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BIOECONOMY INITIATIVE

DRIVING TRANSFORMATION TOWARDS A SUSTAINABLE ECONOMY



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atik-sulianami

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The Government of Indonesia, with its 2025-2045 National Long-Term Development Plan (*Rencana Pembangunan Jangka Panjang Nasional/RPJPN*), has committed to put bioeconomy as one of its economic transformation agenda. However, the definition and concept of bioeconomy at the global stage continue to vary according to the interests of each individual country. Bioeconomy is expected to drive the development of innovative products derived from biological resources and ecosystem services. This underscores the need for a common initiative to build a shared understanding and establish a set of bioeconomy concepts and principles that can be adopted at the national level and serve as an operational basis for bioeconomy development.

Bioeconomy is defined as an economic approach to utilize biological resources and processes in a sustainable manner in order to create higher value-added outputs, thereby contributing to a just, prosperous, and sustainable economy in Indonesia, while upholding the essence of humanity. This definition is founded on three core values, namely value creation, biotechnology implementation, and well-being¹, while also taking into account the trajectory of Indonesia's development to 2045 and the values held by the nation. The bioeconomy approach is also expected to reduce Indonesia's economic dependence on mineral and coal mining by streamlining sustainable value creation across the upstream and downstream segments of bio-based commodity value chains.

Nevertheless, bioeconomy development continues to face various challenges, including unclear policy framework, limited cross-sectoral collaboration, and constraints in funding, investment, technology, and innovation. Therefore, a comprehensive policy framework is essential to provide a solid foundation and guidance for advancing a bio-based economy across sectors such as food, energy, cosmetics, healthcare, and environmental services, while ensuring environmental sustainability.

In summary, this concept outlines the objectives of bioeconomy initiative through a clear definition, followed by the core values that will guide its development, which include value creation, application of technology and innovation, and improvements in human well-being. The Indonesian Bioeconomy Initiative adopts a value chain approach in its implementation, in which development is integrated from upstream to downstream while upholding the core values of bioeconomy. The implementation will also be guided by the framework agreed upon under the G20 Bioeconomy Initiative, as set out in its 10 High-Level Principles. Furthermore, to ensure inclusivity, this concept proposes three models through which communities can actively contribute to Indonesia's bioeconomy development.

Keywords:

bioeconomy, biological resources, environmental preservation, value-added

¹ Well-being refers to the state of being happy, healthy, or prosperous. In the context of the Indonesia Bioeconomy Initiative (IBI), this understanding is extended to encompass broader dimensions of human welfare, including social equity and justice, gender equality, disability inclusion, decent work and sustainable livelihoods, respect for the rights of Indigenous Peoples and local communities, meaningful participation in decision-making, and the fair sharing of benefits derived from biological resources and traditional knowledge.

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A.

INTRODUCTION:

**Key Drivers of Bioeconomy
Development in Indonesia**





INTRODUCTION

Key Drivers of Bioeconomy Development in Indonesia

In the last few decades, the concept of bioeconomy has gained increasing traction as a pathway toward sustainable development and low-carbon economic transition. In general, bioeconomy is understood as an economic system that utilizes biological resources in a sustainable way to produce goods and services capable of replacing fossil-based raw materials. Bioeconomy practices support the green transition by reducing greenhouse gas (GHG) emissions, promoting the use of non-fossil fuels, and regenerating degraded environments.

Many countries have established holistic planning for bioeconomy development, such as South Africa, Colombia, the United States, and Norway (Gardossi et al., 2023). However, there is no single definition agreed-upon globally to date, including in Indonesia. Each country tends to adopt a definition tailored to its own social, economic, and environmental contexts. Bioeconomy practices are implemented in fragmented ways across various sectors, such as forestry, agriculture, and fisheries, without a clear, integrated framework. This poses various management challenges, including limited collective understanding, suboptimal utilization of abundant natural resources, and weak synergy among related sectors. Consequently, on a global scale, bioeconomy has become a key issue raised at the 2024 G20 Brazil summit through the G20 Initiative on Bioeconomy (GIB) to foster a shared understanding of bioeconomy implementation.

As a country with mega-biodiversity, Indonesia holds immense potential for bioeconomy development, which can deliver a significant impact on the national economy, particularly in supporting environmental sustainability and people's well-being. However, this potential

remains underutilized due to the absence of a clear policy framework and practical guidelines that can be adopted by all stakeholders. Therefore, an initiative is urgently needed to formulate bioeconomy concepts and principles that can be adopted nationally. This initiative entails not only developing a clear, agreed-upon conceptual framework, but also its practical implementation across various sectors. Thus, bioeconomy can be effectively integrated into national development, driving inclusive and sustainable economic growth, while contributing significantly to people's well-being and environmental preservation. Under this approach, the utilization of biological resources in Indonesia will shift away from extractive practices toward a model that respects the carrying capacity and ecological limits of its ecosystems.

Bioeconomy is aligned with international objectives under several global frameworks encompassing various initiatives, policies, and international agreements to promote sustainable use of biological resources, including: (i) the 2030 Sustainable Development Goals (SDGs) Agenda; (ii) Convention on Biological Diversity (CBD); and (iii) Kunming-Montreal Global Biodiversity Framework (KM-GBF). Bioeconomy contributes to achieving the SDGs by increasing sustainable use of natural resources, addressing hunger and promoting sustainable agriculture, supporting energy production, and improving people's well-being. With CBD, bioeconomy is promoted through efforts to protect and prevent biodiversity exploitation. Meanwhile, KM-GBF reinforces a more inclusive conservation

paradigm by ensuring biodiversity and ecosystem governance that supports sustainable development and fosters people's well-being. These global frameworks provide a foundational basis to support the development of a sustainable and integrated bioeconomy by emphasizing a balance between economic development, environmental preservation, and people's well-being.

Furthermore, the development of bioeconomy has been established as a strategic policy mandated within the 2025-2045 National Long-Term Development Plan (Rencana Pembangunan Jangka Panjang Nasional/RPJPN) and the 2025-2029 National Medium-Term Development Plan (Rencana Pembangunan Jangka Menengah Nasional/RPJMN). The Government of Indonesia has committed to put bioeconomy as a key economic transformation agenda supporting the achievement of the Indonesia Emas 2045 Vision through sustainable utilization of natural resources. This is grounded in the necessity for fresh innovations to achieve the Indonesia Emas 2045 Vision, as studies indicate that every 10% increase in the demand for bio-based products can drive the growth of economic output by up to 9% (Pérez-Galván et al., 2025).

In addition, bioeconomy serves as an innovative breakthrough in supporting the achievement of: (i) Asta Cita 2, by consolidating the national defense and security system and fostering national self-reliance through self-sufficiency in food, energy, water, creative economy, green economy, and blue economy; and (ii) Asta Cita 5, by continuing the downstreaming and development of natural resource-based industries to enhance domestic added value.

Bioeconomy also supports priority Asta Cita programs, namely: (i) food, energy, and water self-sufficiency; (ii) environmental preservation; and (iii) downstreaming and industrialization of natural resources, including maritime resources, to generate extensive employment opportunities in realizing economic justice.

Given the importance of the bioeconomy approach to Indonesia's development, bioeconomy initiatives must be clearly designed and structured, going beyond mere 'labeling'. Indonesia needs to establish a detailed bioeconomy strategy that can be implemented in alignment with the country's characteristics. Furthermore, the bioeconomy approach is expected to reduce Indonesia's economic dependence on mineral and coal mining sector by streamlining sustainable value creation across the upstream and downstream segments of bio-based commodity value chains.

B.

What is Bioeconomy



B

What is Bioeconomy

B.1. Proposed Definition of Bioeconomy

Indonesia's bioeconomy development must not only consider the trajectory of global development, but also align with Indonesia's national development direction to serve as a driver for achieving the Indonesia Emas 2045 Vision. Based on a curation of existing global definitions, principles agreed upon within the G20 forum, and the policy direction of the 2045 RPJPN, the definition of Indonesia's bioeconomy is proposed as follows:

“Bioeconomy is an economic model that utilizes biological resources and processes in a sustainable manner to create higher value-added goods and services for Indonesia, thereby advancing the nation as a just, prosperous, and sustainable economy while upholding the essence of humanity.”

The definition of bioeconomy is expected to serve as an umbrella concept for various stakeholders so that its implementation can collectively lead toward the same national objectives. In general, three key elements are reflected in the formulation of the definition of bioeconomy above, namely:

1 **The sustainable utilization of processed biological resources,** which refers to the utilization of plants, animals, and microorganisms processed using specific technologies while safeguarding environmental sustainability, thereby ensuring that economic activities remain sustainable.

2 **Higher value-added, which refers to biological resources that have been processed** to yield products with significantly greater economic value. This also drives innovation to produce efficient products and minimize excessive resource consumption while maximizing economic benefits.

