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THE BIOECONOMY AS THE LEAPFROG IMPERATIVE: GOVERNING FOR EQUITY AS THE KEY TO UNLOCK THE TRANSFORMATIVE POTENTIAL OF A GLOBAL BIOECONOMY

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The post-fossil-fuel inflection point

For over two centuries, economic growth has been powered by fossil-fuel-derived and carbon-intensive technologies across industrial supply chains. This model delivered prosperity but relied on ecological externalization and extractive patterns. Planetary boundary science now demonstrates that climate stability and biodiversity integrity are no longer peripheral concerns but structural economic constraints.¹ The global bioeconomy is emerging as one of the few credible pathways capable of structurally displacing the fossil-fuel-based economic model. Rather than relying on finite, carbon-intensive inputs, the bioeconomy reorients production around renewable biological resources, circular material flows, and biological processes, alongside the renewable energy transition. This is not an incremental greening of existing systems; at its most transformative, it represents a fundamental shift in how

¹ Rockström et al. (2009); Steffen et al. (2015).

energy, materials, food, chemicals, and medicines are produced, and how value is distributed across economies. It represents a reconfiguration of production systems around biological metabolism, a shift from fossil extraction to regenerative cycles.²

The often-cited economic potential of the bioeconomy remains striking: The global bioeconomy, currently estimated at \$4 to \$5 trillion, is projected to grow to as much as \$30 trillion by 2050.³ This rapid expansion represents a potential sevenfold increase from its current value, serving as a critical pillar for sustainable economic development.

However, it is important to note that the bioeconomy is not inherently sustainable. Largely understood as replacing, where possible, fossil fuels with renewable biological resources as an economic base, it can carry similar environmental risks of land use change, competition with food production, and biodiversity loss. Many of the countries featured in this chapter have taken these factors into consideration and have policies and regulations in place, as well as participating in and conforming to international commitments. This includes the G20 High-Level Principles on Bioeconomy, which provide clear parameters on what a sustainable and equitable bioeconomy is.⁴ True sustainability in the bioeconomy, as in other realms, requires intentional design to operate in a circular, resource-efficient, and waste-reducing manner—for this, a value web approach is most helpful.

It is also important to note that accelerating climate change and biodiversity loss mean that the window for harnessing the full potential of the bioeconomy is narrowing. Without protecting, restoring, and investing in the ecological infrastructure upon which the bioeconomy depends, its long-term viability and ability to deliver resilience may be significantly undermined.⁵ So while the global trends and opportunities outlined in this chapter are indicative of the bioeconomy's potential to transition the global economy toward a more sustainable economic model, it is worth keeping in mind that the very crises that demand the shift to a more bio-based, circular, and sustainable economic model also threaten the opportunity to harness this potential. Likewise, much of this chapter will focus on equity concerns as a critical design characteristic for achieving a transformative new economic model.

That being said, beyond sustainability considerations, by positioning nature as a transition driver and shock absorber, the bioeconomy offers tools for adaptation and resilience. These range from climate-smart, drought-resilient crops to landscape restoration that reduces flood risk, sustainable forestry that stabilizes watersheds, and other nature-based solutions safeguarding infrastructure and livelihoods.⁶ Decentralized bioenergy systems can improve energy security, especially in rural and peri-urban areas where grid access remains constrained.⁷ Not only do these interventions limit climate- and biodiversity-related losses, but they also establish the basis for emerging economic activities in ecosystem services, bio-inputs, and resilient food systems.⁸

A structurally sound, sustainable, and regenerative bioeconomy should not replicate the extractive patterns that characterize much of the modern economy today. This applies both at the local level, in how Indigenous knowledge is recognized, valued, and fairly remunerated, and at the international level, in how resources, biodiversity, and genetic information from the Global South are utilized and valued across global supply chains.

2 McCormick and Kautto (2013).

3 NatureFinance and IDB (2025).

4 See more on the G20 High-Level Principles on Bioeconomy at <https://www.gov.br/g20/en/tracks/sherpa-track/bioeconomy-initiative>.

5 NatureFinance and IDB (2025).

6 NatureFinance and IDB (2025); NatureFinance (2026).

7 NatureFinance (2026).

8 Ibid.

Defining the bioeconomy

While there is no globally accepted definition of the bioeconomy and each country takes a different approach to policy and implementation, the bioeconomy is broadly “understood as turning renewable biological resources into higher-value products, industries, and jobs; replacing extractive, low-value exports with diversified, innovation-driven value chains.”⁹ In short, the bioeconomy is an economy with a renewable biobase involving the use of biomass and biotechnology in the production of goods, services, and energy.”¹⁰

The bioeconomy represents far more than a shift in production systems. It offers a strategic pathway for decoupling economic growth from resource depletion, while enabling new forms of value creation and a new bio-based development approach. At its core, the bioeconomy seeks to improve resource efficiency by transforming renewable biological resources into valuable products and services with lower waste and reduced environmental impact. Figure 9.1 shows how it operates across a range of economic sectors.

FIGURE 9.1

The bioeconomy is best understood as a broad framework



SOURCE: NatureFinance (2026).

