EUROPEAN PROGRAMS AND GREECE'S FOREST BIO-ECONOMY: REVIEW AND RESEARCH GAP IDENTIFICATION AND METHODOLOGY APPROACH

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Abstract
This paper explores the ongoing debate surrounding the forest bioeconomy and its potential to transform national economies, with a particular focus on Europe's strategic policies and financial tools. In light of the recent report on the progress made in implementing the European Bioeconomy Strategy, this study aims to explore how Europe's renewable organic resources, specifically those derived from forests, can be utilized more sustainably to mitigate the impacts of climate change and address environmental pressures (European Commission, 2011). While significant efforts have been made to monitor and measure forest bioeconomy development across Europe, existing literature reveals a lack of standardized methodologies for assessing its impact across EU member states, making cross-country comparisons challenging. Moreover, there is no consensus on the definition or scope of the forest bioeconomy, further complicating the evaluation of financial support and its effectiveness across different forest bioeconomy sectors, such as sustainable forestry, biomass production, and forest-based industries (Lovrić et al., 2020; Kardung et al., 2020; Rinn et al., 2022).

The objective of this study is to address this gap by evaluating the impact of European funding and expertise on Greece's forest bioeconomy. Specifically, the study will develop an evaluation model to measure the economic benefits derived from European funding, such as co-financed programs and research projects, and analyze their contribution to regional development and sustainability outcomes in Greece's forest bioeconomy.

Keywords*: Forest Bioeconomy, European Programs, Sustainability, Bioeconomy Policies, Greece*

Introduction

The bioeconomy has seen rapid growth in recent years, driven by the need for sustainable resource management and climate change mitigation. It focuses on producing and transforming renewable biological resources into food, animal feed, bio-based products, and bioenergy (Trydeman et al., 2015). Through circular and sustainable models, the bioeconomy can address global challenges like climate change, soil erosion, and increasing demand for food and energy (European Network for European Development, 2019). Additionally, it contributes to economic development and job creation, particularly in rural areas, while promoting environmental sustainability.

The 2018 revision of the European Bioeconomy Strategy emphasizes the importance of financing mechanisms to support bio-based industries. However, research on the role of

European funding programs in forest bioeconomy policy implementation remains limited. Studies such as those by Thöle et al. (2021), Albrecht et al. (2021), and Lovrić et al. (2020) have explored regional bioeconomy financing, yet there is a lack of comprehensive analysis on Greece's forest bioeconomy.

This study aims to assess the impact of European funding on Greece's forest bioeconomy by developing an evaluation model that measures economic and regional benefits. Given Greece's historically low bioeconomy development (Haarich, 2017) but strong interest in its expansion (Silaidi, 2018), understanding the role of EU programs is essential for shaping future policy strategies and setting priorities for sustainable development.

Theoretical Background

Conceptual Approach to the Bioeconomy

The bioeconomy is a broad concept with multiple definitions depending on the context (Mittra & Zoukas, 2020). Initially coined by Enriquez and Martinez in 1997, it refers to economic activities derived from scientific research on biological mechanisms applied in industry (Martinez, 1998). The European Commission (2012) defines the bioeconomy as the economy based on renewable biological resources and their transformation into food, feed, materials, and energy. This broad definition allows for multiple interpretations and strategic approaches. Bugge et al. (2016) identify three main bioeconomy models:

1. **Biotechnology-driven** – Focuses on research commercialization and technological applications, with a strong emphasis on genetic engineering, synthetic biology, and industrial bioprocesses (Philp, 2017).
2. **Bio-resource-based** – Aims to balance economic expansion with environmental sustainability by optimizing resource use, enhancing agricultural productivity, and promoting the use of underutilized land for biofuel crops (Luana & Blind, 2017).
3. **Bio-ecology-oriented** – Prioritizes biodiversity, circular economy principles, and sustainable resource management by emphasizing ecosystem protection, reducing soil degradation, and maximizing organic waste recycling (Hausknost et al., 2017).

These models influence policy and investment decisions worldwide, as nations develop bioeconomy strategies tailored to their economic, environmental, and technological contexts.