3 **A just, prosperous, and sustainable Indonesian economy that upholds the essence of humanity,** which refers to economic value that is generated by prioritizing social justice and natural resources sustainability. This criterion also serves to limit economic activities that degrade the quality of human life and to prevent social disparities, in alignment with the mandates set forth in the Preamble of the 1945 Constitution.

B.2. Indonesia's Bioeconomy Values

The bioeconomy definition outlined above remains general and has yet to fully capture the specific values that Indonesia intends to champion within its bioeconomy framework. These values subsequently form the characteristics of Indonesia's bioeconomy, reflecting the direction of Indonesia's bioeconomy development objectives that distinguishes it from other economic development frameworks.

These values must be translated into criteria to make them more operational.

Establishing these criteria is crucial for guiding bioeconomy development in Indonesia, particularly in specifying, with greater clarity and measurability, the way bioeconomy is applied on the ground, its sectoral scope, and its relevance to the national context. These criteria serve as a guide and reference for determining future bioeconomy objectives and establishing a clear scope. Furthermore, these criteria are connected to bioeconomy principles, which act as operational safeguards for implementing bioeconomy activities on the ground. The three core criteria/values that must be highlighted for Indonesia's bioeconomy are as follows:

1 Creation of a higher value-added

As an economic approach, the utilization of biological resources must generate a higher value-added compared to conventional practices. Bioeconomy holds the potential to transform all forms of biomass into value-added products, creating a broad portfolio of products to meet the needs of society and consumers. This can be achieved through innovation, quality enhancement, or efficiency by applying circular economy principles to generate greater market value in terms of quality, functionality, and competitiveness. In alignment with Indonesia's bioeconomy objectives, the creation of higher value-added must be accompanied by fair benefit-sharing across the entire value chain, preventing the exploitation of any single stakeholder.

2 Deployment of technology and innovation

The deployment of technology or biotechnology, i.e. the application of scientific knowledge and technical innovation, is key to enhancing efficiency, quality, and competitiveness in the utilization of biological resources. The use of technology within the bioeconomy process is expected to provide a key point of differentiation from extractive-based natural resource economic models. Such technology may include, but is not limited to, software, artificial intelligence, robotics, and automation across production, distribution, and service processes, or even the utilization of living organisms or biological components (biotechnology) across the entire value chain. Furthermore, this entails appreciation and recognition of the local wisdom and knowledge historically practiced by traditional communities. Such recognition may take the form of legal certainty over land sustainably managed by traditional communities, while the appreciation may be manifested through fair benefit-sharing derived from the utilization of intellectual property (IP) rights associated with traditional know-how in creating value-added bioeconomy products and innovations.

3 Promotion of enhanced well-being

This criterion aims to drive bioeconomy activities that elevate the quality of life, while restricting development that could be harmful, such as weaponry or products that impair human well-being. To drive sustainable development across economic, social, and environmental dimensions, bioeconomy development must be inclusive to foster human well-being. Economic welfare can be measured through rising community incomes generated by bioeconomy sectors such as sustainable agriculture, renewable energy, and biomass-based industries. The bioeconomy industry holds the potential to generate extensive employment opportunities across various stages of the value chain with diverse skill requirements, therefore offering opportunities to enhance people's well-being. Social well-being is measured by the active engagement and empowerment of communities in implementing bioeconomy programs.

B.3. Bioeconomy Principles

The bioeconomy initiative conceptualized in the GIB by G20 member states recommends ten bioeconomy principles. These principles were agreed upon for adoption by G20 member countries. Indonesia's bioeconomy can adopt these ten high-level bioeconomy principles in alignment with the context of Indonesian values, as follows:

Bioeconomy Principle 1

Integrate and promote sustainable development across its economic, social and environmental dimensions, contribute to eradicating hunger and poverty and improving health and well-being, whilst ensuring global food security and nutrition.

Relevance to the Indonesian context:

Sustainable Development:

2025-2045 RPJPN: Increasing added value in the processing of biological natural resources using bioeconomy as a new source of economic growth.

Eradication of Hunger and Poverty:

2025-2045 RPJPN: Creation of mid-to-high-level employment opportunities in productive sectors, including green and blue jobs.

Global Food Security and Nutrition:

2025-2045 RPJPN: Transforming food systems toward sustainable, healthy, and resilient food system eco-regions based on local resources and local wisdom.

Bioeconomy Principle 2

Be inclusive and equitable, uphold the rights of all individuals, including Indigenous Peoples and members of local communities, promote gender equality and the participation of all stakeholders. Relevance to the Indonesian context:

Indigenous Peoples and Local Community Rights

2025-2045 RPJPN: Thousands of Indigenous Peoples and local communities in Indonesia inhabit various regions rich in biodiversity and demonstrating high commitment to environmental sustainability. Agroforestry approach involves local communities.

Gender Equality

2025-2045 RPJPN: Strengthening gender mainstreaming and social inclusion to ensure no one left behind in development.

Bioeconomy Principle 3

Advance mitigation and adaptation efforts against global climate change, in line with applicable multilateral climate agreements. Relevance to the Indonesian context:

Climate change mitigation and adaptation:

2025-2045 RPJPN: Climate-resilient development to minimize potential economic losses resulting from climate change.

Bioeconomy Principle 4

Contribute to the conservation of biodiversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, subject to national laws and in line with applicable international agreements and instruments. Relevance to the Indonesian context:

Biodiversity components:

2025-2045 RPJPN: Genetic, species, and ecosystem diversity.

Sustainable utilization of biodiversity:

2025-2045 RPJPN: The utilization of biological resources as high value-added products, specifically pharmaceuticals, food, feed, materials, and energy to reduce reliance on fossil resources.

Bioeconomy Principle 5

Advance sustainable consumption and production patterns and the efficient and circular use of biological resources, whilst promoting the restoration and regeneration of degraded areas and ecosystems. Relevance to the Indonesian context:

Fair and equitable sharing of benefits arising from the utilization of genetic resources and traditional knowledge

2025-2045 IBSAP: The engagement and provision of financial and/or non-financial benefits for Indigenous Peoples and/or traditional communities as custodians of biological resources, including genetic resources, which serve as the source of livelihood for the community.

Bioeconomy Principle 6

Be developed through safe, secure, and responsible use of science, technology, innovation, and traditional knowledge, with potential benefits, risks, and impacts assessed scientifically. Relevance to the Indonesian context:

Use of innovation:

2025-2045 RPJPN: Strengthening the sustainable research and innovation ecosystem, including regulatory frameworks, financing and investment, and research personnel for bioeconomy development.

Bioeconomy Principle 7

Benefit from robust and coherent policy frameworks that foster trade for bioeconomy products and services, market conditions, sustainable business models, decent jobs, local value creation, and private sector and civil society participation. Relevance to the Indonesian context:

Coherent policy frameworks:

2025-2045 RPJPN: Macroeconomic stability is maintained, supported by increasingly robust synergy between fiscal and monetary policies in addressing various global and domestic pressures.

Sustainable business models:

Green Economy Index: This strategy aims to drive economic growth while fostering social well-being and preserving environmental quality.

Decent jobs:

Law No. 6 of 2023: The state must undertake various efforts to fulfill citizens' rights to work and a livelihood that is humane through job creation.

Bioeconomy Principle 8

Utilize transparent, comparable, measurable, inclusive, science-based, and context-specific criteria and methodologies to assess sustainability across the entire value chain. Relevance to the Indonesian context:

Sustainability assessment:

Example: Indicators from the Green Economy Index.

Bioeconomy Principle 9

Be fostered by international collaboration and cooperation that addresses global challenges, leverages complementary strengths, innovation, and entrepreneurship, and promotes financing, capacity building, and the sharing of best practices. Relevance to the Indonesian context:

International collaboration and cooperation:

President Regulation No. 59 of 2017: Enhancing North-South, South-South, and triangular cooperation at regional and international levels, as well as access to science, technology, and innovation, and improving knowledge-sharing based on mutual agreement, including through enhanced coordination among existing mechanisms, particularly at the United Nations (UN) level and via global technology facilitation mechanisms.

Bioeconomy Principle 10

Be based on country-specific approaches and implemented in line with national priorities and regional and local circumstances. Relevance to the Indonesian context:

National priorities, regional and local circumstances:

Enshrined in Law No. 59 of 2024 concerning the 2025-2045 RPJPN.

