Czech University of Life Sciences Prague

Faculty of Forestry and Wood Sciences

Department of Forestry and Wood Economics

Bachelor Thesis

Bioeconomy as a form of innovation

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BACHELOR THESIS ASSIGNMENT

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Forestry

Economics and Management of Forestry

Thesis title

Bioeconomy as a Form of Innovation

Objectives of thesis

The aim of the bachelor thesis will be to identify the potential of forest bioeconomy as an indispensable part of global development.

Methodology

The bachelor thesis will focus on the analysis of the concept of bioeconomy with an emphasis on forest bioeconomy. First, the current state of the forest bioeconomy at the level of the European Union will be described, followed by the identification of obstacles and challenges for further development with regard to economic growth, global change and sustainable development. Subsequently, recommendations and possibilities for further development of forest bioeconomy as a form of innovation will be presented.

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Declaration

I declare that I have worked on my bachelor thesis titled "Bioeconomy as a form of innovation" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on _____

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Bioeconomy as a form of innovation

Abstract

In order to solve complex problems in a variety of industries, including agriculture, forestry, and environmental conservation, bioecology is used as a form of innovation. It emphasizes the value of promoting biodiversity, utilizing renewable resources, and working with nature rather than against it. We can achieve sustainable development while preserving and protecting our natural resources by implementing bioecological approaches. The incorporation of bioecology into a variety of industries has the potential to stimulate innovation, open up fresh avenues for economic expansion, and advance the health and welfare of our planet and its inhabitants.

Keywords: innovation, forestry, forest bioeconomy, European Union, biotechnology, renewable energy, biobased products, climate change, sustainability, circular economy, economic development, policy, biomass

Bioekonomie jako forma inovace

Abstrakt

Za účelem řešení složitých problémů v různých odvětvích, včetně zemědělství, lesnictví a ochrany životního prostředí, se bioekologie používá jako forma inovace. Zdůrazňuje hodnotu podpory biodiverzity, využívání obnovitelných zdrojů a spolupráce s přírodou spíše než proti ní. Implementací bioekologických přístupů můžeme dosáhnout udržitelného rozvoje a zároveň zachovat a chránit naše přírodní zdroje. Začlenění bioekologie do různých odvětví má potenciál stimulovat inovace, otevírat nové cesty pro ekonomický růst a podporovat zdraví a blaho naší planety a jejích obyvatel.

Klíčová slova: inovace, lesnictví, lesní bioekonomika, Evropská unie, biotechnologie, obnovitelná energie, bioprodukty, změna klimatu, udržitelnost, oběhové hospodářství, ekonomický rozvoj, politika, biomasa

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1 Introduction

The concept of bioeconomy has gained increasing attention in recent years as a potential solution to global challenges such as climate change, resource scarcity, and population growth. The sustainable production and use of biological resources, such as those found in crops, forests, fisheries, and microorganisms, for the production of food, energy, and materials is referred to as the bioeconomy. It signifies a change from the conventional economy based on fossil fuels to one that is more sustainable, circular, and dependent on renewable resources. In this sense, the bioeconomy can be viewed as a type of innovation that solves social and environmental problems while opening up new avenues for economic growth.

Bioeconomy has emerged as a key strategy for achieving the United Nations' Sustainable Development Goals (SDGs), which aim to eradicate poverty, protect the planet, and ensure prosperity for all. The bioeconomy has the potential to support many of these objectives by encouraging sustainable patterns of production and consumption, generating new employment opportunities, and lowering greenhouse gas emissions. Additionally, the bioeconomy can help to increase biodiversity, improve food security, and lessen reliance on fossil fuels.

Innovation is the key to the bioeconomy's success. In order to produce and utilize biological resources in a sustainable manner, new technologies, procedures, and products must be developed. Public and private investments in education and training, as well as policy and regulatory frameworks, all contribute to this innovation. To ensure that innovation is socially and environmentally responsible, the bioeconomy requires collaboration between a variety of stakeholders, including the government, industry, academia, and civil society.

The bioeconomy as a form of innovation has the ability to tackle some of the most important environmental and social issues that the human race is currently facing. For instance, sustainable agriculture and forestry can support biodiversity and soil health, while bioenergy and biofuels can reduce greenhouse gas emissions and offer alternative energy sources. Additionally, especially in developing nations, the bioeconomy can open up new possibilities for rural development, job creation, and social inclusion.

However, there are some difficulties in developing and implementing the bioeconomy as a type of innovation, that I describe in this thesis and try to figure out if there are possible solutions for them. Concerns with intellectual property, social and environmental effects, and governance and regulation are a few of these that must be addressed. Additionally, substantial investments in infrastructure, skill development, and research and development are needed to make the transition to a bio-based economy.

2 Bioeconomy concepts in the European Union

The bioeconomy is one of the key industries for long-term growth and job creation, according to the European Union (EU). The production of food, materials, and energy through the sustainable use of renewable resources from the land, forests, oceans, and other biological sources is referred to as the bioeconomy. The traditional economy, which relies on fossil fuels, can be seen as an alternative because fossil resources are limited and their exploitation and use have an adverse effect on the environment.

The EU has created a bioeconomy strategy outlining the vision and objectives for the EU's bioeconomy. The plan acknowledges the bioeconomy's potential for environmental protection, job creation, and sustainable economic growth. Strengthening the body of knowledge, fostering innovation and markets, and implementing the bioeconomy across sectors are the three main areas of action identified by the strategy.

One of the core principles of the bioeconomy is sustainable production. In order to create renewable biological resources, it entails the efficient use of natural resources, such as land, water, and air. The bioeconomy must be able to sustain itself over the long term, which calls for sustainable production methods. In the EU, a number of laws and programs, such as the Common Agricultural Policy (CAP) and the Forest Strategy, support sustainable production.

An additional important pillar of the bioeconomy is sustainable consumption. It entails the creation and adoption of bio-based goods and services that are beneficial to society, the environment, and the economy. The equitable distribution of the benefits of the bioeconomy and the social inclusion of the transition to a more sustainable economy depend on sustainable consumption habits. The Circular Economy Action Plan and the Single Market Strategy, among other policies and programs, support sustainable consumption in the EU.

Sustainable waste management is the third pillar of the bioeconomy. It involves the efficient use of waste as a resource, such as through recycling, composting, and energy recovery. Sustainable waste management practices are essential for minimizing waste and maximizing the value of biological resources. In the EU, sustainable waste management is supported through a range of policies and initiatives, including the Waste Framework Directive and the Bioeconomy Strategy.

2.1 Knowledge-Based Bioeconomy

The Knowledge-Based Bioeconomy (KBBE) is a key concept in the EU bioeconomy strategy. The KBBE refers to the use of knowledge and technology to convert renewable biological resources into food, feed, bio-based products, and bioenergy. The KBBE is seen as a way to increase the efficiency, productivity, and sustainability of the bioeconomy by leveraging advances in science and technology.