NOTE: This framing is deliberately broad, encompassing the use of biomass and biotechnology in well-established sector-based categories, including the blue, green, red, white, and circular economies.

⁹ Escobar and Laibach (2021); NatureFinance (2026), 20.

¹⁰ Ólives (2024); NatureFinance (2026), 20.

When a whole-of-government, mainstream approach is taken with the bioeconomy, it is able to leverage natural resources and technologies to tackle:

- Natural resource scarcity, including food security, energy security, and various inputs across agriculture, construction, and manufacturing;
- Fossil resource dependence;
- Climate change;
- Waste generation;
- Loss of biodiversity; and
- Macroeconomic risks by investing in economic diversification and restoring ecological infrastructure.

While the bioeconomy is often framed in climate and nature circles in terms of the creation of value from extraction of raw materials from natural resources, a core element of it is primarily driven by bio-innovation and is knowledge-intensive in character.¹¹ Synthetic biology, AI-enabled protein modeling, and digital sequence information are accelerating biological innovation at unprecedented rates.¹² Industrial biotechnology now underpins sectors ranging from bio-based plastics to pharmaceutical bio-fermentation. The convergence of biology and data has led some analysts to describe this as the biological industrial revolution.¹³ The commercial opportunity therefore lies in biological design capacity, value addition, intellectual property, and supply chain resilience, not simply raw biomass extraction. In practice, much of this innovation must take place within existing and established sectors and industries, to make them more circular, less resource-intensive, and less reliant on fossil fuels, while also creating entirely new value chains and industrial opportunities such as the use of biofuels, biofertilizers, and biomaterials such as bioplastics, among others (for example, see figure 9.2, which takes a cross-cutting value web approach to understanding the bioeconomy's cross-sectoral potential).

However, this emerging biological industrial revolution also carries significant risks. Increasingly, countries are beginning to view bio-innovation, genetic resources, and biological data not only through an economic lens but also as matters of strategic and national security importance. Control over biological data, sequencing capabilities, food systems, pharmaceutical innovation, and biomanufacturing capacity may increasingly shape geopolitical influence, industrial competitiveness, and economic resilience in the decades ahead.¹⁴

There is a concern that while this new revolution has the potential to create multibillion-dollar enterprises, advanced manufacturing ecosystems, and high-value intellectual property in more developed markets, it may simultaneously deepen existing inequalities in less developed economies if governance, financing, scientific capacity, and value retention mechanisms are not deliberately addressed. There is therefore a real risk that biodiversity-rich countries once again remain suppliers of raw biological materials and genetic resources, while the highest-value innovation, processing, ownership, and commercial benefits accrue elsewhere. As explored later in this chapter, this tension is becoming increasingly visible in discussions around digital sequence information, benefit-sharing, and bioeconomic sovereignty.

11 Birch and Tyfield (2013); Levidow et al. (2012).

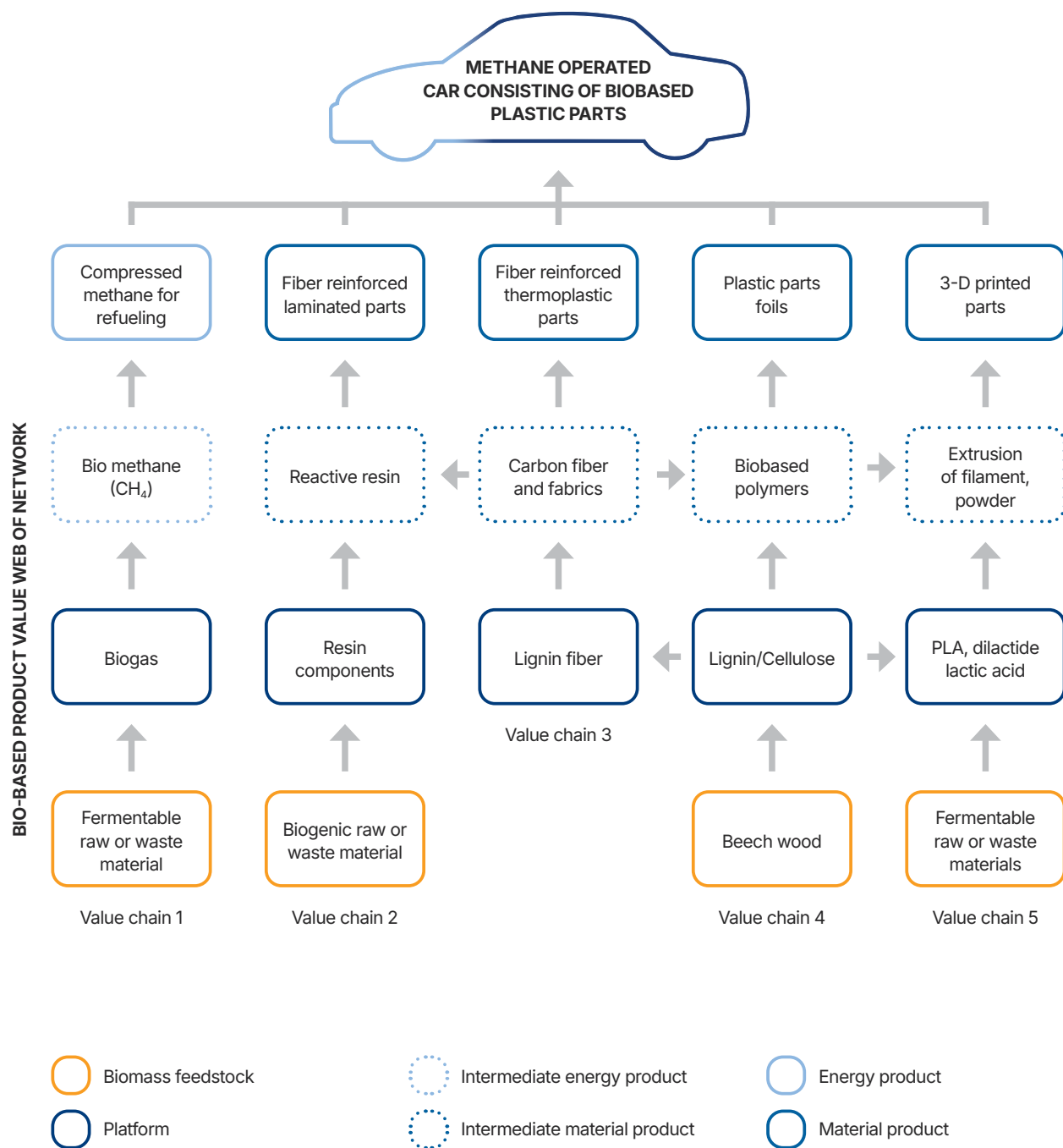
12 Das et al. (2026).