B.4. How Bioeconomy, Green Economy, and Blue Economy are Interconnected

In the sustainable economy landscape, bioeconomy is interconnected with other paradigms such as green economy and blue economy, despite differences in scope, focus, and content (Kardung et al., 2021). These concepts are mutually connected and share a common objective, namely, to develop a sustainable and environmentally friendly economic system. As illustrated in Figure 1, the interconnection between bioeconomy and green economy focuses on the sustainable use of biological resources, such as biofuel production from crops, which simultaneously reduces carbon emissions and support green economy. Meanwhile, the interconnection between bioeconomy and blue economy involves the sustainable use of marine resources, such as ecosystem-based aquaculture, representing an intersection of both concepts. Furthermore, the interconnection between green economy and blue economy emphasizes sustainable ocean management, including marine renewable energy and marine conservation.

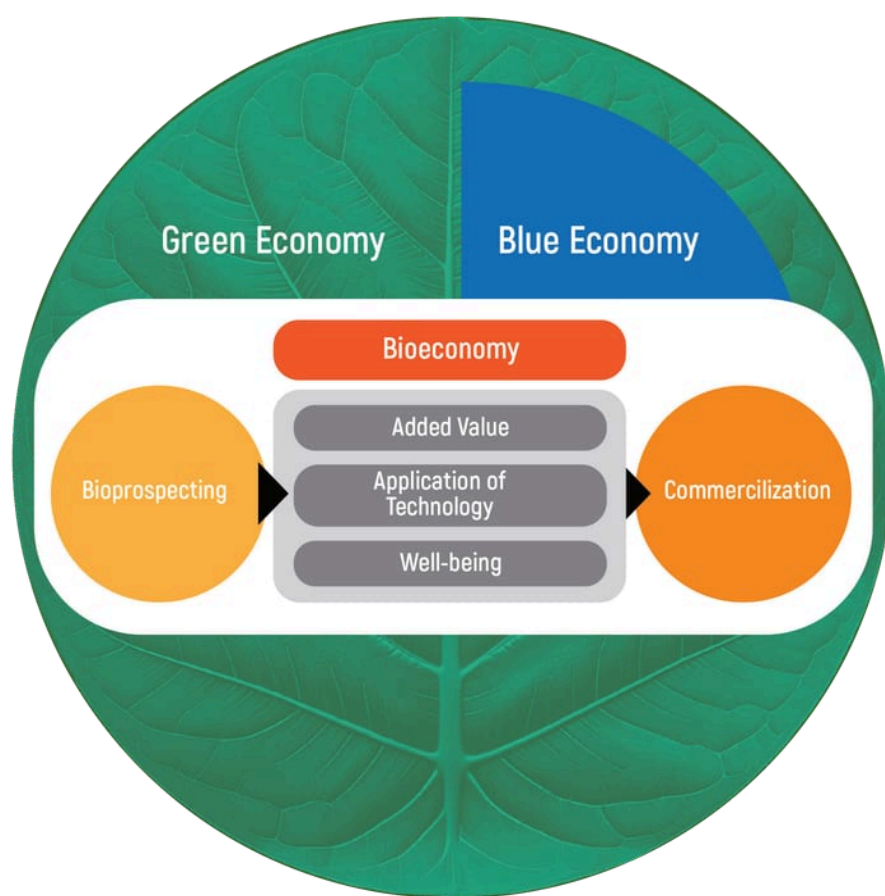


Figure 1. Bioeconomy Framework in Indonesia's Economic System

Understanding the interconnections between bioeconomy, green economy, and blue economy centers on three key aspects: (i) synergy: integrating these three concepts can lead to better outcomes in sustainable development; Understanding the interconnections between bioeconomy, green economy, and blue economy centers on three key aspect;

(ii) innovation: understanding the relationships between these concepts can spur new innovation and more comprehensive solutions; and (iii) decision-making: a sound understanding of these relationships can help policymakers design more effective policies.

A study conducted by Cendekia Iklim Indonesia, based on a systematic literature review and policy document analysis, examined 147 documents retrieved from the Scopus database, 87 of which were selected through the PRISMA process. The study identified differences in focal areas among the concepts of the circular economy, bioeconomy, green economy, and restorative economy. While these concepts overlap in certain areas, they complement each other in others. A summary of their key differences is presented in the following table.

Dimension/ Concept	Bioeconomy	Circular Economy	Green Economy	Restorative Economy
Natural capital	Management of biomass (bioresources) stock and quality , and sustainable valorization of residues and by-products .	Natural capital maintenance and regeneration by closing the loop (reuse, recycle, remanufacturing, reduction of waste).	Natural capital investment and protection with safeguards as the basis of green growth .	Rehabilitation and restoration of damaged ecosystems through active restoration.
Human capital	Technical and social skills across the biomass value chain (farmers, fishers, technicians, scientists, local communities).	Organizational capacity building and knowledge development to support the adoption of circular models.	Improvement of public knowledge and awareness of sustainability.	Technical and social expertise for long-term restoration and stewardship.
Financial capital	Investment and business viability across bio-based value chains (production, processing, and biotechnology).	Capital as a driver of innovation and circular business models .	Green incentives and financing to steer the economy.	Financing for restoration projects and the transition to restored ecosystems.
Policy & regulation	Cross-sectoral policy frameworks for the management of biomass, bioindustry, ethics, and research and development (R&D).	Regulations that promote circularity, including extended producer responsibility (EPR), design standards, and incentives for circular businesses.	General green policies covering environmental standards, emissions, and nature conservation.	Policies that ensure ecological restoration and long-term tenure security.
Community role	Communities as producers, industry partners, and ecosystem stewards within bioeconomy value chains.	Stakeholder involvement in value creation within circular business models , with communities often positioned as users or markets.	Participation in green programs and policies, which are often top-down in nature.	Communities are central actors in socio-ecological restoration projects.

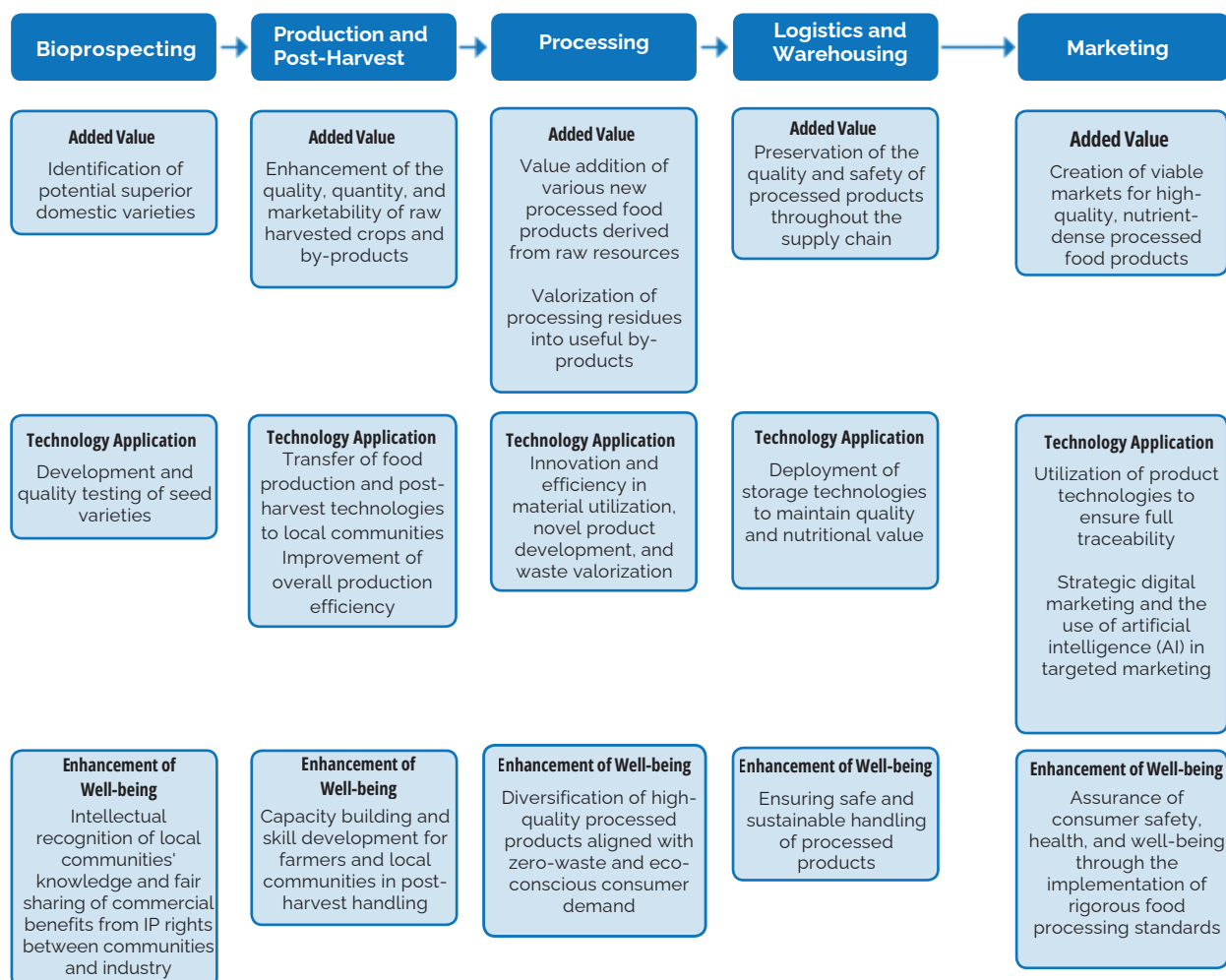
The study indicates that each economic concept has a distinct focus, allowing them to complement one another. Bioeconomy primarily emphasizes value chain development for bio-based products, while circular economy focuses on efficient use of resources through closed-loop principles. Meanwhile, literature on green economy tend to emphasize on investment, policy, and shifts toward more sustainable behavior. Restorative economy, in contrast, places greater emphasis on ecosystem conservation and restoration.

