Unlocking economic growth: circular bioeconomy implementation and the role of forestry industry

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Abstract. The circular bioeconomy is increasingly recognized as a strategy to tackle natural resource constraints and environmental degradation. This paper examines the prospects of applying circular bioeconomy principles to drive economic growth in Indonesia's forestry sector. Using both quantitative and qualitative data, the study analyzes the sector through upstream, midstream, and downstream value chains. The findings indicate that integrating these principles can boost economic growth by fostering industrial development, innovation, added value, and job creation. In the upstream chain, sustainable forest management, planting, and conservation activities ensure raw material availability and create employment opportunities. The midstream chain sees the growth of creative industries focused on waste processing and logistics, driving innovation, added value, and job absorption. Downstream activities, such as repair, maintenance, refurbishment, upcycling, and rental services, also contribute to economic growth. For further economic development, the study highlights the importance of exploring technology-based activities like biorefineries and innovative product development. This integration at various stages of the value chain demonstrates that a circular bioeconomy can significantly contribute to sustainable economic growth in the Indonesian forestry sector.

1 Introduction

In addressing global issues like climate change, natural resource depletion, and the rising volume of waste, the circular bioeconomy (CBE) concept is emerging as a groundbreaking and sustainable solution [1]. CBE incorporates circular economy (CE) principles into the bioeconomy (BE) in improving the oversight of biological renewable resources [2]. Collectively, BE, green economy (GE), and CE embody cross-sectoral sustainability knowledge and practices aimed at addressing sustainability challenges [3]. Besaid that, CBE represents a significant economic opportunity, projected to reach USD $7.7 trillion by 2030 [4]. In addition, CBE plays a vital role in advancing sustainable development and aligning it with the various Sustainable Development Goals (SDGs) including SDG 7, SDG 11, SDG 12 and SDG 13 [5, 6].

The CE is a model of production and consumption that creates value of resources, materials and products for as long an economic cycle as possible, to minimize waste and reduce resource use [7]. This concept is different from a linear economic system with a 'take-make-waste' model. By utilizing renewable raw materials and eco-friendly production processes, the CBE provides a means to integrate the principles of both circular and bio-based economies [8].

CBE is an economic system that leverages bioresources to sustainably produce products with the maximum possible added value [9]. CBE serves as a framework to lessen reliance on natural resources, revolutionize manufacturing, and encourage the sustainable production of renewable resource [10], focuses on the efficient and sustainable use of integrated biomass such as biorefineries. Through a cascading approach, residue and waste are utilized to maximize biomass value [11].

Economic growth is built upon the increase in production of goods and services in the economic system in a certain period, which is reflected in Gross Domestic Product (GDP). [12]. This growth has historically depended heavily on natural resource extraction, production and consumption. Traditional economic growth is often associated with increased resource consumption and waste production [13]. CE models attempt to decouple economic growth from natural resource depletion [14]. This decoupling can lead to a more sustainable form of economic growth that minimizes environmental impact.

Several sectors are pivotal in supporting the CBE due to their reliance on biological resources and their potential for circularity. Extractive industries such as fisheries, agriculture and forestry, are important in a CBE [15, 16] in addition to sectors, Food and Beverage Industry [17], Bio-based Chemicals and Materials, Bioenergy, and Waste Management and Recycling [18]. Forestry, agriculture, and fisheries are essential to the CBE because they supply the primary biological resources. Forests, offer various ecosystem services and commodities such as biodiversity, climate regulation, carbon storage, raw materials, non-timber forest products, which are crucial to the economy [19]. The forestry sector faces several critical challenges that necessitate the implementation of the CBE concept. These challenges include deforestation, biodiversity loss, waste generation, and climate change [20].

In the period 1970-1990, the Indonesian forestry sector has become the main capital for national economic development, providing a positive impact on increasing government revenues, absorbing labour, encouraging regional development and economic growth [21]. The contribution of the forestry sector to foreign exchange earnings in 1992 - 1997 was recorded at US$ 16.0 billion, or around 3.5 percent of national GDP [22]. Forest degradation and deforestation causes the potential for wood to decrease over time. According to Grimm and van Heemst [23], in 2005, the forestry industry accounted for 0.53% of total Indonesian employment and made up 0.78% of Indonesia's GDP. Over the nine-year period from 1997 to 2005, the sector's contribution to Indonesia's GDP declined from 1.56% in 1997 to 0.78% in 2005 The export of products from primary forests has been declining annually in both volume and value, with an average annual volume reduction of 18% and an average annual value reduction of 6% [23]. Between 2021 and 2023, the forestry sector's contribution to the national GDP ranged from 0.6% to 0.7% [24]. Given these circumstances, it is crucial to decouple economic growth from the exploitation of natural resources. Implementing the concept of a CBE is a key approach to achieving this objective. The goal of CBE is decoupling economic growth from resource use [1]