The KBBE involves the integration of different disciplines such as biology, chemistry, engineering, and economics to develop new products and processes that are based on renewable resources. The KBBE also promotes the use of sustainable production methods that minimize waste and environmental impact.

Examples of KBBE initiatives in the EU include research on the development of bio-based materials such as bioplastics and biofuels, the use of precision agriculture to increase the efficiency of crop production, and the development of biorefineries that convert biomass into a range of valuable products.

The knowledge-based bioeconomy is a rapidly growing field that combines various sectors such as biotechnology, agriculture, and industry to create sustainable and eco-friendly solutions for economic development. Knowledge-based bioeconomy, on the other hand, focuses on the role of knowledge and innovation in driving economic growth through the sustainable use of biological resources. As a university student, it is important to understand the concept of knowledge-based bioeconomy and its potential impact on society.

The sustainable use of biological resources and the knowledge and innovation required to use them effectively form the foundation of the knowledge-based bioeconomy. This idea is predicated on the notion that biological resources can serve as a source of raw materials, renewable energy, and other valuable goods. It involves utilizing biotechnology, genomics, and other life sciences to develop new, sustainable goods and services.

The knowledge-based bioeconomy includes a number of industries, including those in the food, pharmaceutical, forestry, fisheries, and aquaculture sectors. The objective is to develop a sustainable economy that uses renewable resources and knowledge and innovation to produce goods and services with added value.

Production must be sustainable, without sacrificing resources. The bioeconomy must be able to adapt to different kind of future changes, such as climate. Forests and the forestry sector are at the heart of the bioeconomy of the EU countries. In addition, they are considered to play a major role in mitigating the effects of climate change. Forests cover almost 40% of the land area in the EU. It is not surprising that in the process of developing bioeconomy, European countries pay special attention to biological products based on forest resources. Due to this, scientists are facing serious challenges. However, we live in a time that is characterized by a high level of technological and scientific methods of solving problems.

2.2 Circular bioeconomy

As the world becomes increasingly aware of the impact of human activity on the environment, a new approach to economic development has emerged. The circular bioeconomy is an economic model that seeks to reduce waste and maximize the use of renewable resources. This model is gaining traction in many sectors of the economy, and its potential benefits are becoming increasingly clear.

The term "bioeconomy" refers to the use of biological resources to create goods and services. This includes agriculture, forestry, and fishing, as well as the production of biofuels and biomaterials. The circular bioeconomy takes this one step further by focusing on the reduction of waste and the creation of closed loops that ensure that resources are used efficiently and effectively.

The circular bioeconomy is based on three fundamental principles: the use of renewable resources, the reduction of waste, and the creation of closed loops. Renewable resources are resources that can be replenished over time, such as crops, forests, and fisheries. These resources are used to create products and services, but their use is limited to ensure their long-term sustainability.
Essentially, circular bioeconomy is a model that promotes the use of renewable resources and the recycling of waste and byproducts in a closed-loop system, in order to create sustainable economic growth and mitigate the impact of human activities on the environment.

The circular economy aims to develop products that go through a cycle of disassembly / dismantling and reuse, as well as waste disposal. Bioeconomy provides an opportunity to

replace fossil, non-renewable and non-biodegradable materials with renewable and biodegradable materials. It can also offer new features for bio-based materials, such as longer lifespan, higher endurance, less or no toxicity, and others that circular economics alone cannot offer. Bioeconomy and circular economy do not in themselves imply sustainable development; they need to be built on the principles of sustainability. For this, it is imperative that the production of biomaterials does not compete with food production and does not negatively impact other ecosystem services (biodiversity, protection from climate change and natural disasters, etc.). At the same time, the circular economy must reduce its dependence on fossil and non-renewable materials with a high ecological footprint.

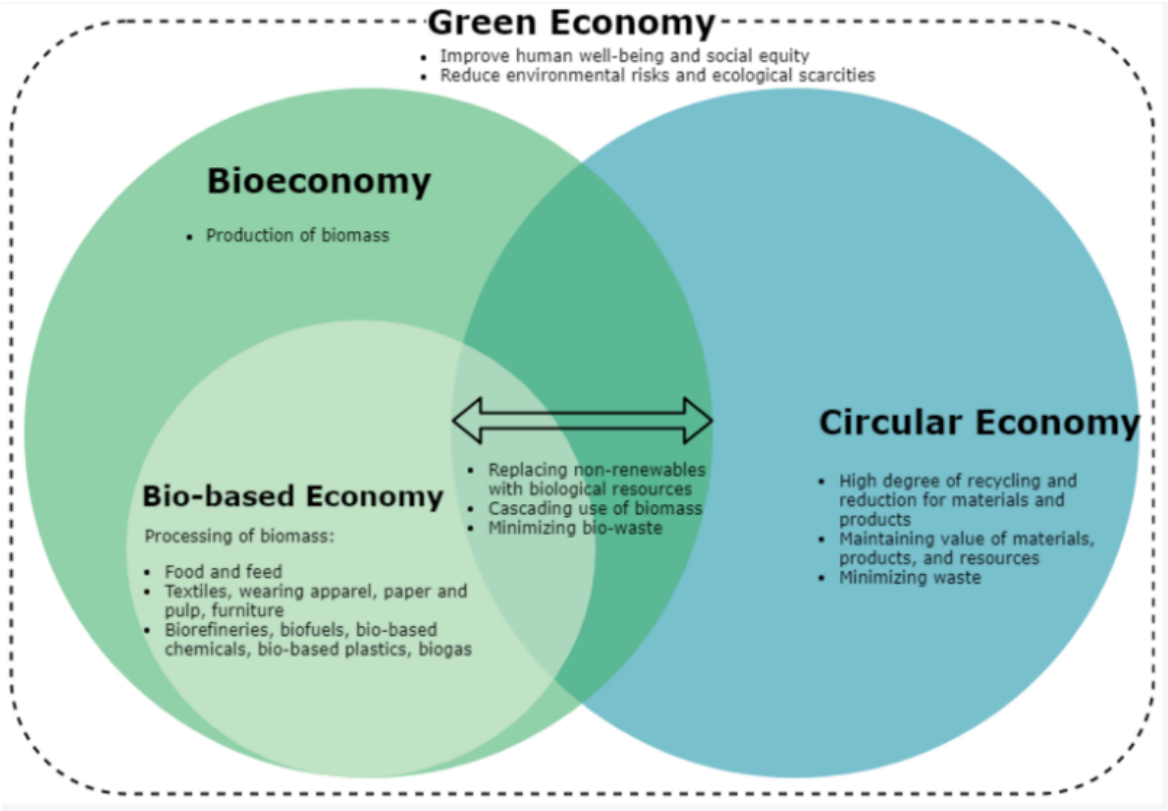

Figure 1 Relations between bioeconomy, bio-based economy, green economy, and circular economy.

Picture n. 1 – Relations between bioeconomy, bio-based economy, green economy and circular economy.