B.5. Indonesia's Bioeconomy Value Chain Approach and Its Illustration

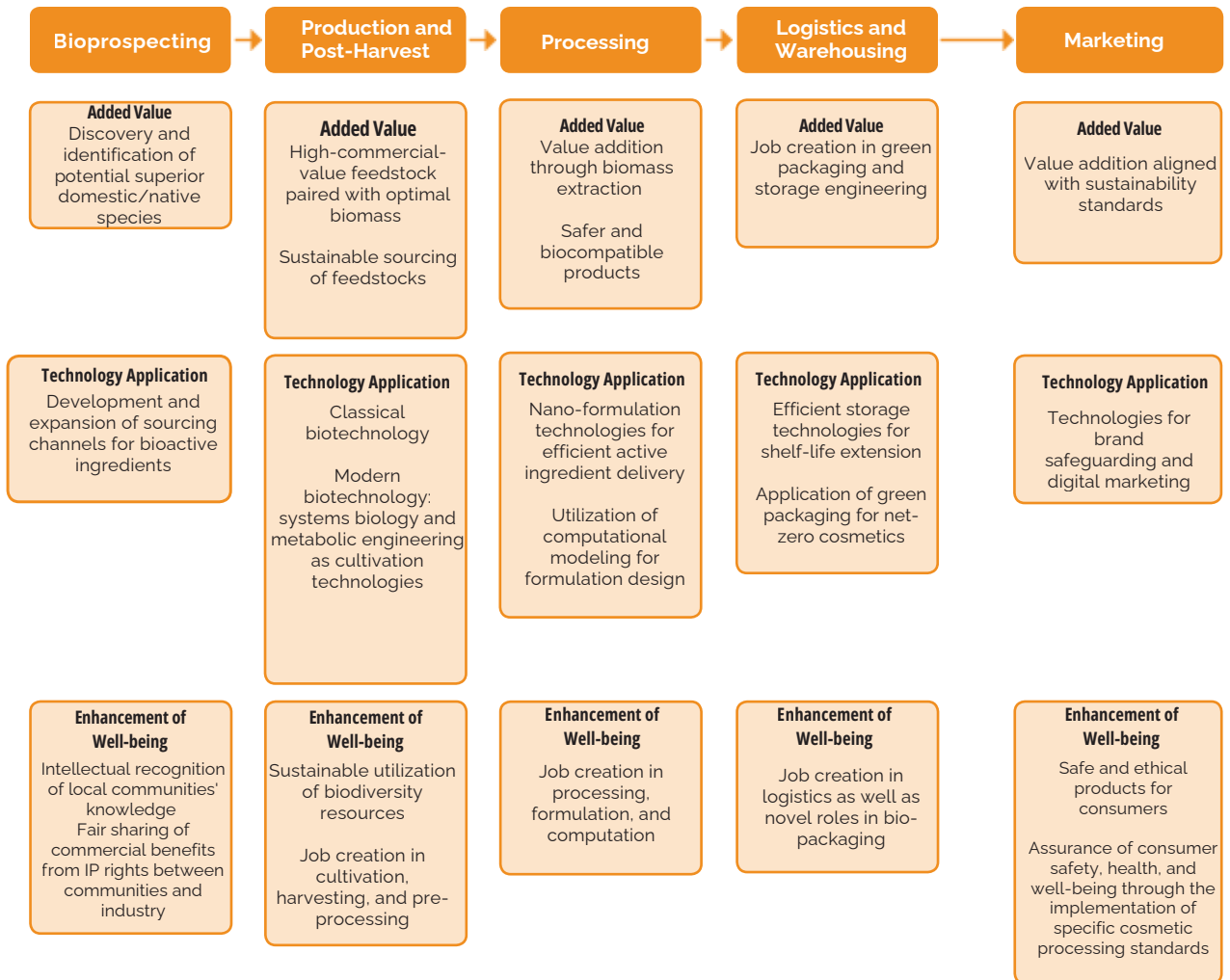
Building upon the framework for Indonesia's bioeconomy outlined above, the bioeconomy value chain spans from upstream to downstream operations and commercialization. Consequently, given bioeconomy's core emphasis on creating added value for bio-based products, Indonesia adopts an approach focused on comprehensive value chain development. To this end, bioeconomy development necessitates the prioritization of superior products or commodities to ensure that policymaking remains targeted and incisive.

Informed by expert insights and relevant stakeholder discussions, this concept emphasizes five leading clusters. These comprise high-value-added clusters such as cosmetics and health, clusters addressing fundamental human needs such as energy and food, and a cluster dedicated to safeguarding Indonesia's biodiversity, which serves as the primary source for bioeconomy development, namely, the environmental services cluster.

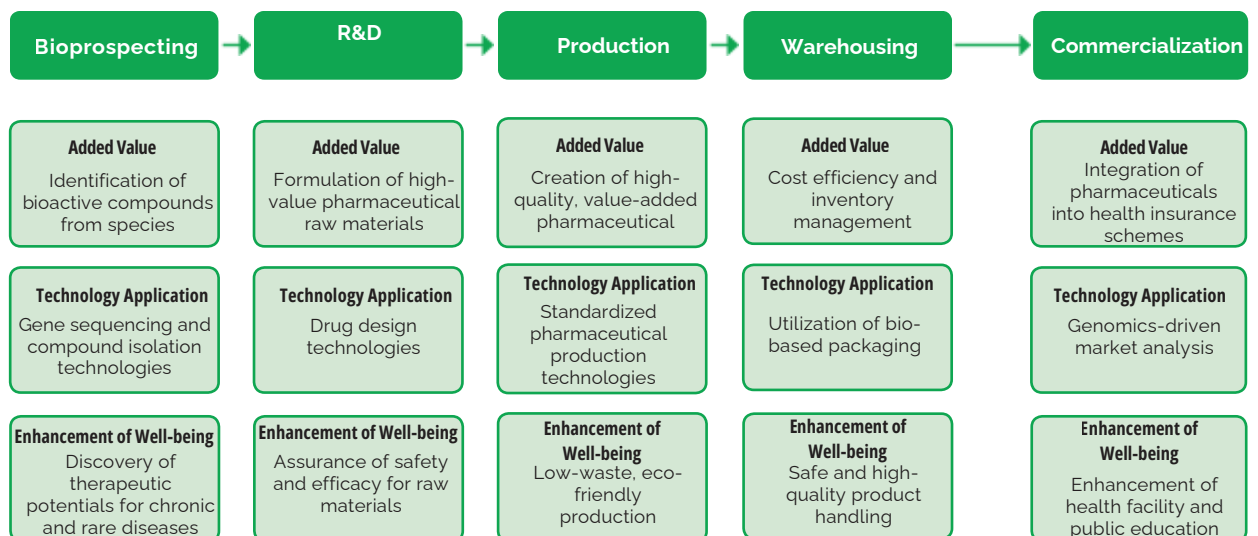
This section illustrates value addition, the application of biological resource processing technologies, and the enhancement of well-being across every tier of the bioeconomy value chain within selected clusters.