Bioeconomy as a Policy Project

The bioeconomy has been central to EU policy since the 1993 White Paper, which emphasized investment in biotechnology for economic growth. The concept gained prominence with OECD reports (2001, 2009) and the European Commission's strategies, including "Bioeconomy for Europe 2020" and the 2012 Bioeconomy Strategy, which integrated sustainability and circular economy principles. The 2018 revision expanded the definition to encompass all sectors using biological resources, highlighting innovation and the role of digitalization in bio-based industries (EC, 2018).

Bioeconomy Policies in Europe

Since 2007, EU policies have actively promoted the bioeconomy as a driver of sustainable development. Germany pioneered national bioeconomy strategies in 2010, followed by Finland in 2014. By 2015, several EU member states had adopted bioeconomy policies, aligning them with green growth and circular economy principles (Global Bioeconomy Policy Report, 2020). The integration of bioeconomy policies with other EU frameworks, such as the

Green Deal and Farm to Fork Strategy, underscores the shift toward sustainable resource use and climate resilience.

The Bioeconomy in Greece

Despite its relatively low ranking in bioeconomy development compared to other EU member states (Haarich, 2017), Greece possesses significant potential for bioeconomy expansion (Silaidi, 2018). The sector generates €27 billion in turnover and employs approximately 500,000 workers, with agriculture accounting for 80% of bioeconomy activities (Karagouni, 2017). Although Greece lacks a dedicated national bioeconomy strategy, several policies support biological resource management, including:

1. **Common Agricultural Policy Strategic Plan (2023-2027)** – Promotes sustainable agriculture and bio-based innovations.
2. **National Climate Change Adaptation Strategy** – Encourages the sustainable use of biological resources to mitigate climate change.
3. **National Smart Specialization Strategy (RIS 2021-2027)** – Focuses on regional innovation in bio-based industries.
4. **National Development Strategy (2021)** – Identifies the agro-food sector as a priority for economic growth.

Forests and the Bioeconomy

Forests play a crucial role in the bioeconomy by providing raw materials, supporting biodiversity, and offering ecosystem services. The European Green Deal promotes forest resilience within the circular bioeconomy framework, emphasizing the transition to bio-based products and sustainable forestry practices. Non-timber forest products (e.g., medicinal plants, mushrooms) are valued at €23 billion annually in the EU, yet Greece lacks systematic data collection and policy integration for these resources (Lovrić et al., 2020). Sustainable forest management is critical for maximizing the economic and ecological benefits of forest-based bioeconomy activities.

Biomass and Sustainability Indicators

Biomass plays a pivotal role in bioeconomy development, as it serves as a renewable energy source and a raw material for bio-based industries (Lewandowski, 2015). Biomass sources include forestry and agricultural residues, organic waste, and algae-based materials. Assessing the sustainability of biomass production requires evaluating key indicators such as resource efficiency, pollution reduction, and socio-economic impacts (Fritsche et al., 2018).
Two primary approaches to sustainability in the bioeconomy include:

- **Weak sustainability** – Maintains a market-driven perspective, allowing economic growth while implementing compensatory environmental measures (Hoffman, 2012).
- **Strong sustainability** – Imposes strict ecological constraints, ensuring that natural resource use does not exceed regenerative capacities (Bennich & Belyazid, 2017).

Understanding these frameworks is essential for evaluating bioeconomy policies and shaping Greece's transition to a sustainable bioeconomy model. A holistic approach to bioeconomy policy must integrate economic, environmental, and technological factors while ensuring long-term ecological balance.

Monitoring and Evaluation of the forest bio-economy

Tracking bioeconomy transitions and their impacts can be seen as a Herculean task, as they cannot be easily captured using current economic statistics. Organic and non-organic products

are rarely distinguished when official data are collected. However, production along bioeconomy supply chains and its impacts on sustainability require measurement and evaluation to enable informed policy making. (Jander, 2020).

For example, the BioMonitor project (2022) attempts to address the information gap in bioeconomy research by reframing the existing data and modeling framework. The study Kutay (2021): A Cross-Country Measurement of the EU Bioeconomy: An Input–Output Approach, within the Biomonitor project, manages to measure the added value of the bioeconomy that is not immediately apparent but rather hidden in other industries in part bioeconomy. The information platform created within the project provides a measure of the share of the bioeconomy for the EU-28 countries for the period 2005–2015 based on input-output tables.