There is currently a limited amount of literature on the implementation of the CBE concept in Indonesia, particularly in relation to the forestry sector and its impact on economic growth. This paper aims to explore new sources of economic growth stemming from the adoption of CBE principles within Indonesia's forestry sector. Addressing these challenges necessitates innovative approaches that promote sustainability, resource efficiency, and

environmental protection. Applying CBE principles in forestry can offer effective solutions to these critical issues.

2 Material and Method

This study focuses on forestry sector in Indonesia, utilizing a value chain approach from upstream to downstream processes. The value chain approach is essential because opportunities to close the loop for products and raw materials are intertwined with the structure of their value chains [25]. The potential for a CBE in the forestry sector hinges on its structural organization. The research began with a comprehensive review of existing academic literature, industry reports, and relevant publications to establish a theoretical foundation and contextual understanding.

2.1 Data Collection

2.1.1 Quantitative Data

Quantitative data were gathered from diverse information to provide a statistical overview of the sector. This included:

- Wood Production Statistics: Data on the volume of wood produced, processed, and sold within the industry.
- Employment Statistics: Information on the number of economic growths supported by the wood forestry sector.
- Economic Indicators: Metrics such as revenue, market growth, and contribution to the GDP from the woodworking industry.
- Environmental Impact Data: Quantifiable impacts such as carbon emissions, energy consumption, and waste generation from wood processing activities.

2.1.2 Qualitative Data

Qualitative data were gathered to provide in-depth insights into industry practices and expert perspectives. This included:

- Case Studies: Detailed examinations of specific instances where CBE principles were successfully implemented in the woodworking industry.
- Interviews with Industry Experts: Structured interviews with professionals and stakeholders to gain insights into best practices, challenges, and opportunities within the sector.
- Reports on Best Practices: Analysis of industry reports documenting successful strategies and methodologies for implementing sustainable practices in the woodworking-based forest industry.

This study intends to deliver a comprehensive understanding of the woodworking-based forestry industry by merging quantitative and qualitative data, emphasizing the value chain from raw material extraction to the end product usage.

2.2 Data Analysis

Quantitative and qualitative data were analysed descriptively and qualitatively to examine and illustrate how the application of the CBE concept can encourage economic growth in Indonesia. Descriptive analysis is used to present a general overview of the data collected, while qualitative analysis helps in understanding the deeper context and dynamics related to the implementation of the CBE. Through this approach, various potentials and challenges faced can be identified, as well as strategic steps that can be taken to optimize the benefits of a CBE for improving the national economy. It is hoped that the implementation of this concept will not only increase the efficiency of using natural resources but also create new jobs and improve the welfare of the Indonesian people.

3 Result

3.1 Strategy for implementing circular bioeconomy in the forestry sector

The adoption of the CBE follow the principles of the CE, utilizing strategies known as R-imperatives to achieve this goal [26]. The number and order of these R-imperatives is inconsistent and has evolved. CE was initially associated with the 3R imperatives (reduce, reuse and recycle) which are the basis of the waste management process [27]. The increasing understanding of CE introduces several new imperatives, the 6Rs "reuse, reduce, recycle, redesign, improve and reuse" [28] and then the 10Rs "reject, rethink, reduce, reuse, repair, renewal, remanufacturing, reuse, recycling and recovery" [29]. In general, there are 3 main goals in the CE strategy: There are 3 goals, namely: reducing the use of resources and materials, expanding the use of products and materials, and recycling and utilizing production and consumption waste. Reduction of resources and materials, carried out through rejecting, rethinking and reducing. Expanding the use of products and materials, has four strategies, namely reuse, repair, refurbishment and remanufacturing. The goal of recycling and utilizing production and consumption waste can be achieved with 2 strategies, namely recycling and recovery. Use it as an alternative fuel for electricity generation. In Table 1, CBE strategies are presented that can be applied to the Indonesian forestry sector

Table 1. Goals, R Strategy, definition and example of CBE activity in forestry sector.