Cosmetic Illustration

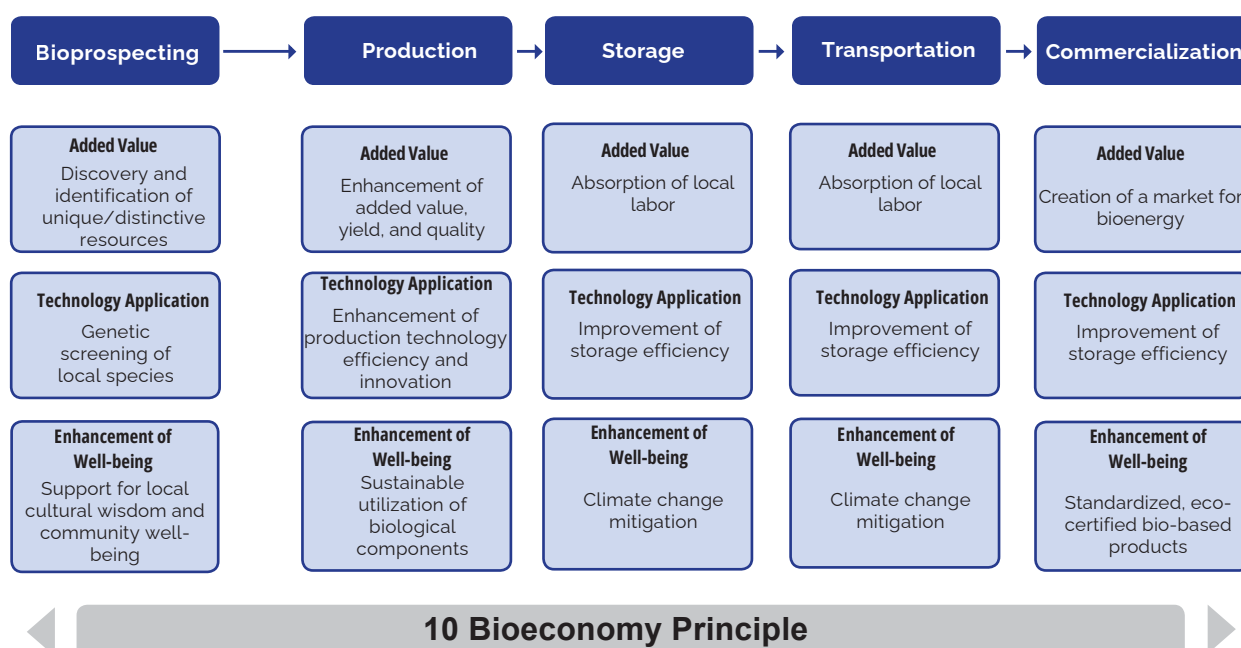


Green Pharmacy Illustration



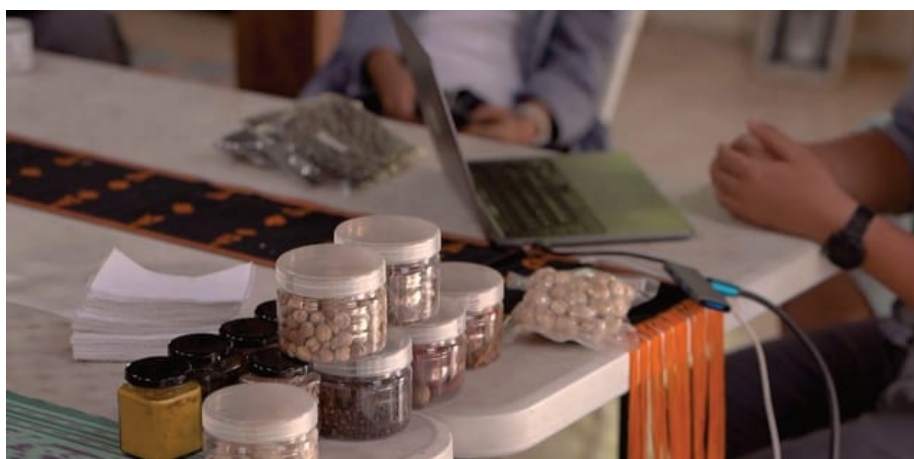
10 Bioeconomy Principle

Bioenergy Illustrationi



The two illustrations above depict the function of bioeconomy criteria and principles in guiding bioeconomy activities across Indonesia. The criteria serve to identify activities that must be carried out to achieve Indonesia's bioeconomy objectives. Concurrently, the principles serve as detailed safeguards to oversee bioeconomy implementation. Together, these criteria and principles function as essential instruments to safeguard the core values upheld in Indonesia's bioeconomy implementation.

In practice, the emphasis on principles and criteria within bioeconomy activities may vary across different product groups, depending on their respective operations. As illustrated above, for instance, the strategic focus in development of the phytopharmaceutical industry differs from that of bioenergy. Specifically, within the criteria for bioenergy, the emphasis on well-being centers primarily on generating low-pollution energy and contributing to climate change risk mitigation. Conversely, well-being in the phytopharmaceutical sector prioritizes products that enhance people's well-being, while emphasizing safe production backed by rigorous scientific evidence. Moving forward, further exploration is required for several priority activity groups in the implementation of bioeconomy.



B.6. The Role of Community Groups in Indonesia's Bioeconomy

The definition adopted as Indonesia's benchmark explicitly states that the development of bioeconomy aims to foster a just, prosperous, and sustainable economy while upholding the essence of humanity. Consequently, the advancement of bioeconomy in Indonesia represents not only an economic transformation, but a social transformation as well. Therefore, society must be viewed as a primary driver determining the successful implementation of bioeconomy, moving beyond an exclusive focus on large industries, and ensuring that citizens are not reduced to mere beneficiaries or laborers. Instead, they must be recognized as vital stakeholders within the bioeconomy value chain and governance structure.

Within the context of Indonesia's rich cultural diversity, the role of society, which includes local communities, Indigenous Peoples, and both formal and informal small-scale enterprises, can be articulated through an inclusive community-based bioeconomy model in three key roles: as community-based producers, industrial partners, and ecosystem stewards.



1. Communities Community-Based Producers

Communities act as direct managers of biological resources through various schemes such as social forestry, agroforestry, small-scale fisheries, family farming, and biodiversity-based micro-enterprises. As community-based producers, they form the backbone of local bioeconomy. Through this model, community groups can generate bio-based products tailored to their local capacities and needs.

To implement this model, policy interventions must focus on empowering communities to produce bio-based products capable of competing in the market. Such enterprise strengthening can be achieved by providing access to capital, fair market pricing, and capacity building and mentoring, including for technology adoption.



2. Communities as Industrial Partners

The development of bioeconomy focused on value addition and technological application is closely linked to industrial-scale downstreaming, which economically achieves higher efficiency than community-group economic models. In this context, Indonesia's bioeconomy requires community involvement in the industrialization of downstream bio-based products. However, community participation must not be restricted to providing labor; rather, communities must be positioned as equal partners within the supply chain. This includes roles as raw material suppliers or service providers to generate added value for bioeconomy products.

Within this bioeconomy model, key requirements include ensuring transparent and fair profit-sharing mechanisms, safeguarding the bargaining position of communities in partnership agreements, and facilitating technology and skills transfer so that community groups can meet the quality and quantity standards required by industrial partners.



3. Communities as Ecosystem Stewards

Within Indonesia's bioeconomy framework, the objective of this transformation extends

beyond economic considerations for the enhancement of human well-being. Consequently, preserving the sustainability of ecosystems and biodiversity, which serve as the foundational resources for bio-based production activities, constitutes a core pillar of Indonesia's bioeconomy framework. Given Indonesia's diverse societal and cultural landscape, ecological preservation is deeply embedded as local wisdom reflected in the cultural identity of its communities. Therefore, within this model, Indigenous Peoples and community-based groups serve as the frontline guardians of Indonesia's biodiversity, thus securing the continuous availability of raw materials and safeguarding future innovation potential for bioeconomy development.

This model requires formal recognition of community-driven efforts in biodiversity and ecosystem conservation. Such recognition can be carried out by providing legal certainty regarding land access, thus enabling Indigenous Peoples to practice sustainable land management rooted in local wisdom, whether through the legal recognition of customary land, the allocation of land via agrarian reform objects (Tanah Objek Reforma Agraria/TORA), or social forestry schemes. Furthermore, it is essential to strengthen capacity building and expand access to innovative financing mechanisms for biodiversity conservation, such as donor funding, carbon credits, biodiversity credits, and state budget (APBN) allocations.



Foto: Iswanto Arif

C.

Challenges and Opportunities for Bioeconomy Development in Indonesia





Challenges and Opportunities for Bioeconomy Development in Indonesia

C.1. Governance Framework for Bioeconomy Development in Indonesia

Policy and Regulation. The development of Indonesia's bioeconomy remains in its early stages, which operates within a fragmented policy framework that lacks comprehensive integration. While several overarching policies relevant to the bioeconomy exist, they remain heavily divided across sectoral silos. Consequently, greater policy alignment is imperative to foster cross-sectoral synergy.

Institutional Framework, Coordination, and Ecosystem. A robust ecosystem among key stakeholders encompassing the government, investors, industry, and market actors remains underdeveloped, underscoring the need for an integrated policy framework spanning from upstream production to downstream commercialization.

Financing, Investment, and Business. Indonesia currently faces a shortage of commercially viable business models, resulting in limited corporate investment appetite due to high risks and costs.

Technology and Innovation Development. Investments in R&D remain insufficient and tend to be concentrated within isolated business units, thus limiting Indonesia's capacity to optimize the full scope of its bioeconomy potential.