Source: mdpi-res.com

2.3 „Socially Oriented“ bioeconomy

I'm eager to learn more about the new idea of a socially conscious bioeconomy as a student. The production, conversion, and utilization of biological resources and waste streams to

produce food, materials, and energy are collectively referred to as the "bioeconomy." The socially oriented bioeconomy prioritizes social equity, inclusivity, and moral behaviour, placing people at the centre of this framework.

The idea of a socially oriented bioeconomy acknowledges the importance of social equity in creating inclusive, sustainable economies. It emphasizes how crucial it is to guarantee that everyone, regardless of social standing, race, gender, or nationality, has equal access to the advantages of the bioeconomy. This strategy aims to address social and environmental issues while also advancing economic growth.

In order to achieve a socially oriented bioeconomy, several key principles must be considered. These include:

Inclusivity: The socially oriented bioeconomy must be accessible to all members of society, regardless of their social status, gender, race, or nationality. This includes providing equal access to education, training, and job opportunities.

Sustainability: The bioeconomy must be developed in a way that promotes the sustainable use of natural resources and reduces environmental impact.

Collaboration: Collaboration between different stakeholders, including government, industry, academia, and civil society, is crucial in developing a socially oriented bioeconomy.

Ethical practices: Ethical practices must be integrated into the development of the bioeconomy, including fair trade, labour rights, and responsible sourcing of materials.

Innovation: Innovation is essential in developing new technologies, processes, and products that promote social and environmental sustainability.

The socially oriented bioeconomy has the potential to address some of the most pressing social and environmental challenges of our time. For example, it can help to reduce poverty by creating new jobs in the agriculture, forestry, and fisheries sectors. It can also help to promote food security by developing new sustainable food production methods and reducing waste.

Moreover, the socially oriented bioeconomy can play a crucial role in mitigating climate change. This can be achieved by reducing greenhouse gas emissions through the use of renewable energy sources, such as biofuels, and the adoption of more sustainable agricultural practices, such as conservation agriculture.

However, the development of a socially oriented bioeconomy also presents several challenges. For example, there may be conflicts between different stakeholders over the use of natural

resources. In addition, there may be a lack of investment in research and development, particularly in developing countries. Finally, there may be resistance from established industries and interests that are not aligned with the principles of a socially oriented bioeconomy.

To overcome these challenges, it is important to adopt a collaborative approach that engages all stakeholders in the development of the bioeconomy. This includes engaging with local communities to ensure that their needs and concerns are addressed, and providing training and education to promote the adoption of sustainable practices.

The concept of a socially oriented bioeconomy is an exciting and promising development in the field of sustainable development. It offers the potential to address some of the most pressing social and environmental challenges of our time while promoting economic growth and social equity. By adopting a collaborative, inclusive, and ethical approach, we can realize the full potential of the socially oriented bioeconomy and create a more sustainable and just world for future generations.

3 Biotechnology

3.1 Situation and prospects

Biotechnology is an interdisciplinary field that combines biology, chemistry, physics, and engineering to develop new tools and techniques for understanding and manipulating biological systems. In the context of the bioeconomy, biotechnology is used to develop sustainable and efficient processes for the production of biofuels, bioplastics, biopharmaceuticals, and other bioproducts.

The creation of new biocatalysts and bioprocesses for the production of biofuels is one of the most important areas of biotechnology research in the bioeconomy. Biofuels have the potential to lower greenhouse gas emissions and lessen reliance on fossil fuels because they are made from renewable biomass sources like algae, plants, and agricultural waste. However, low yields and high costs are a limitation of conventional biofuel production techniques like fermentation and hydrolysis. New biocatalysts, such as enzymes and microorganisms, are being created using biotechnology to boost the productivity and efficiency of the processes used to produce biofuel.

The creation of biodegradable plastics is another area of biotechnology study in the bioeconomy. Traditional plastics are not biodegradable and made from non-renewable fossil fuels, which significantly damages the environment. New bioplastics are being created using biotechnology that are biodegradable and have less of an impact on the environment. They are made from renewable biomass sources. Applications for bioplastics are numerous and include packaging, agriculture, and medical equipment.

Biotechnology is being used in the biopharmaceutical sector to create novel therapies and treatments for a variety of diseases. Biopharmaceuticals, which include vaccines, monoclonal antibodies, and gene therapies, are made from living organisms like bacteria or yeast. New bioprocesses that can produce these complex molecules in significant quantities and with high purity are being developed using biotechnology. Personalized medicine, which adapts treatments to a patient's genetic profile to increase treatment effectiveness and lower the risk of adverse reactions, is another application of biotechnology.

Looking ahead, biotechnology is expected to play an even more significant role in the bioeconomy as new technologies and applications are developed. For example, advances in

synthetic biology and metabolic engineering are expected to lead to the development of new bioprocesses for the production of high-value chemicals and materials. Additionally, biotechnology is being used to develop new bio-based materials for construction, textiles, and other industrial applications.

Overall, biotechnology is a critical component of the bioeconomy, providing innovative solutions for sustainable and efficient production of bioproducts. With continued investment in research and development, biotechnology has the potential to transform the bioeconomy and contribute to a more sustainable and prosperous future.

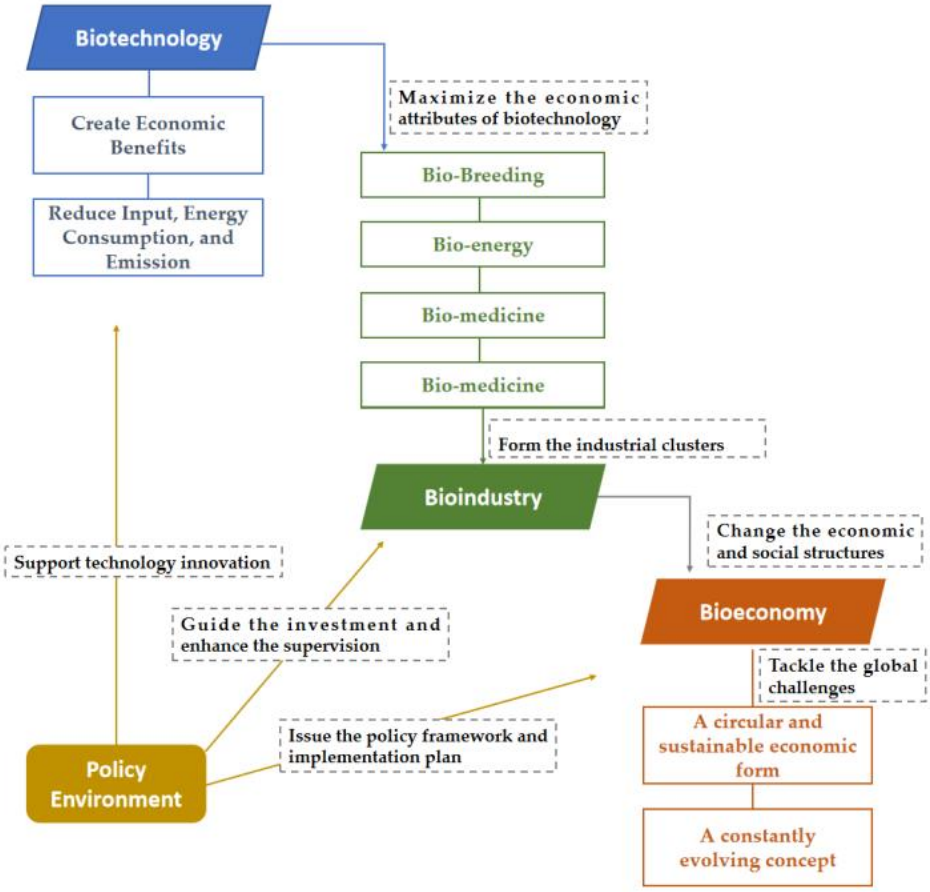

Figure 2 A flowchart of the development of future bioeconomy.