In the study by Lovrić, et al. (2020), an attempt was made to form an overview of the European forest-based bioeconomy research field by mapping the actual research activity in the field, based on projects from the EU Framework Programs and the European Research Area, supplemented with data on self-reported research abilities. Projects included in the CORDIS database were used as the main data source for mapping research activity in the field of forest-based bioeconomy. The analysis is limited to the period 2008–2018, where the projects listed fall under FP7, H2020 and the European Research Area Work Program (ERA-NETs). The study assesses the coherence and synergies of public research and innovation programs and maps research activity across industries and sectors in order to help improve the existing knowledge base, while making two clear policy recommendations: the need for stronger involvement of research organizations from countries of Eastern Europe to the international scientific community in the field of forest-based bioeconomy, emphasizing a geographical coverage criterion in future research and innovation planning and the design of research and innovation calls for projects that thematically cover multiple forest-based bioeconomy supply chain categories.

In the recent study by Rinn, et al. (2022), a comparative analysis of forest bioeconomies and our understanding of them in selected countries is carried out, and the level of comprehensive data on projects supported by the RDP 2014–2020 is assessed. This analysis showed that the perception and definition of the forest bioeconomy varies from country to country. That is why it is not possible to compare the level of financial support of the forest bioeconomy between countries. It is also not possible to use it as a single and comparable indicator to measure sustainability.

The study by Lovric, et al. (2021) provide an insight into the future of the forest-based bioeconomy sector in selected countries in South-Eastern Europe. It elicits forest-based bioeconomy experts' understanding, opinion and level of agreement on the future implementation of the bioeconomy concept by 2030/2050, through two rounds of the Delphi method. The study contributes to a better understanding of regional contexts related to forest-based bioeconomy status and further development, while demonstrating that regional and national priorities in forest-based bioeconomy should be set in regional, national and sub-national strategic documents (Winkel, 2017), to further support the implementation of the concept.

Research Objective

Over the past twenty years, EU policymakers have prioritized the expansion of organic value chains through various EU policy initiatives and research programs. Despite the growing popularity of the bioeconomy in Europe, its research and statistics lag in several ways, such as the lack of a comprehensive database and statistics for bio-based industries, the lack of a transparent methodology for bio-based data collection, and the lack of comprehensive data

and value chain indicators depicting the processing system flows of different biological materials (Kardung et al., 2019).

Despite efforts to monitor the EU's bioeconomy and individual national bioeconomies, there is still no common approach to monitoring and measuring the bioeconomy across EU states, making cross-country comparisons difficult. Furthermore, according to Kardung (2020), there is a pressing need for methodological improvements in monitoring and measuring bioeconomy-based production models.

In particular, Greece currently lacks a targeted National Strategy for the bioeconomy, despite the high priority assigned by the Greek government to resource efficiency, energy efficiency, and low-carbon investments (Papadopoulou, 2018). While the importance of the bioeconomy is widely recognized globally for its economic, social, environmental, and touristic dimensions, in Greece, the bioeconomy model has not yet received the attention it deserves.

From a review of the relevant literature, the following key gaps have been identified:

- **Lack of a comprehensive database**: Despite increasing policy interest, the absence of structured, evidence-based monitoring systems for bioeconomy sectors hinders effective policymaking and adaptation (Ronzon, 2021).
- **Absence of a transparent methodology for data collection**: While agriculture and forestry sectors are always included in bioeconomy monitoring, other sectors, such as the chemical industry, are only partially accounted for in most international monitoring frameworks, resulting in inconsistencies in data collection and interpretation (Jander, 2020).

Additionally, as the concept of bioeconomy evolves, it becomes increasingly necessary to integrate various interdisciplinary approaches that combine economic, environmental, and technological perspectives. A successful bioeconomy model relies not only on the sustainable use of biological resources but also on innovative processing techniques, digitalization, and market-oriented solutions. The role of digital tools, artificial intelligence, and blockchain technology in monitoring and improving supply chain traceability is becoming more prominent, highlighting the need for more advanced methods in data collection and analysis.

Furthermore, policy fragmentation remains a key challenge. While several EU member states have developed targeted bioeconomy strategies, Greece still lacks a coherent national policy framework dedicated to bioeconomy implementation. This creates inconsistencies in the allocation of resources, regulatory frameworks, and investment strategies. A critical aspect of this research will be to assess the effectiveness of existing policy instruments in supporting the forest bioeconomy in Greece, identifying both best practices and bottlenecks that hinder progress.