C.2. The Role of Biodiversity Potential in Supporting Bioeconomy Development in Indonesia

Indonesia is one of the world's mega-biodiversity countries, possessing exceptionally high terrestrial and marine biological resources. However, the vast majority of this potential remains largely unexplored and underutilized to this day. Based on recent data from the Ministry of Forestry, Indonesia's forest cover reached approximately 95.5 million hectares in 2024,

representing immense potential to supply raw materials for food, bioenergy, pharmaceuticals, cosmetics, and various other biomaterial products.

On the other hand, portions of production forest areas continue to face productive utilization challenges due to limited legal access, infrastructure, and investment, restricting their full optimization in supporting sustainable bioeconomy development.

Beyond terrestrial potential, Indonesia's marine bio-wealth harbors substantial opportunities, particularly for the development of aquaculture, marine-based food systems, and algae- or aquatic-based bioenergy. Based on recent data from the Ministry of Marine Affairs and Fisheries, Indonesia's maximum sustainable yield for capture fisheries is estimated at approximately 12 million tons per year. Meanwhile, average national fisheries production for the 2020-2024 period was recorded between 7.3 and 7.4 million tons annually, indicating ample room for expanding the sustainable utilization of marine resources through science-based and precautionary management.

To illustrate the application of bioeconomy principles in biological resource

management, bioeconomy modeling has been deployed to govern shrimp fisheries management in the Arafura Sea by estimating optimal harvest capacity based on two core parameters: biological and economic dimensions. Simulation results demonstrate that implementing a closed-season policy combined with a 2% resource rent tax successfully generates economic surplus via Non-Tax State Revenue (Penerimaan Negara Bukan Pajak/PNBP) while supporting stock recovery. This seasonal management approach has proven effective in safeguarding shrimp population sustainability, encouraging larger average shrimp sizes, and elevating the economic value of catches through higher market pricing. This practice highlights the importance of integrating biological science, economic instruments, and resource management to strengthen Indonesia's marine bioeconomy.

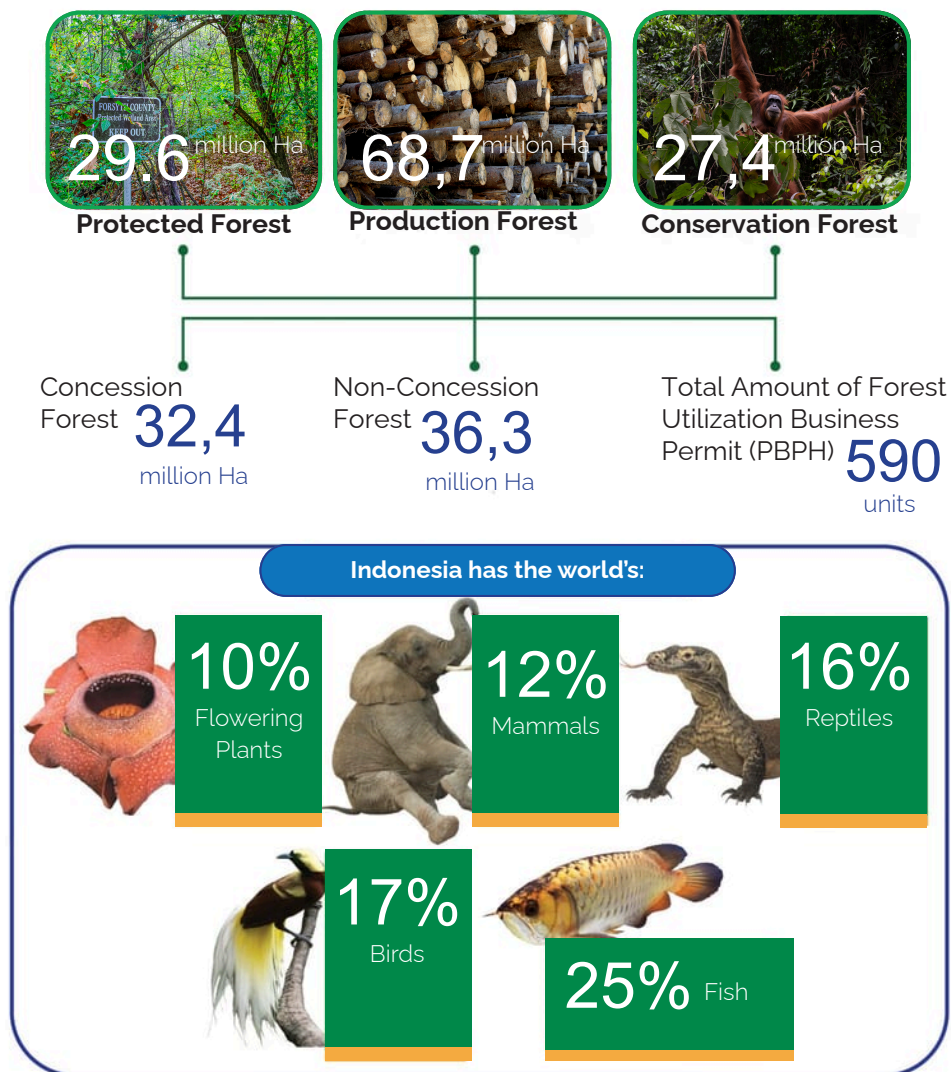


Figure 2. Biodiversity potential in Indonesia to support bioeconomy development
(Source: MoEF 2024)

C.3. Bioeconomy to Support Economic Growth

The contribution of bioeconomy to Gross Domestic Product (GDP) and exports demonstrates significant potential, particularly within the agriculture, forestry, fisheries, and renewable energy sectors. According to data from Statistics Indonesia (BPS), the agriculture, forestry, and fisheries sectors contributed approximately 12.61% to the total national GDP in 2024, with an absolute value reaching IDR2,791,428 billion.

This positions these sectors as core pillars of the national economy, driven primarily by the value addition generated from bio-based products.

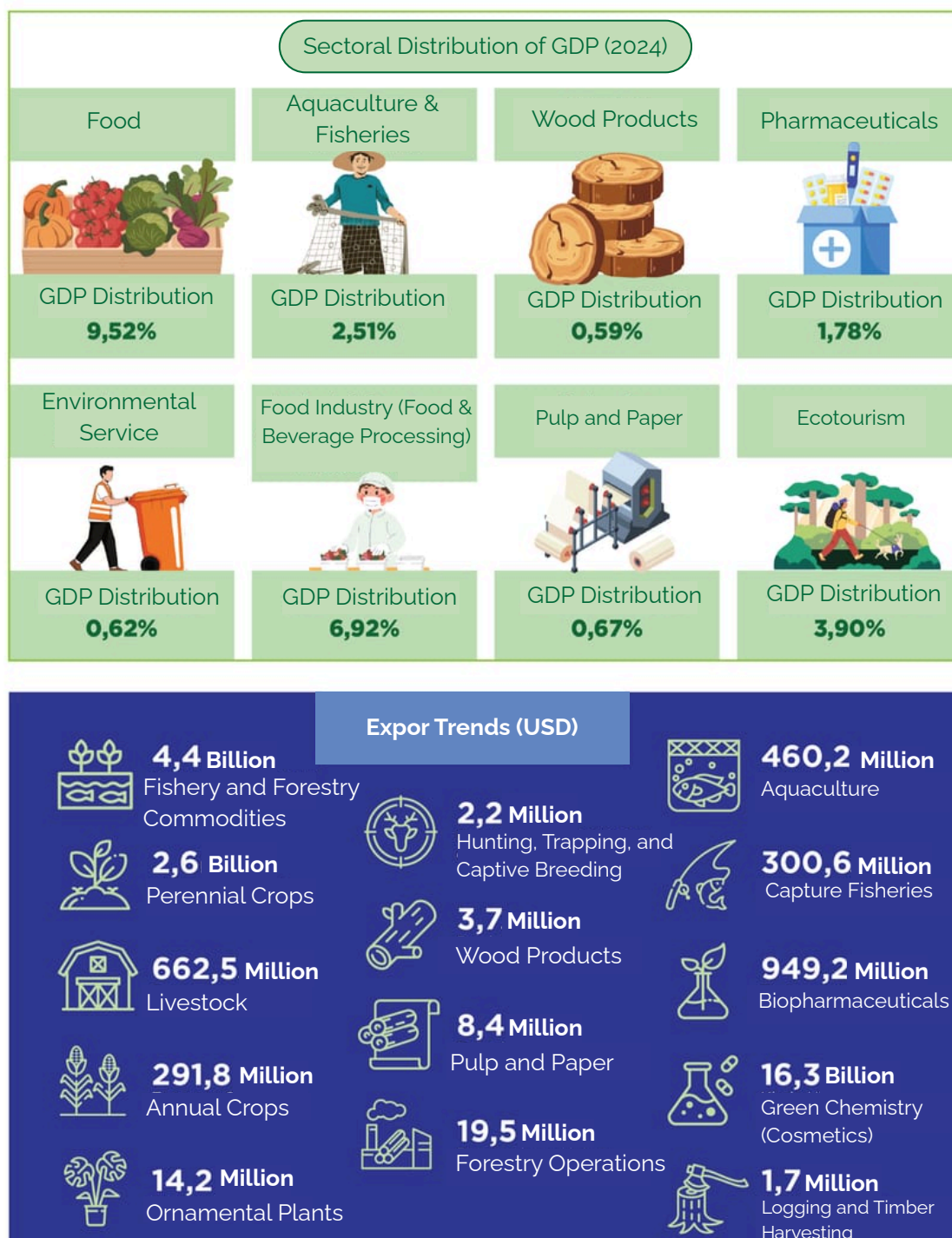


Figure 3. Sectoral Distribution of GDP and Export Trends of Potential Bioeconomy Commodities (Source: BPS 2023; 2024).