Source: mdpi-res.com

3.1.1 Production in raw materials

The bioeconomy is an economic system that relies on renewable biological resources and the conversion of these resources into value-added products. Raw materials are a critical

component of the bioeconomy, as they are used to produce biofuels, bioplastics, biopharmaceuticals, and other bioproducts.

The main source of raw materials in the bioeconomy is biomass. A variety of biological sources, such as plants, trees, algae, and waste streams, are used to create biomass. Biomass production is a multi-step process that includes harvesting, transportation, and storage as well as agricultural and forestry practices. For the bioeconomy to be sustainable over time, biomass production must be done in a sustainable way.

Climate, soil quality, land use regulations, and consumer demand are just a few of the variables that affect biomass production. In order to make sure that the production process is sustainable and that the resulting bioproducts are competitive on the market, biomass production for the bioeconomy must strike a balance between environmental, social, and economic factors.

Agriculture is a significant source of biomass for the bioeconomy. Crops such as corn, sugarcane, and soybeans are used to produce biofuels, bioplastics, and other bioproducts. The production of these crops is influenced by a range of factors, including weather patterns, soil quality, and market demand. The use of agricultural residues, such as corn stover and wheat straw, is also a potential source of biomass for the bioeconomy. The use of agricultural residues can help reduce waste and increase the sustainability of the agricultural system.

Another important source of biomass for the bioeconomy is forestry. Biofuels, bioplastics, and other bioproducts are made from wood and other forest products. Climate, forestry practices, and market demand are just a few examples of the variables that have an impact on the production of forest biomass. Another potential source of biomass for the bioeconomy is the use of forest residues like sawdust and wood chips. Utilizing forest residues can decrease waste and improve the forestry system's sustainability.

Algae is a promising source of biomass for the bioeconomy. Algae can be grown in a variety of environments, including ponds, raceways, and photobioreactors. Algae can be used to produce biofuels, bioplastics, and other bioproducts. The production of algae biomass is influenced by factors such as light, nutrients, and temperature. The use of algae biomass can help reduce greenhouse gas emissions and increase the sustainability of the bioeconomy.

A potential source of biomass for the bioeconomy is waste streams. Biofuels, bioplastics, and other bioproducts can be made from municipal solid waste, industrial waste, and agricultural

waste, among other waste types. Utilizing waste streams can aid in waste reduction and improve economic sustainability. To ensure the quality of the resulting bioproducts, however, the production of biomass from waste streams can be challenging and requires careful management. A variety of biological sources, such as plants, trees, algae, and waste streams, are used to create biomass. For the bioeconomy to be sustainable over time, biomass production must be done in a sustainable way. Climate, soil quality, land use regulations, and consumer demand are just a few of the variables that affect biomass production.

3.1.2 Economic attributes

Biotechnology is an important tool for improving the economic efficiency and sustainability of various industries. The use of biotechnology in various fields can lead to the development of new products, processes, and services, and can also help reduce costs, increase productivity, and enhance the quality of products.

One of the primary economic attributes of using biotechnology is the potential for cost savings. Biotechnology can help reduce production costs by increasing the efficiency of various processes. For example, biotechnology can be used to develop new enzymes that can break down plant material more efficiently, reducing the cost of producing biofuels. Biotechnology can also help reduce waste and increase the efficiency of various processes, leading to cost savings for companies.

The potential to generate income from using biotechnology is another economic benefit. New products that can bring in money for businesses can be created using biotechnology. For instance, biotechnology can be used to create new medications that treat diseases more successfully, increasing sales for pharmaceutical firms. Additionally, new agricultural products that boost crop yields and bring in money for farmers can be created using biotechnology.
Additionally, biotechnology can aid in raising product quality. As an illustration, biotechnology can be used to create novel strains of crops that are resistant to pathogens and pests, producing crops of higher quality. Additionally, biotechnology can be used to create new approaches to food processing, resulting in food products of higher quality.

Biotechnology can also have a positive impact on the environment, leading to economic benefits. For example, biotechnology can be used to develop new methods for waste management, reducing the environmental impact of various industries. Biotechnology can also be used to develop new biofuels that can reduce greenhouse gas emissions, leading to economic

benefits through carbon credits and other incentives.The use of biotechnology in various industries is not without its difficulties. The regulatory environment is one of the primary difficulties. It can cost more money and take longer to bring biotechnology products to market because they are frequently subject to strict regulations. Additionally, there are worries about the security and environmental effects of biotechnology products, which could result in opposition from consumers and authorities.

The demand for qualified personnel represents another obstacle. Specialized knowledge and abilities are necessary for biotechnology, but they can be challenging to acquire and maintain. This could result in a skills gap, which would constrain the biotechnology sector's ability to expand and advance.

3.2 Improvements in the future

One of the areas where biotechnology can improve is the development of sustainable feedstocks. Sustainable feedstocks are crucial for the production of biofuels, biomaterials, and other bio-based products. Biotechnology can enable the development of new feedstocks that are more efficient, cost-effective, and environmentally sustainable. For example, genetic engineering can be used to develop crops that are more resistant to pests and diseases, leading to higher yields and better quality feedstocks.

Another area where biotechnology can contribute to the development of bioeconomy is in the development of new enzymes and biocatalysts. Enzymes and biocatalysts are essential for the production of bio-based chemicals, materials, and fuels. Biotechnology can enable the development of new enzymes and biocatalysts that are more efficient, cost-effective, and environmentally friendly. For example, metabolic engineering can be used to develop microorganisms that can produce enzymes and biocatalysts that are more efficient and effective in specific applications.

The effectiveness of bio-based product production can also be increased by biotechnology. The production of bio-based products can be improved with the help of biotechnology, resulting in higher yields, better quality, and lower costs. For instance, synthetic biology can be used to create microorganisms that are tailored for particular manufacturing procedures, resulting in increased output and improved product quality.

Future advancements in biotechnology may also make it possible to create new bio-based materials that are more environmentally responsible and long-lasting. Biotechnology can be used to create new materials that perform better than conventional materials while also being renewable and biodegradable. For instance, biotechnology can be used to create bioplastics, which can replace conventional plastics and lessen their environmental impact.