Goal	R Strategy	Definition
Reduction in resource and material usage (Creation)	R0: Refuse	Creating a product that can be reused through offering the same product function using different products/services, example: developing environmentally friendly alternatives to wood
	R1: Rethink	Using a product more intensively (for example: through product sharing or introducing more multifunctional products to the market), example: Developing product designs that are lighter yet still strong and durable, thus requiring less wood in their construction
	R2: Reduce	Increasing efficiency in the production process of products or in their usage by consuming fewer materials and natural resources, example: Precision processing techniques to produce products that require less wood while still maintaining the necessary strength and durability
Extension of product and material usability (Maintaining)	R3: Reuse	Discarded products are reused by different consumers, with the products still in good condition and fulfilling their functions, example: Wood building materials such as beams, boards, or panels from unused structures can be salvaged and reused in construction or other renovation projects
	R4: Repair	Repair and maintenance of damaged products so that they can be reused according to their function, example: Damaged wooden furniture such as tables, chairs, cabinets, or shelves can be repaired by replacing the damaged parts
	R5: Refurbish	Restoring an old product and updating it with current conditions (which may include cosmetic repairs), example: Used wooden furniture, such as tables, chairs, or cabinets, is refurbished by replacing upholstery, smoothing the surface, and applying new paint or varnish
	R6: Remanufacture	Reusing components of a discarded item to create a new item with the same purpose, example: old wooden pallets can be transformed into book shelves, garden benches, or small tables
	R7: Repurpose	Using components of a discarded item to create a new item with an alternative purpose, example: used wood can be used to create art pieces, or unique home decorations

Table 1. Goals, R Strategy, definition and example of CBE activity in forestry sector (continued)

Goal	R Strategy	Definition
Recycling and utilization of production and consumption waste (Recover)	R8: Recycle	Processing materials to obtain the same quality (high quality) or lower example used wooden boards or production waste such as wood chips, wood shavings, are recycled into new building materials such as particle boards, OSB (Oriented Strand Board), or MDF (Medium-Density Fiberboard)
	R9: Recover	Incineration of materials along with energy recovery, example Wood waste such as wood chips or sawdust is utilized as an alternative fuel for power generation

3.2 Activities driving economic growth in Indonesia's forestry sector through the implementation of circular bioeconomy.

The forestry sector is located in a biological and technical cycle so it is very suitable for implementing a bio-based CE model [25]. The value chain approach is used in implementing and evaluating efficiency levels. The value chain is a combination of "the entire sequence of activities or parties that provide or receive value in the form of products or services" [30]. The opportunities to close the cycle of primary resources and products related to the structure of the respective value chains.

The division of the forestry sector into upstream, midstream and downstream links allows a clearer understanding of the various activities involved in forest management and the production of timber and non-timber forest products. Starting from planting and conservation upstream, processing and innovation in the middle, to production, use, marketing and recycling downstream. Each stage contributes to sustainable forest resource management and supports sustainable economic growth. Applying the CBE concept at each of these stages can further optimize resource use and minimize environmental impacts.

3.2.1 Upstream

The starting point for implementing the CBE concept in the forestry sector is the application of the principles of sustainable forest management (SFM) [25]. SFM is an effort to meet the growing demand for forest services and goods to maintain biodiversity and forest health. Therefore, in bioeconomics, SMF requires a balanced supply of biomass and other forest ecosystem services. CBE and SMF are closely related, as both aim to harmonize the utilization of natural resources with ecological conservation through the utilization of renewable resources and sustainable production practices. Job opportunities that arise from this sector are SMF consulting services by mainstreaming CBE concepts

Several activities in the upstream sector that reflect the implementation of the CBE concept have had economic impacts such as planting and forest conservation and protection. Sustainable forest conservation activities and planting practices for land rehabilitation have been implemented in forest management practices in Indonesia. Apart from creating employment opportunities, the results of this activity can renew forest potential for both wood and non-timber forest products.

3.2.2 Midstream

The midstream sector includes activities starting from logging, processing wood and/or wood forest products into products, to processing waste from these activities. Logging activities, companies holding forest use concessions have also implemented the reduce impact logging (RIL) method. Application of the Reduce Impact Logging (RIL) concept is a CBE practice in logging activities. RIL is a wood harvesting technique that is planned intensively and carefully, carried out by workers to reduce the adverse effects of logging [31]. RIL aims to reduce the negative impacts of timber harvesting in tropical forests and has been proven to be able to reduce damage to remaining stands [32] so that it will reduce

logging waste and increase forest productivity in the future. This aligns with the statement by [33] that the application of RIL can enhance the efficiency of timber extraction while reducing costs and damage to the remaining stand.