The primary objective of this research is to create a comprehensive database consolidating all funding sources that have supported forest bioeconomy initiatives in Greece—whether in research, business support, or project development. The goal is to evaluate the impact of these funding mechanisms and the expertise they provide on the forest bioeconomy sector in Greece through the development of an evaluation model. This model will assess the economic benefits derived from these support mechanisms and their contribution to regional development.

Through this research, a better understanding of the bioeconomy’s role in achieving sustainability goals will be established, ensuring that Greece can harness its rich natural resources effectively while balancing ecological conservation with economic growth. The study will also explore how Greece can align its national bioeconomy strategies with broader EU objectives to attract more funding, stimulate innovation, and enhance the competitiveness of its forest-based industries in the global market.

This study aims to examine the role of European programs in the implementation of bioeconomy policies in the forestry sector in Greece. It seeks to identify the main challenges and constraints that hinder the effective application of these policies in Greek forests. Furthermore, it explores how bioeconomy policies can be better integrated into forest management practices to enhance sustainability and economic growth. A key focus is assessing the impact of European programs on local economies and environmental sustainability through the promotion of forest bioeconomy initiatives. Additionally, the study aims to develop proposals and best practices that can optimize the use of European resources in advancing Greece's forest bioeconomy.

This research provides a unique contribution by focusing on the application of bioeconomy policies in the forestry sector, an area of significant importance that remains underexplored in Greece. While the bioeconomy has gained traction across Europe, limited research has been conducted on how these policies are effectively implemented in Greek forests and the extent to which they contribute to sustainable resource management and regional development.

A key aspect of this dissertation is its in-depth analysis of European funding mechanisms, including Horizon Europe, the LIFE Programme, the European Agricultural Fund for Rural Development (EAFRD), Interreg Europe, and the Bio-Based Industries Joint Undertaking (BBI JU). By assessing the role of these programs, the study aims to identify both the opportunities and barriers associated with financing the forest bioeconomy in Greece. Furthermore, it examines how EU-funded initiatives align with national and regional priorities, ensuring that bioeconomy strategies are effectively integrated into forestry management and economic planning.

To provide a comprehensive assessment, the research employs an innovative mixed-method approach that combines qualitative and quantitative methodologies. This includes stakeholder interviews, case study analysis, policy evaluation, and statistical modeling to measure the economic, environmental, and social impacts of bioeconomy policies. By incorporating diverse analytical techniques, the study ensures a holistic understanding of how EU programs influence the forest bioeconomy and their potential to drive sustainable development.

Beyond policy evaluation, this dissertation seeks to develop actionable recommendations that address Greece's specific challenges in implementing bioeconomy initiatives. The findings will support the design of tailored policy proposals that enhance the effectiveness of bioeconomy programs, promote investment in forest-based industries, and encourage the adoption of sustainable practices. These recommendations will be grounded in empirical evidence, making them valuable for policymakers, industry stakeholders, and researchers seeking to strengthen Greece's bioeconomy framework.

Ultimately, this research aims to contribute significantly to both scientific knowledge and policy discourse on the forest bioeconomy in Greece. By shedding light on the role of European funding in fostering sustainable forest management, it provides insights that can inform future bioeconomy strategies at the national and EU levels. The study underscores the importance of aligning economic growth with environmental sustainability, ensuring that Greece can fully capitalize on its natural resources while meeting long-term ecological and economic objectives.

Methodology approach

The research employs a mixed-method approach, incorporating both quantitative and qualitative methodologies to ensure a comprehensive analysis of the impact of European

programs on Greece's forest bioeconomy. The methodology is structured into two main components: data collection and data analysis.

Data Collection

To obtain robust and diverse insights, a quantitative survey will be conducted using a structured questionnaire. The survey will target key stakeholders from the quadruple helix model, ensuring representation from multiple sectors that influence and are influenced by the bioeconomy. The target groups include:

1. **Research Community**: This category includes universities, research institutions, and innovation hubs specializing in bioeconomy, forestry, and sustainability. Their input will provide valuable information on technological advancements, research gaps, and knowledge transfer within the sector.
2. **Businesses & Industry Representatives**: Engaging chambers of commerce, trade associations, and forest-based industries will shed light on the role of private investment in the bioeconomy, the commercialization of bio-based products, and the market dynamics shaping the sector.
3. **Public Sector**: Ministries, local and regional authorities will be surveyed to assess policy implementation, regulatory frameworks, funding mechanisms, and governmental support for bioeconomy-related initiatives.
4. **Civil Society**: Non-governmental organizations (NGOs), forest management organizations, and environmental advocacy groups will provide insights into community engagement, sustainability concerns, and the social impact of bioeconomy policies.