The development of biotechnology can also lead to the development of new healthcare solutions. Biotechnology can enable the development of new drugs and therapies that are more effective, efficient, and targeted. For example, genetic engineering can be used to develop new therapies that are targeted to specific genetic traits or mutations, leading to more effective treatment of diseases.

The use of biotechnology can also improve the sustainability of various industries. Biotechnology can enable the development of new methods for waste management, reduce the environmental impact of various industries, and improve the efficiency of various processes. For example, biotechnology can be used to develop new methods for the conversion of waste into biofuels, leading to the production of renewable energy and reducing the amount of waste that goes to landfills.

However, there are also challenges associated with the development of biotechnology. The regulatory environment is one of the primary difficulties. It can cost more money and take longer to bring biotechnology products to market because they are frequently subject to strict regulations. Additionally, there are worries about the security and environmental effects of biotechnology products, which could result in opposition from consumers and authorities.

4 Forest Bioeconomy

As one of the most valuable natural resources on the planet, forests make up almost one-third of its surface. In addition to their ecological and environmental advantages, forests are significant from an economic standpoint. The forest bioeconomy is a young field that aims to use sustainable management and utilization to increase the value of forest resources. The concept of forest bioeconomy, its significance, and the various approaches and technologies employed to improve it will all be covered in this undergraduate thesis.

Forest bioeconomy refers to the sustainable use of forest resources to create economic value. The forest bioeconomy includes all economic activities related to the production and utilization of forest products, including timber, paper, and biomass for energy production. The forest bioeconomy is based on the principles of sustainability and resource efficiency, with the aim of maximizing the value of forest resources while minimizing their environmental impact.

Sustainable forest management is a key aspect of the forest bioeconomy, as it ensures that forests are managed in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs. Forests provide employment for approximately 13.2 million people globally and are a source of timber, non-timber forest products, and ecosystem services such as carbon sequestration and biodiversity conservation. Forest certification is gaining in popularity, with over 230 million hectares of forest certified under the Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC) schemes as of 2020. This ensures that forests are managed in a way that is environmentally, socially, and economically sustainable.

There are several reasons why the forest bioeconomy is significant. First, by generating income and jobs, it aids in the development of rural areas. Second, it offers sources of energy and materials that are sustainable and renewable, which are essential for the shift to a low-carbon economy. Thirdly, it encourages sustainable methods of forest management, which helps to safeguard and preserve forests.

The forest bioeconomy can be improved by implementing a number of strategies, such as:
The management of forests in a way that balances ecological, economic, and social factors is known as "sustainable forest management." This covers procedures like selective logging, reforestation, and biodiversity preservation.

Forest Certification: Forest certification is a voluntary process that involves the independent assessment of forest management practices. Forest certification provides consumers with assurance that the products they are purchasing come from responsibly managed forests.

Biomass Utilization: Biomass utilization involves the use of forest biomass for energy production. This includes the production of wood pellets, which can be used as a renewable source of energy for heating and electricity production.

Several technologies can be employed to enhance the forest bioeconomy, including:
Biorefineries: Biorefineries are facilities that convert biomass into a range of products, including biofuels, bioplastics, and chemicals. Biorefineries provide a way to extract value from forest biomass that would otherwise be wasted.

Advanced Forest Management: Advanced Forest management involves the use of technologies such as remote sensing, Geographic Information System (GIS), and drones to monitor and manage forests. This allows for more precise and efficient forest management practices.

Forest Genetic Engineering: Forest genetic engineering involves the modification of forest trees to enhance their growth and productivity. This can lead to higher yields of timber and biomass, as well as trees that are more resistant to pests and diseases.

Precision Forestry: Precision forestry involves the use of sensors and data analysis to optimize forest management practices. This includes the use of precision harvesting, where trees are selectively harvested based on their size and quality.

An important new field called the "forest bioeconomy" aims to maximize the value of forest resources while reducing their negative effects on the environment. The principles of sustainability and resource efficiency are the foundation of the forest bioeconomy, which incorporates techniques like sustainable forest management, forest certification, biomass utilization, and the circular economy.

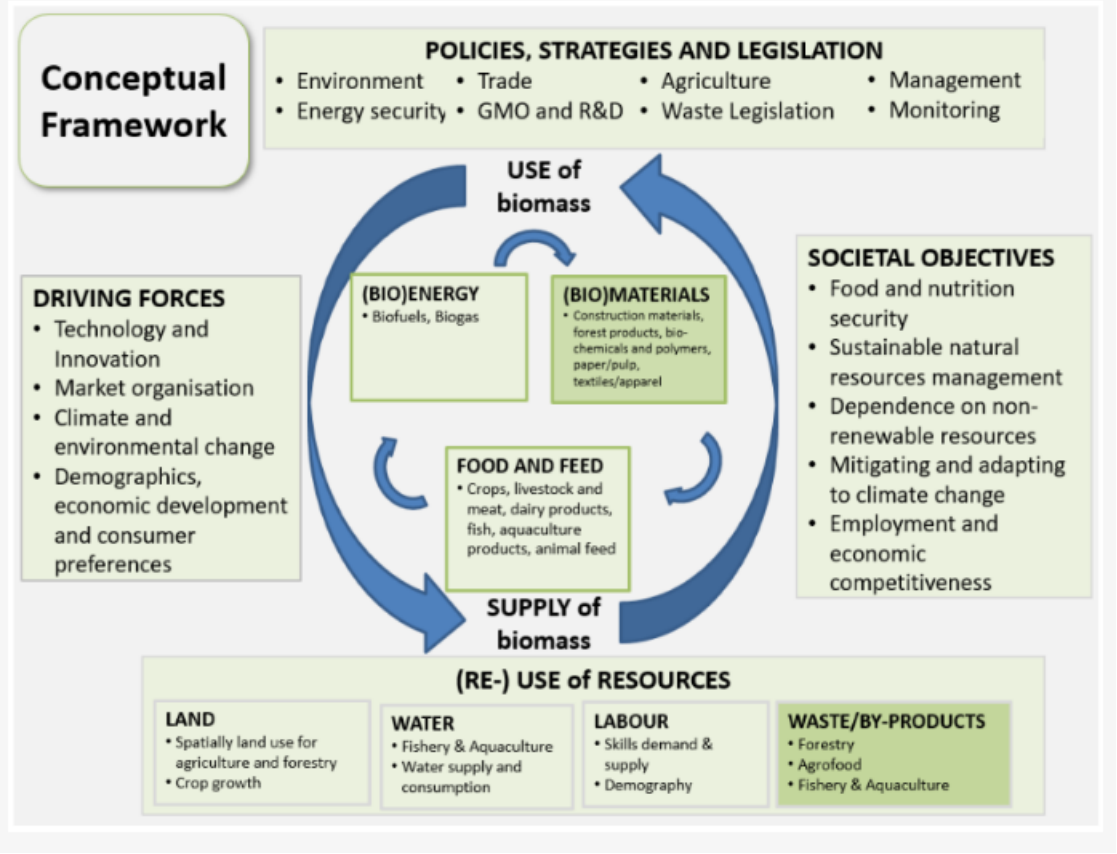

Figure 3 Overview of the relations within the bioeconomy.