C.4. Technology, Research, and Innovation to Support Bioeconomy Development in Indonesia

Indonesia continues to face significant challenges in strengthening its national technology, research, and innovation capabilities despite positive developments in recent years. According to the latest data from the World Intellectual Property Organization (WIPO) through its Global Innovation Index (GII), Indonesia ranked 54th out of 133 economies in 2024 for overall innovation capacity. This improvement suggests that national efforts to build the innovation ecosystem are yielding tangible results following a period of stagnation. Indonesia ranked 75th in 2022, improved to 61st in 2023, and rose further to 54th in 2024.



Figure 4. The condition of technology, research, and innovation to support bioeconomy development (Source: GII 2025).

However, structural challenges remain significant, particularly regarding investment in R&D and human capacity for research. Although the GII assesses multiple dimensions of innovation, its 2024 report highlights that Indonesia 'performs worse in innovation inputs than innovation outputs.' This indicates that innovation inputs, including institutions, human capital and research, infrastructure, and business sophistication, remain areas of weakness.

On the output side, progress is demonstrated

by the growing number of IP registrations, including patents, copyrights, and industrial designs. Recent reports have also highlighted significant IP achievements by national institutions, alongside increases in scientific publications and global citation rates. However, these innovation outputs have yet to be adequately matched by sustained improvements in innovation inputs, raising the risk of stagnation unless investments in R&D and human research capacity are strengthened.

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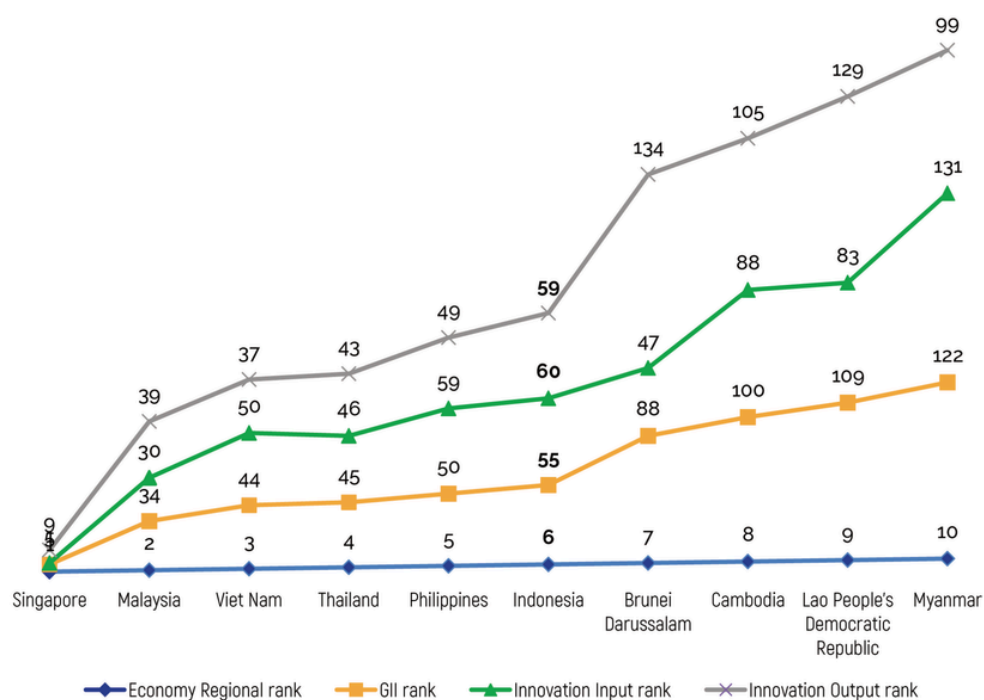


Figure 5. The condition of technology, research, and innovation to support bioeconomy development (Source: GII 2025)

Human resource capacity in research, science, and technology also remains a structural challenge. According to a report by the National Research and Innovation Agency (BRIN), Indonesia had approximately 445,521 human resources in science and technology (HRST) in 2023, equivalent to approximately 1,596 personnel per million inhabitants. However, the vast majority of HRST personnel (approximately 95%) were concentrated in the higher education sector, while private-sector and industry involvement remained limited, despite their importance in technology commercialization and industrial downstreaming. This imbalance restricts Indonesia's ability to drive technological innovation across sectors, accelerate knowledge transfer, and translate research into productive applications. It also highlights the country's reliance on the public sector for research and innovation, representing a structural weakness in the national innovation ecosystem.

The upward trend in Indonesia's GII ranking indicates a growing innovation potential. However, fully realizing this potential will require strategic measures,

including increased R&D investment, expansion of the research workforce, enhancement in researcher quality, as well as fostering the role of the private sector and strengthening public-private collaboration.

In the context of bioeconomy, which involves economic transformation through the utilization of biological resources, agroforestry, green technology, and environmental innovation, research and innovation play a critical role. Bioeconomy requires research, technology, and innovation to support the downstreaming of natural resources, creation of biodiversity-based products, efficient and sustainable use of resources, and development of green industries. Without adequate investment in R&D and strong research capacity, Indonesia will face difficulties in developing bioeconomy technologies, translating research outputs into downstream applications, and building science-based sustainable industries and practices.

Therefore, R&D and innovation must be acknowledged as key enablers of bioeconomy. Policies that incentivize increased R&D expenditure, STEM education, and effective incentive structures for research and innovation will be critical to the success of Indonesia's bioeconomy transformation in the years ahead.

D.

Policy Directions for Bioeconomy Development in Indonesia



D

Policy Directions for Bioeconomy Development in Indonesia

Bioeconomy plays a strategic role in driving sustainable economic growth and preserving environmental integrity in Indonesia. The formulation of a comprehensive policy direction serves as a foundation and guiding framework to advance bioeconomy-related sectors such as food, energy, cosmetics, pharmaceuticals, and environmental services while upholding environmental sustainability. Key policy directions for bioeconomy development in Indonesia, based on national and global bioeconomy policy trajectories, include:



1

Advancement of Research and Innovation

Strengthening basic and applied research in biotechnology, particularly across the agriculture, forestry, maritime, and industrial sectors. Research outputs are expected to drive innovation in developing high-value bioeconomy products.



2

Integration and Application of Research Findings

Integrating biotechnology research outputs into industrial sectors to enable practical applications in product and technology development. This aims to establish efficient supply chains and enhance value addition for bioeconomy products.



3

Development of Supporting Components

Preparing foundational supporting components for bioeconomy, such as infrastructure development, human resource capacity, and raw material supply.



4

Strengthening of Value-Added Chains

Building value-added chains for bioeconomy products by processing raw materials into higher-value goods for both domestic and export markets. This includes the development of complex products derived from Indonesia's natural resources.



5

Promotion of Bioeconomy Product Exports

Enhancing the competitiveness of Indonesia's bioeconomy products in global markets. Bio-based products, particularly those with high value-added, are incentivized for export to increase foreign exchange earnings.

In addition, supporting policy directions for Indonesia's bioeconomy development include:



Conserving and Restoring Ecosystems

To maintain the sustainability of bioeconomy, this policy includes ecosystem conservation and restoration measures. This is critical for safeguarding Indonesia's biodiversity wealth and ensuring resilience against climate change.



Developing Monitoring and Evaluation Instruments

To ensure the sustainable development of bioeconomy, monitoring and evaluation (M&E) instruments are established to govern and monitor the implementation of bioeconomy policies. This M&E framework plays a key role in ensuring that bioeconomy development aligns with sustainability principles.

Based on the formulated policy directions, the implementation of Indonesia's bioeconomy development will be carried out across in phases to align with the Indonesia Emas 2045 Vision, as illustrated in Figure 5 below.

