to conventional synthetic biocides commonly employed in these industries. Shikimic acid has demonstrated potential as a multifunctional antimicrobial agent, effectively inhibiting the growth of various bacteria, fungi, and viruses. Its distinctive mode of action, broad-spectrum effectiveness, and potential for synergistic applications make it a valuable focus of research and practical implementation in medicine, agriculture, and food safety.

The analysis BM for a forest side-stream product was developed and presented using the Business Model Canvas (BMC) framework. This strategic management tool enables entrepreneurs and business owners to visualise, create, refine, and adapt their BMs. Designed by Alex Osterwalder (Osterwalder, Pigneur, and Tucci 2005), the BMC comprises nine essential building blocks that outline the core aspects of a business (Islam and Iyer-Raniga 2023).

The project aims to successfully demonstrate and validate these business models, providing practical recommendations to facilitate the wider adoption of circular CE practices in forestry. These guidelines will align with the objectives of the European Union (EU) Green Deal (Smol et al. 2020), the EU CE strategy, and the BSR bioeconomy strategy. By maximising the utilisation of forestry biomass residues, the initiative supports a more sustainable and circular forest economy, benefiting businesses while fostering the development of high-value, eco-friendly products.

Ultimately, CEforestry marks a significant step toward integrating CE principles into forestry by transforming underutilised biomass residues into valuable resources. Through innovative collaboration and practical implementation, the project seeks to strengthen sustainability, economic resilience, and environmental responsibility across the BSR.

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