Source: SAT-BBE

4.1 The current state of affairs in the European Union

With forests covering about 40% of the EU's land area, the forest bioeconomy is a significant industry in the EU. With a market worth roughly €660 billion and 20% of the world's forest-based sector, the EU is a significant player in the global forest industry.

The EU Forest Strategy aims to promote sustainable management of forests in the EU. Sustainable forest management is a crucial component of the EU's forest bioeconomy. The strategy outlines the EU's goals and plans for protecting, conserving, and managing forests sustainably in the EU. This includes promoting sustainable forest management, biodiversity preservation, the provision of ecosystem services, and the growth of the bioeconomy..

The EU is a leader in the use of forest biomass for energy production, with the renewable energy directive (RED II) setting a target of 32% of the EU's energy to come from renewable sources by 2030. Biomass can provide a renewable and low-carbon energy source, replacing fossil fuels and reducing greenhouse gas emissions. The EU is also investing in the

development of advanced biofuels and other advanced bioenergy technologies, which can further reduce emissions and provide additional economic opportunities.

The biorefinery industry is also a growing sector in the EU forest bioeconomy, with the EU aiming to promote the development of a circular bioeconomy. Biorefineries use a variety of feedstocks, including forest biomass, to produce a range of products such as biofuels, biochemicals, and biomaterials. The EU is supporting the development of biorefineries through research funding and policy incentives, such as the bio-based industries joint undertaking (BBI JU).

Forest genetic engineering research is ongoing in the EU, with the aim of developing genetically modified trees that can grow faster and produce higher yields of timber and biomass. The EU has a regulatory framework for genetically modified organisms (GMOs), which includes the environmental risk assessment of GMOs before they can be placed on the market. However, there are concerns about the potential environmental impacts of genetically modified trees, and their social acceptability is uncertain.

The use of precision forestry technologies such as drones and sensors is increasing in the EU, with the aim of improving the efficiency and effectiveness of forest management. These technologies can provide real-time data on the health of forests, soil moisture, and nutrient levels while lowering costs and minimizing environmental impacts. Through funding for research and policy incentives, the EU is promoting the development of precision forestry technologies.

The potential environmental effects of using biomass from forests, public acceptance of genetically modified trees, and the need to implement sustainable forest management practices are just a few of the difficulties the EU's forest bioeconomy must overcome. However, the forest bioeconomy also offers a variety of advantages, such as the possibility of job creation, economic expansion, and the provision of clean, low-carbon energy sources.

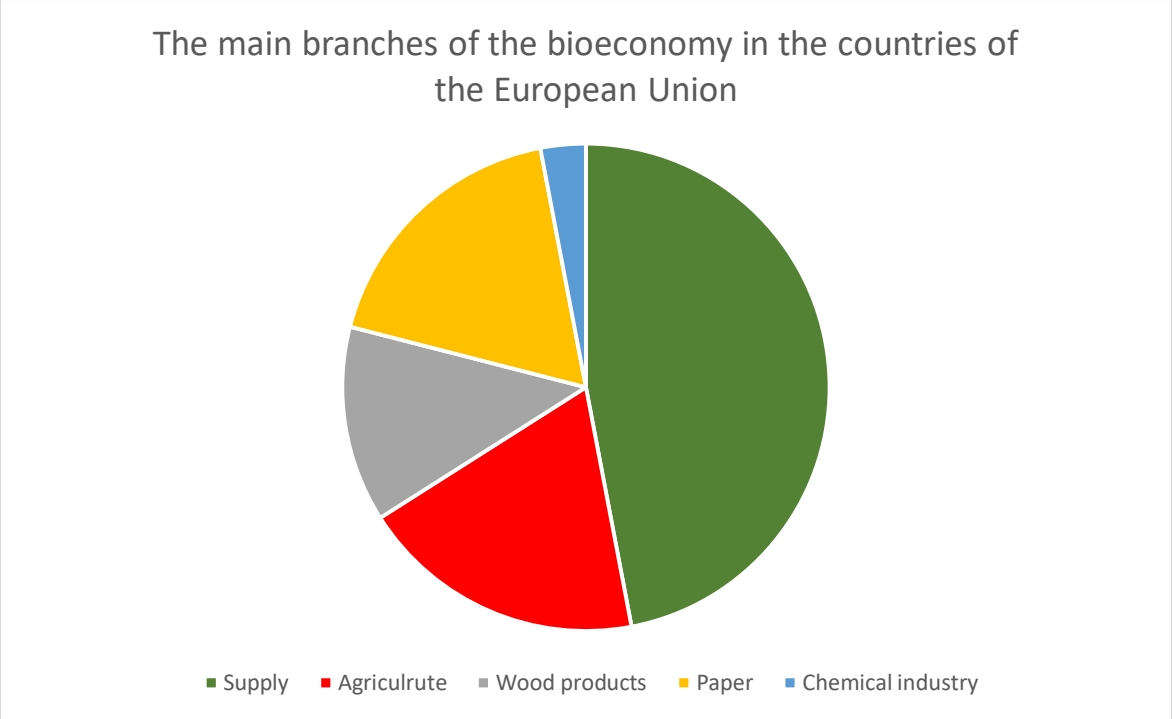

Figure 4 The main branches of the bioeconomy in the countries of the EU

Source: own elaboration

4.1.1 Benefits of implementing forest bioeconomy

The implementation of forest bioeconomy has many benefits for the European Union and its member states. Here are some of the main advantages of forest bioeconomy:

Economic Growth: The forest bioeconomy has the potential to boost the economy and create new jobs. Forest bioeconomy can help local and regional economies by creating new forest-based goods and services and using forest biomass for energy production.

Low Carbon Economy: Forest bioeconomy can help to reduce greenhouse gas emissions by providing renewable and low-carbon energy sources. By using forest biomass for energy production, the EU can reduce its reliance on fossil fuels and transition to a low-carbon economy.

Sustainable Forest Management:. The forest bioeconomy encourages sustainable forest management techniques that support the preservation of biodiversity, the upkeep of healthy forests, and the provision of ecosystem services. The EU can guarantee that forests will continue to provide environmental, social, and economic benefits for future generations by managing forests sustainably.

Rural Development: Forest bioeconomy can contribute to rural development by providing economic opportunities for rural communities. By developing new forest-based products and services, and by using forest biomass for energy production, forest bioeconomy can create new jobs and support rural livelihoods.

Innovation and Research:. The development of new forest-based goods and services can be facilitated by the forest bioeconomy, which encourages innovation and research in the forestry industry. The EU can create new technologies and procedures that increase the sustainability and competitiveness of the forest-based industry by investing in research and innovation.

Circular Economy: Forest bioeconomy supports the transition to a circular economy by promoting the use of renewable and biodegradable resources. By using forest biomass for energy production and developing biorefineries that produce a range of products from forest biomass, the EU can reduce waste and increase resource efficiency.