Logging activities, both conventional and RIL techniques, produce waste. The results of research conducted at Perum Perhutani showed that waste produced from logging activities was in the form of root twigs, hollow wood and damaged wood. This waste is processed into high-value crafts by small industries [34, 35].

In the production process chain, implementation of the CBE concept starts from managing the use of raw materials. Raw material management starts from planning products that use minimal raw materials but have the same function as products with more raw materials. Besides that, it is necessary to design products so that they can be used for a long period of time. In designing such products, expertise regarding the strength and durability of wood is required, combined with the art of designing a product. This opens up job opportunities by becoming a product designer who mainstreams the CBE concept.

Cascading based on value is applied by reusing remaining raw materials to make goods of lower value (still in the same industry). This cascading technique will provide high economic value to raw materials by maximizing the use of raw materials. Usually, large industries that have complete and comprehensive equipment and diverse market shares will practice this concept. However, not many wood-based forestry industries in Indonesia have implemented this concept. In general, the wood industry in Indonesia is small and medium scale which has limited equipment, resources and market share.

Reuse activities have been widely carried out in the furniture industry by utilizing and utilizing used wood as raw material. According to [36], the furniture industry in Jepara Regency has long used wood as its raw material. Used wood can be obtained from used wood collectors. Used wood usually comes from demolished buildings, households, especially bicycles, offices and schools that are no longer used. Usualy this wood is decades old and has good quality because it is made from wood that was felled when the tree was old. The use of used wood for the furniture industry has given rise to new businesses known as old furniture.

Production waste recycling activities have grown creative industries. Furniture industry waste in Jepara is processed into household equipment, high-value crafts, wood parquet (flooring), kitchen ware, children's toys, and raw materials for small-scale industries. Processes in these industries are able to provide added value, reduce waste and absorb labor. The results of our research show that 1 (one) kitchen ware industrial unit can absorb 8-10 workers and absorb 60-75 m3/year of waste. Waste from sawdust and shavings is used as raw material for mosquito coils and wood pellets. So almost all waste from industry can be utilized and provide added value.

Another economic potential of waste management lies in the creation of economic activities through the collection, trade, and transportation of waste. These activities can generate employment and provide added value for businesses in this sector. Moreover, they simplify the procurement of raw materials for waste management companies. For furniture manufacturers, efficient waste management by other parties can streamline the production process by preventing disruptions caused by waste accumulation.

Wood waste can also be processed into valuable chemicals like lignin, cellulose, and hemicellulose through biorefinery techniques. These chemicals have applications in various industries, including pharmaceuticals, textiles, and food. However, this practice is not yet widespread among industries in Indonesia.

3.2.3 Downstream

Downstream sector activities in the forestry sector include utilization, maintenance, repair, recycling of used products. Apart from that, there are also activities related to product

management, namely distribution and marketing. Product care and maintenance activities such as providing structural maintenance services for wooden furniture aim to extend the period of use. Surface treatment by applying protective coatings, varnishes and treatments to prevent rot and damage. These activities give rise to economic activities in the form of repair and maintenance services for wooden products. These services have long been found around us.

Currently, furniture refurbishment activities are booming, namely the process of restoring, repairing and updating furniture to improve its appearance, function and lifespan. This activity is more than just repair and maintenance services. This practice involves a series of steps tailored to the specific needs of each piece of furniture, aimed at returning it to like-new condition or giving it a new look. Refurbishment services are often found around us. This service is also an economic activity that mainstreams the CE by reducing the use of fresh biomass.

In terms of product management, activities that mainstream the CBE concept are rental services. Rental services are one of the schemes in the sharing platform which is a strategy for saving resource use. Many furniture rental services are developing around us which are used for party equipment, conferences and seminars, exhibitions and expos, temporary offices, film production and photo shoots, sporting events, art exhibitions and galleries. Rental service activities give rise to economic activities that can encourage economic growth through employment.

Furniture waste has the potential to be reused through recycling activities into engineered wood. Wood furniture waste is crushed into chips or sawdust which is then combined with adhesive to make products such as plywood, MDF (Medium Density Fiberboard), and OSB (Oriented Strand Board).

Apart from recycling, furniture waste can also be carried out by upcycling activities to make new models of furniture by utilizing parts of old furniture, such as table legs, panels or drawers, which can be reused to make new furniture with creative designs. Wooden pieces from used furniture can be turned into home decorations, such as wall shelves, photo frames, or wall hangings. This activity is mostly carried out by small-scale industries. Furthermore, waste that cannot be recycled is used as biomass fuel to produce energy through combustion in power plants.