In addition to the survey, semi-structured interviews with key informants from these groups will be conducted to gain deeper qualitative insights. This will help capture expert opinions, challenges faced in the implementation of bioeconomy policies, and potential solutions to enhance effectiveness.

Data Analysis

The collected data will be processed using advanced statistical and analytical techniques to ensure meaningful interpretations and actionable conclusions. The analysis will involve:

- **Descriptive Statistical Methods**: Measures such as averages, percentages, and variance analysis will be employed to summarize the data and identify key trends in funding allocation, policy implementation, and stakeholder participation.
- **Trend Analysis**: Historical data and survey responses will be analyzed to examine changes in bioeconomy-related indicators over time, such as investment trends, technological advancements, forest area utilization, and sustainability practices.
- **Comparative Analysis**: The study will compare Greece's bioeconomy development with other EU countries, identifying best practices and areas for improvement.
- **Regression and Correlation Analysis**: These methods will be used to assess the relationships between different variables, such as the impact of EU funding on economic growth, employment rates, and sustainability outcomes.
- **Thematic Content Analysis**: Qualitative data from interviews and open-ended survey responses will be systematically categorized and analyzed to identify recurring themes, stakeholder perceptions, and policy recommendations.

By employing this rigorous methodology, the study aims to provide a detailed assessment of the effectiveness of European programs in shaping Greece's forest bioeconomy. The findings will offer valuable insights for policymakers, researchers, and industry stakeholders,

facilitating evidence-based decision-making and strategic planning for sustainable bioeconomy growth.

Conclusion

The transition to a sustainable society is increasingly challenged by complex factors such as climate change, population growth, rapid urbanization, and widening income disparities. Recognizing the need for a balanced approach, the United Nations affirmed in 2018 that sustainable development must integrate economic progress, social inclusion, and environmental protection. Over the past two decades, EU policymakers have acknowledged the bioeconomy as a crucial driver of sustainability, emphasizing its alignment with the Sustainable Development Goals (Wesseler & von Braun, 2017; Zilberman et al., 2018). This recognition has led to the launch of various policy initiatives and research programs at the EU level, including the European Bio-Based Industries Joint Undertaking, which aims to accelerate the transition to a circular bioeconomy (Wesseler & von Braun, 2017). The recent revision of the European Commission's Bioeconomy Strategy (European Commission, 2018a) further underscores the high priority of bioeconomy policies on the EU's political agenda.

Despite these efforts, quantifications of the bioeconomy have traditionally focused on economic and social aspects, with less emphasis on environmental considerations (European Commission, 2018b). A holistic approach is required to assess the broader implications of bioeconomy activities, particularly regarding their dependency on forest ecosystems. Evaluating the contribution of forest ecosystems to gross domestic product (GDP) demands an in-depth examination that extends beyond the direct economic impact of the forestry sector. This includes an assessment of the indirect and induced effects of forestry-related activities on other industries and their role in broader economic systems.

A resource-based bioeconomy necessitates a comprehensive understanding of available natural resources, their geographic distribution, and their economic potential. Identifying the synergies and trade-offs between forests and other land uses is essential for ensuring sustainable resource management. As Wolfslehner et al. (2019) highlight, a well-defined framework for resource utilization, property rights, and economic valuation is critical for optimizing bioeconomy strategies.

This research contributes to this broader understanding by applying a robust methodological framework to collect and analyze relevant data on Greece's forest bioeconomy. Through the identification of key sustainability indicators, this study aims to provide a comprehensive assessment of the forestry sector's role in the Greek bioeconomy. The findings will offer valuable insights for policymakers, industry stakeholders, and researchers, enabling more informed decisions that support sustainable development, economic resilience, and environmental stewardship. Ultimately, by advancing knowledge in this field, this dissertation seeks to enhance the effectiveness of bioeconomy policies and contribute to the long-term sustainability of Greece's natural and economic resources.

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