4.1.2 Energy efficiency

Energy efficiency is an important aspect of forest bioeconomy, as it can help to reduce the environmental impact of forest-based products and services while increasing their economic viability. In this section, we will discuss the various ways in which energy efficiency can be improved in the forest bioeconomy.

By promoting sustainable forest management practices, energy efficiency in the forest bioeconomy can be increased. Sustainable forest management aims to keep forests in good condition so they can continue to offer a variety of environmental, social, and economic advantages. This includes forest management practices that maximize resource use while reducing waste and environmental impact. The forest bioeconomy can lower the amount of energy needed for forest operations and boost the effectiveness of products and services derived from forests by promoting sustainable forest management techniques.

To increase energy efficiency, forest biomass harvesting can also be made more effective. There are numerous methods for harvesting forest biomass, such as clearcutting, selective cutting, and thinning. Selective cutting involves removing only specific trees, whereas clearcutting involves removing all the trees from a designated area. To encourage the growth of larger trees, thinning entails removing smaller trees. The forest bioeconomy can reduce the

amount of energy needed for harvesting and boost the effectiveness of forest-based goods and services by using selective cutting and thinning techniques.

Transportation is another area where energy efficiency can be improved in the forest bioeconomy. Forest biomass is often transported from the forest to processing facilities, which requires energy. By optimizing transportation routes and modes, the forest bioeconomy can reduce the amount of energy required for transportation and increase the efficiency of forest-based products and services. For example, transporting forest biomass by rail or barge can be more energy efficient than transporting it by truck.

It is also possible to optimize the conversion of forest biomass into a variety of goods and services to increase energy efficiency. This includes utilizing cutting-edge methods and technologies to conserve energy and improve the effectiveness of goods and services derived from forests. For instance, the production of biofuels, biochemicals, and biomaterials from forest biomass can be more effectively increased with the use of advanced bio-refining technologies.

Finally, the end use of forest-based products and services can also be optimized to improve energy efficiency. For example, using biomass for energy production can be more efficient than using fossil fuels, as biomass is a renewable resource that does not emit greenhouse gases when burned. In addition, using forest-based products that are biodegradable and can be recycled can help to reduce waste and increase resource efficiency.

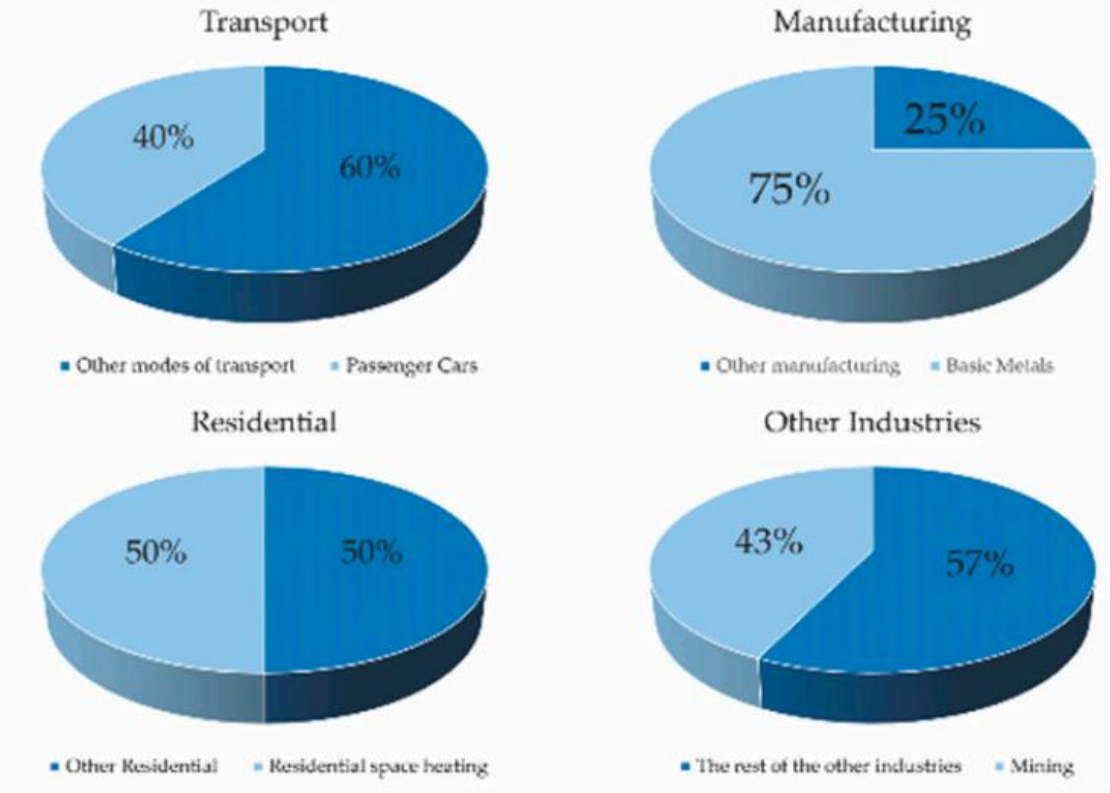

Figure 5 Use of energy by sector in 2019..

Source: mdpi-res.com

4.2 Overview of existing EU regulations in the bioeconomy sector

The European Union has implemented various regulations in the bioeconomy sector to promote sustainable economic growth and environmental protection. In this section, we will provide an overview of the existing EU regulations in the bioeconomy sector.

The Circular Economy Package was adopted in 2018 and includes a range of measures to promote a circular economy, which aims to keep resources in use for as long as possible and minimize waste. The package includes legislation on waste management, product design, and eco-design. It also includes targets for recycling and reuse of materials, as well as measures to reduce food waste and promote sustainable resource use.

The Renewable Energy Directive was adopted in 2009 and revised in 2018. The directive sets targets for renewable energy use in the EU, with a target of 32% by 2030. The directive also includes measures to promote the use of bioenergy, including biomass, biogas, and biofuels.

The revised directive includes sustainability criteria for bioenergy, which aim to ensure that the production of bioenergy is sustainable and does not have negative environmental impacts.

The Common Agricultural Policy (CAP) is the EU's agricultural policy, which aims to support sustainable agricultural production and rural development. The CAP includes measures to promote sustainable land use and biodiversity conservation, as well as measures to support the development of rural areas. The CAP also includes measures to promote the use of renewable energy and the sustainable production of bioenergy.

The Water Framework Directive was adopted in 2000 and aims to promote the sustainable management of water resources in the EU. The directive includes measures to protect water quality and ensure the sustainable use of water resources. The directive also includes measures to promote the use of renewable energy, including the use of hydropower and other forms of renewable energy production that do not have negative environmental impacts.

The Forest Strategy is the EU's strategy for sustainable forest management. The strategy includes measures to promote the sustainable management of forests, including measures to conserve biodiversity and protect forest ecosystems. The strategy also includes measures to promote the use of wood and other forest-based products, including measures to increase the efficiency of wood use and promote the use of wood in construction and other applications.