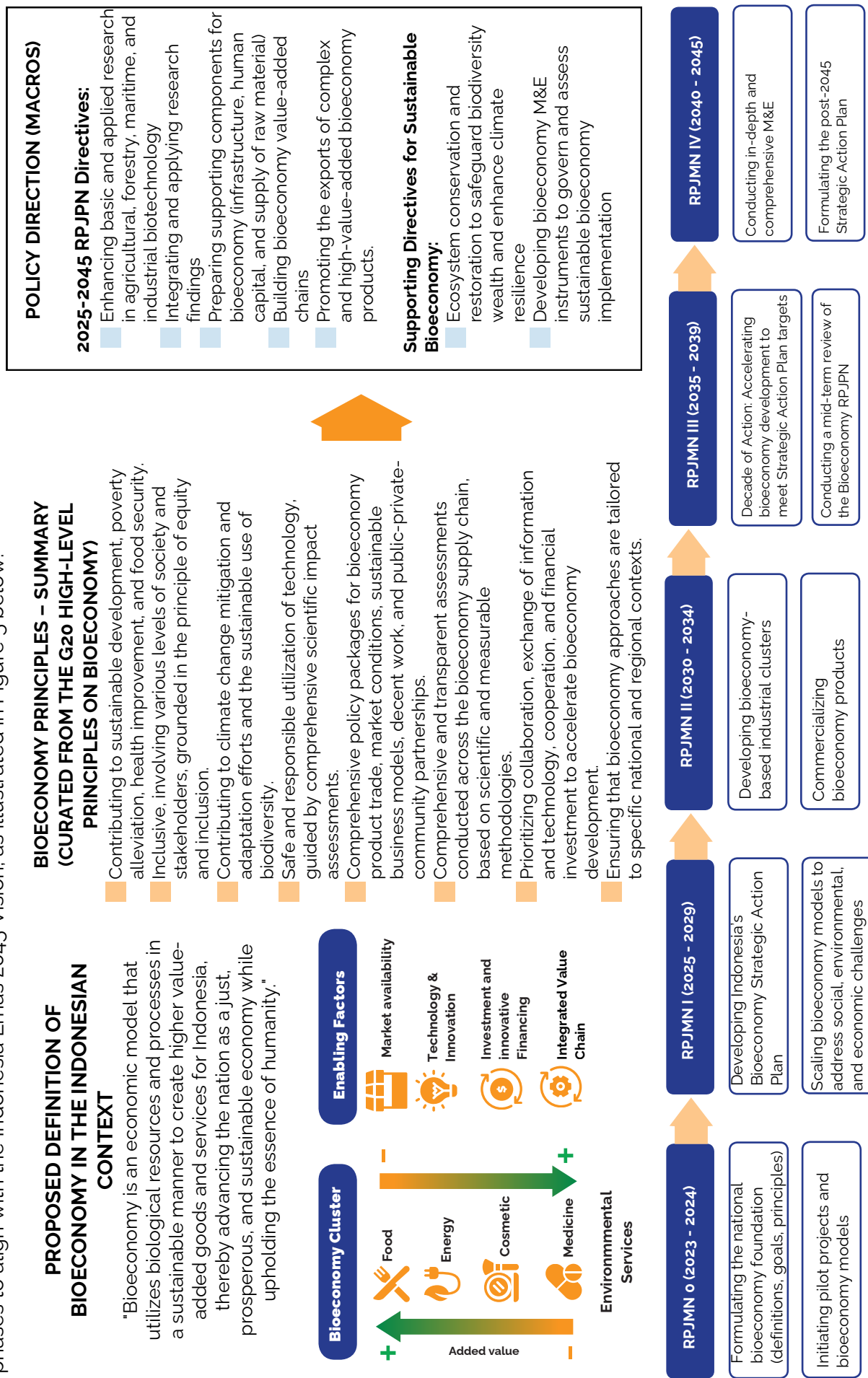


Figure 5. Bioeconomy Policy Direction

During Period 0, the outline of Indonesia's direction for bioeconomy development is prepared while defining and refining the scope of bioeconomy development to be adopted in Indonesia. The scope, principles, and definition need to be formulated by taking into account Indonesia's 2045 development trajectory and global bioeconomy developments. In addition, the initiation of bioeconomy pilot projects is also carried out to obtain an operational overview and identify the ideal model for bioeconomy development.

In Period 1 of the RPJMN (2025-2029), bioeconomy development will focus on formulating a detailed plan for future bioeconomy development. This plan will be articulated in a Strategic Action Plan that serves as a framework for cross-sectoral collaboration in developing bioeconomy. Development includes bioeconomy models that address three core values: economic growth, social well-being, and environmental preservation. This step aims to obtain effective and sustainable bioeconomy models for addressing development issues in Indonesia.

In Period 2 of the RPJMN, bioeconomy strategy is directed toward the establishment of bio-based industrial zones. This strategy is formulated to enhance bioeconomy's contribution to Indonesia's GDP growth through an industrial cluster approach. The bio-based industrial cluster approach is expected to: 1) increase efficiency in producing bio-based commodities; 2) accelerate innovation and R&D in bio-based product development; and 3) share existing resources, including human capital with specialized expertise, to optimize the quantity and quality of available resources, thereby enhancing the operational capabilities of the cluster.

Periods 3 and 4 represent the final stages, which can be referred to as the "period of action." Implementation efforts are accelerated to achieve the established bioeconomy targets. Additionally, in Period 3, efforts will prioritize the mid-term review of the RPJPN. In Period 4, activities are focused on conducting in-depth and comprehensive M&E, as well as formulating post-2045 bioeconomy policy directions based on key lessons learned.



E.

Way Forward



This study offers a strong foundational framework for bioeconomy development in Indonesia, but effective implementation requires further elaboration on several strategic aspects. One key area is refining the scope of bioeconomy, which includes clearly defining which activities can be classified under bioeconomy. This is essential for creating a shared understanding among stakeholders. For example, the inclusion of environmental services in bioeconomy programs requires further examination to define their position within bioeconomy's three criteria.

The next step is to formulate a detailed and actionable Strategic Action Plan to guide bioeconomy development. This plan must include measurable targets, indicators, and implementation stages to support the integration of the bioeconomy into national and regional development. Furthermore, new policies and regulations need to be identified to establish a supportive ecosystem. Examples include specific regulations regarding biotechnology utilization, incentives for bioeconomy industries, and governance of environmental services. Adjustments to existing regulations are also required to ensure policy synergy across sectors. This strategic plan policy approach will further account for the proportional role of business actors alongside the government. This is founded on

the fact that business actors serve as the spearhead for successful bioeconomy value chain development, while the government serves as an enabler through its policies.

This initiative also focuses on developing a traceability system, which holds strategic value in ensuring responsible practices from upstream to downstream. Furthermore, traceability system will serve as a hub for sustainable business actors to coordinate regarding off-takers and upstream producers committed to sustainable practices, thus accelerating the establishment of value chains between business-to-business actors as well as community-to-business entities.

In addition, policy innovations supporting the development of bio-based economic zones must be examined as potential strategic measures to enhance Indonesia's bioeconomy competitiveness. Challenges such as the limited shelf life of biological raw materials and high logistics costs require solutions in the form of integrated biomass processing infrastructure within designated areas. A bio-industry cluster-based approach will enable efficient processing, reduced logistics costs, and increased economies of scale. This supporting infrastructure must be complemented by the strengthening of value chains and technological innovation to produce competitive bio-based products in domestic and global markets.



Conclusion

Bioeconomy plays a strategic role as a new driver of economic growth to achieve the Indonesia Emas 2045 Vision. As a holistic approach, bioeconomy enables the sustainable utilization of biological resources by balancing economic growth, environmental preservation, and people's well-being. Through bioeconomy development, Indonesia is committed to low-carbon development, targeting a 93.5% emission reduction, an environmental quality index increase to 83.0, and a 0.8% reduction in poverty levels. Furthermore, a 10% increase in demand for bio-based products is projected to generate a 9% contribution to national GDP.

In the future, Indonesia is expected to serve as a benchmark for other countries in developing a sustainable and innovative bioeconomy. The forestry, agriculture, fisheries, industrial, and private sectors along with civil society must work together to build an integrated bioeconomy ecosystem. Cross-sector collaboration will ensure that every segment of the supply chain functions optimally, from raw material sourcing to industrial downstreaming.

Overall, bioeconomy acts as a catalyst capable of accelerating the realization of the Indonesia Emas 2045 Vision, leading the nation onto a more inclusive, innovative, and sustainable path for development. By optimizing biological wealth and applying circular and low-carbon economy principles, Indonesia can achieve sustainable and highly competitive economic growth in the era of globalization, while preserving environmental sustainability and social well-being for future generations.









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