4 Discussion

CBE creates a sustainable economic model that utilizes biological resources efficiently, minimizes waste, and promotes the regeneration of natural [9]. Important components of CBE include environmentally friendly chemistry, microbial manufacturing, enzyme technology, biotechnology, environmentally friendly chemistry, integrated physical and chemical processes, conducive regulations, policy support, and collaboration between the private and public sectors [37]. Shifting towards a CBE necessitates innovation in product design, business strategies, and operational processes [38, 39].

The change to a CBE necessitates a workforce skilled in new technologies and processes related to biomass conversion, waste management, and sustainable production [40]. This transition can create jobs in research and development, manufacturing, and supply chain management [39]. It also necessitates upskilling existing workers and developing educational programs focused on bioeconomy and circular principles [41].

CBE drives innovation in biotechnology, materials science, and industrial processes [42]. Innovation is crucial for enhancing current utilization methods to promote resource efficiency and for developing new products and applications that can substitute fossil-based alternatives [15]. Developing new technologies for converting biomass into high-value products stimulates research and development activities. Innovation can lead to the commercialization of new technologies, fostering the growth of start-ups and attracting investment. It also

enhances the competitive edge of economies that lead in bio-based innovation. CBE facilitates new market development for bio-based services and products [43]. This includes biofuels, bioplastics, biochemicals, and sustainable food systems. By diversifying product offerings and creating high-value markets, businesses can tap into new revenue streams. For instance, the global bioplastics market is projected to grow significantly, driven by demand for sustainable packaging solutions.

CBE encourages waste reduction and increased efficiency of resource use through the reuse and recycling of biological materials [11]. This reduces dependency on virgin resources and minimizes waste management costs. Businesses can achieve cost savings through reduced raw material expenses and lower waste disposal costs [11]. Additionally, enhanced resource efficiency can lead to more competitive production processes and products [44]. By focusing on resource efficiency and, businesses can develop new competitive advantages and open new markets contributes to economic growth and competitiveness [45]. For example, sectors such as recycling, repair and remanufacturing can create jobs and stimulate economic activity. Businesses in the CBE concept also focus on designing products that last longer, can be reused, or are easier to repair. This reduces dependence on raw materials, lowers production costs, and mitigates risks related to resource scarcity and price volatility. Savings from reduced material use and waste disposal costs can make a significant contribution to economic growth. Implementing CBE principles, companies can reduce costs associated with raw material procurement, waste management and energy consumption. These cost savings can increase profitability and contribute to overall economic growth. In addition, resource efficiency can mitigate risks in the form of volatile prices and resource scarcity.

CBE can offer environmental benefits such as preserving ecosystems, reducing pollution and reducing greenhouse gas emissions. These environmental benefits can be translated into long-term economic benefits by preserving the natural resources on which the economy depends. This can encourage social benefits such as improved public health and improved quality of life which are important components of sustainable economic growth. By reducing environmental degradation and encouraging sustainable resource use, the CBE contributes to the long-term stability of ecosystems, which is essential for sustainable economic growth. Healthy ecosystems provide important services for economic activities, such as clean water, fertile soil, and stable climate conditions. This can address environmental challenges thereby reducing costs associated with health issues and disaster management.

In summary, the relationship between the implementation of a CBE and economic growth follows the following scheme: (1). Resource efficiency and cost savings. In a CBE, businesses focus on designing products that last longer, can be reused, or are easier to repair. This reduces dependence on raw materials, lowers production costs, and mitigates risks related to resource scarcity and price volatility. Savings from reduced material use and waste disposal costs can make a significant contribution to economic growth. (2). Innovation and job creation. The transition to a CBE requires innovation in product design, business models and processes. This fosters a culture of innovation, leading to the development of new industries and job opportunities. For example, sectors such as recycling, repair and remanufacturing can create jobs and stimulate economic activity. (3). Increase competitiveness. Companies that implement circular practices can differentiate themselves through sustainable practices, meeting growing consumer demand for environmentally friendly products. This can open new markets and increase their competitiveness, thereby encouraging economic growth. The figure 1 illustrates the role of CBE in driving economic growth.