The Bioeconomy Strategy is the EU's strategy for promoting the transition to a bio-based economy. The strategy includes measures to promote sustainable production and use of biomass, as well as measures to promote the development of bio-based products and services. The strategy also includes measures to promote research and innovation in the bioeconomy sector and to ensure that the bioeconomy is sustainable and does not have negative environmental impacts.

5 Adoption and development of bioeconomy

5.1 Challenges associated with the application of the bioeconomy

The implementation of the bioeconomy faces various challenges that hinder its growth and development. Some of the main challenges include:

One of the biggest problems the bioeconomy is facing is a lack of funding. Numerous bioeconomy initiatives demand sizable investments, which might not be easily accessible. The scope and rate of development of the bioeconomy may be constrained by this lack of funding.

Lack of public awareness: Because the bioeconomy is still a new idea, many people are unaware of its potential and advantages. Initiatives related to the bioeconomy may encounter resistance or apathy as a result of this lack of public awareness, which could limit their success.

Policy and regulatory challenges: The bioeconomy is subject to various policies and regulations that can make it difficult to implement. These challenges can include issues such as land use restrictions, environmental regulations, and intellectual property laws, among others.

Infrastructure shortage: The bioeconomy depends on specialized infrastructure, such as facilities for processing biomass, which may not be widely accessible. It may be challenging to expand bioeconomy initiatives and make them commercially viable due to this inadequate infrastructure.

Technical difficulties: The bioeconomy depends on cutting-edge technologies that may not yet be fully developed or widely accessible, such as bioreactors and gene editing tools. The pace and reach of the bioeconomy's development may be constrained by these technological obstacles.

Competition with other industries: For resources, funding, and market share, the bioeconomy faces competition from other industries. The bioeconomy's growth may be constrained by this competition, which also makes it challenging for initiatives to establish themselves.
Socioeconomic Difficulties: The bioeconomy has the potential to have a significant impact on local communities, and socioeconomic issues can influence the success of bioeconomy initiatives. The viability of the bioeconomy in a particular area can be affected by factors like infrastructure, access to healthcare, and education.

5.2 Solutions to facilitate the adaptation of the bioeconomy

To facilitate the adaptation of the bioeconomy, there are various solutions that can be implemented. Some of the key solutions include:

Creating awareness and education: One way to facilitate the adaptation of the bioeconomy is to increase public awareness and education about its benefits and potential. This can be done through education campaigns, seminars, and workshops to highlight the importance of the bioeconomy and its role in promoting sustainable development.

Increasing funding: Increasing funding for bioeconomy initiatives is another way to aid in the adaptation of the bioeconomy. This can be accomplished through public-private partnerships, government funding, and other methods that support both the growth of infrastructure and research and development.

Creating supportive laws and policies: Creating supportive laws and policies is crucial for facilitating the bioeconomy's adaptation. This includes laws and rules that, among other things, promote the development of renewable energy sources, waste management, and sustainable land use.

Enhancing infrastructure: Another way to facilitate the adaptation of the bioeconomy is to enhance infrastructure to support the development of the bioeconomy. This includes investing in infrastructure such as biomass processing facilities, transportation networks, and renewable energy infrastructure.

Encouraging innovation: Encouraging innovation is another key solution for facilitating the adaptation of the bioeconomy. This includes supporting research and development of new technologies, products, and processes that can promote sustainable development.

Collaboration is key to facilitating the bioeconomy's adaptation, so it must be encouraged between the government, business, and civil society. Partnerships that encourage information exchange, joint investment, and cooperation in research and development fall under this category.

Supporting rural communities: Rural community support is essential for facilitating the bioeconomy's adaptation. This includes making essential services like healthcare, education,

and other necessities accessible, as well as encouraging organic farming and creating new markets for bio-based goods.

Lead international efforts to move towards sustainable development. Europe cannot achieve its sustainable development goals alone. The world's environmental and sustainable development challenges call for worldwide action. The EU has considerable diplomatic and economic clout, which it can use to push for stronger agreements in areas such as biodiversity and resource use. If Europe is to take the lead in making global development sustainable, it is important to fully realize the objectives of the UN 2030 Agenda for Sustainable Development in Europe and actively promote its implementation in other regions. Using the Sustainable Development Goals as a basis for policy development over the next 10 years could be an important step towards realizing the vision of Europe 2050.

Support for a variety of innovative solutions. Changing the trajectory of development will depend critically on the emergence and dissemination of various innovative solutions that can lead to the emergence of new ideas and ways of life. The seeds for this shift have already been sown. More and more businesses, entrepreneurs, scientists, city governments and local governments are trying to introduce different ways of production and consumption.

Reduce the adverse effects of the transition and ensure its social equity. To be successful in sustainable development transition management, societies will need to recognize existing risks, opportunities and trade-offs, and develop mechanisms to overcome the former and exploit the latter. Policies play a critical role in making the transition fair, for example by supporting companies and workers in industries at risk of phasing out, through retraining, subsidies, technical assistance or investments to help affected regions. Timely identification of emerging risks and opportunities associated with technical and societal change must be combined with the flexibility of approaches based on experimentation, tracking change and acquiring new knowledge.

6 Conclusion

The bioeconomy has emerged as a form of innovation that offers tremendous potential for sustainable development, economic growth, and job creation. With its focus on using renewable resources and waste products to produce new and innovative products and processes, the bioeconomy represents a paradigm shift in the way we think about and utilize natural resources.

Given the European Union's dedication to sustainable development and lowering its carbon footprint, the bioeconomy is particularly significant in this region. The EU has taken action to support the development of the bioeconomy through funding, policy, and regulatory measures after realizing the potential of the sector. Furthermore, the EU has taken action to support the development of the forest bioeconomy because it recognizes its significance as a crucial element of the larger bioeconomy.

The bioeconomy has many advantages, but there are also issues that need to be resolved. These include concerns about financial resources, legislative and regulatory frameworks, the development of infrastructure, and the requirement for greater awareness and education about the bioeconomy.

However, the bioeconomy can be a potent force for good change if the right plans and solutions are put in place. We can realize the full potential of the bioeconomy and contribute to the development of a more sustainable and prosperous future by fostering collaboration, advancing infrastructure, supporting research and development, and increasing accessibility to funding and education.

In conclusion, the forest bioeconomy is a crucial component of this larger initiative and the bioeconomy offers a significant opportunity for innovation and sustainable development. We can utilize the potential of the bioeconomy to address some of the most pressing issues of our time and build a better future for ourselves and future generations by cooperating and taking a comprehensive approach.

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8.2 List of graphs

Graph n. 1 – The main branches of the bioeconomy in the countries of the EU.

8.3 List of abbreviations

EU – European Union

CAP – Common Agricultural Policy

UN – United Nations

FSC – Forest Stewardship Council

PEFC – Programme for the Endorsement of Forest Certification

RED II – renewable energy directive

BBI JU – bio-based industries joint undertaking

GMOs – genetically modified organisms

GIS – Geographic Information System

KBBE – The Knowledge-Based Bioeconomy

SDGs – Sustainable Development Goals