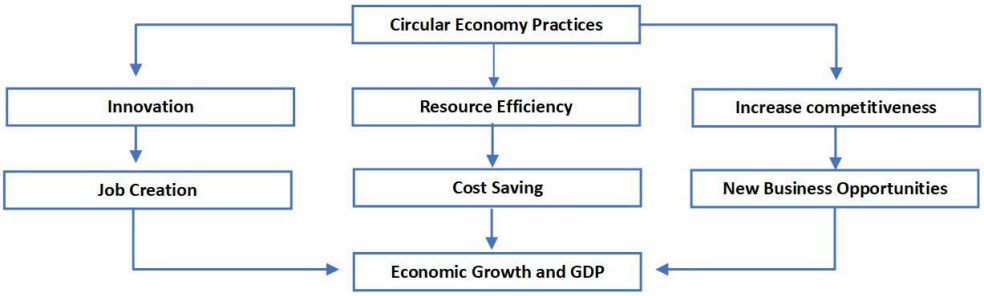

Fig. 1. The role of CBE in driving economic growth

The implementation of CBE in the forestry sector is currently still focused on European countries [46, 47, 48]. Biorefinery as a platform for innovation with a main focus covering governance and discourse, business and industry [15]. On the other hand, the forestry sector has very broad scope for implementing the CBE concept which can stimulate economic growth.

Deforestation and forest degradation are significant issues driven by logging, agricultural expansion, uncontrolled fires, mining, urban expansion and infrastructure development [49]. These activities lead to the loss of vital ecosystems, carbon sequestration capacity, and biodiversity [50]. The concept presented by Marchi, Chung [51], sustainable forest operations prioritize wood as a renewable and eco-friendly material, alongside ensuring the safety of forest workers and maximizing the efficient use and management of waste, all crucial aspects of sustainability.

In the context of the forestry sector, an example of the synergy between the CE and the BE is the principle of cascading biomass use [15]. This approach is to optimize the use of wood throughout its life cycle, taking into account technical, ecological and economic feasibility aspects so as to minimize trade-offs while maximizing economic, social and environmental benefits [15].

The destruction of forests directly impacts biodiversity, threatening numerous plant and animal species. Loss of habitat and ecosystem services further exacerbates the decline in biodiversity. Integrating biodiversity conservation into forest management plans is crucial. Practices such as mixed-species plantations, maintaining natural forest patches, and creating wildlife corridors help protect and enhance biodiversity. The CBE emphasizes the value of ecosystem services, promoting their sustainable use and conservation.

Forests are crucial for carbon sequestration, and forest destruction contributes to greenhouse gas emissions, accelerating climate change. Unsustainable forestry practices further exacerbate this problem. Promoting sustainable forestry practices that increase carbon sequestration, such as maintaining forest cover and improving soil health, is critical. Circular use of forest products, where they are reused, recycled and ultimately returned to the environment in a non-harmful way, will help mitigate climate change by reducing the carbon footprint and encouraging the use of renewable resources.

The forestry sector generates substantial amounts of waste, including branches, bark, and sawdust, which are often underutilized or discarded, leading to inefficiencies and environmental issues. Utilizing forest residues and by-products for bioenergy and bio-based products ensures that all parts of the tree are used efficiently, reducing waste and preserving forest resources. Developing technologies and processes to convert forestry waste into valuable products like biofuels, bio-based chemicals, and materials can significantly reduce waste. For example, lignocellulosic biomass can be transformed into bioenergy or biodegradable plastics, contributing to a circular system where waste becomes a resource.

5 Conclusion

The integration of CBE principles within Indonesia's forestry sector offers a viable pathway to sustainable economic growth. By adopting CBE strategies, the sector can attain greater efficiency and environmentally friendly resource utilization, thereby decoupling economic growth from natural resource exploitation. Integrating CBE strategies into the forestry sector can encourage economic growth through industrial development, innovation, increasing added value, and creating jobs. Integration in the upstream chain, starting with SMF, planting and conservation activities which play a role in maintaining the continued availability of raw material sources and employment opportunities. In the middle chain, various creative industries based on waste processing and waste management logistics are developing and triggering innovation, increasing added value and absorbing employment opportunities. In the downstream chain, the existence of repair, maintenance, refurbishment, upcycle and rental services is a driver of economic growth. To unlock further economic growth, it is essential to investigate activities based on progress and use of technology such as biorefineries, innovative technology and product development. Based on the findings that the integration of CBE principles in Indonesia's forestry sector offers a viable pathway to sustainable economic growth, several avenues for further research can be developed including assessing the effect of CBE integration on economic growth, SMF practices, biorefineries development, innovative technology and product development, policy and regulatory frameworks as well as public awareness and education in implementing the bioeconomic concept.

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