13 Stansfield and Borge (2025).

14 Ibid.

FIGURE 9.2

Bio-based value webs in action



NOTE: A car built with bio-based plastic components and running on biomethane shows how biomass feedstock enters multiple value chains.

SOURCE: Adapted by NatureFinance from Lewandowski et al. (2026), 80, licensed under CC BY 4.0 (<https://creativecommons.org/licenses/by/4.0/>). Spelling and visual presentation modified to conform to Brookings style.

Global momentum to scale the bioeconomy

The recognition of this shift has been gaining greater traction in multilateral fora. As president of the G20 in 2024, Brazil led the creation of the G20 Bioeconomy Initiative (GIB), the first structured effort at a plurilateral level to define High-Level Principles on Bioeconomy.¹⁵ These principles promote the circular use of biological resources, sustainable production, shared benefits, decent jobs, and innovation; they serve as a voluntary guide for member countries. The G20 initiative was designed to embed bioeconomy thinking across multiple policy dimensions, not just environment ministries but also industry, trade, science, and technology, precisely to ensure that bioeconomy agendas are coherent with broader development and innovation policies. Under the Brazilian and the subsequent South African G20 presidencies, the GIB has also started translating principles into actionable workstreams, including trade and innovation cooperation. Brazil's leadership on the bioeconomy deepened during its 2025 COP30 presidency, where it helped launch the Bioeconomy Challenge—a multistakeholder platform to operationalize the G20 principles and support measurable, inclusive market development by 2028.¹⁶ For the first time at a COP summit, the bioeconomy was formally acknowledged as a strategic mechanism for accelerating the implementation of Nationally Determined Contributions (NDCs).¹⁷ The Bioeconomy Challenge targets gaps in metrics, finance, market development, and Indigenous knowledge, aiming to make the bioeconomy measurable, investable, and inclusive.

South Africa's GIB in turn helped shape the establishment of the African Bioeconomy Finance Hub, set up to catalyze and drive investment into the potential of the African bioeconomy across four pillars: (i) policy enablement, (ii) capacity building, (iii) data and metrics, and (iv) investment catalyzation.¹⁸ Likewise, Germany's Global Forum for Food and Agriculture in January 2025 took "Farming a Sustainable Bioeconomy" as its key theme, and in the Final Communiqué, over 60 agriculture ministers recognized the bioeconomy's role in a sustainable, resilient, and inclusive economy.¹⁹ The Food and Agriculture Organization of the United Nations (FAO) has been convening global consultations toward a formal Bioeconomy for Sustainable Transformation (BEST) Partnership, with regional nodes under development, and held the first-ever Bioeconomy Innovations and Investment Forum in Bangkok in November 2025, drawing nearly 600 participants from governments, the private sector, investors, and civil society.²⁰ On the private capital side, dedicated investment vehicles are maturing, including Forbion's BioEconomy Fund, which launched in 2024 and was oversubscribed and closed at €200 million in 2025, with backers including public investment banks and mission-driven funds.²¹

15 G20 Brazil (n.d.); NatureFinance and FGV (2024).

16 Bioeconomy Challenge (n.d.).

17 Federative Republic of Brazil (2024); NatureFinance (2025).

18 ANCA (2025).

19 GFFA (2025).

20 FAO (2025). The Forum was co-organized with 18 partners including the United Nations Conference on Trade and Development, United Nations Environment Programme, United Nations Economic and Social Commission for Asia and the Pacific, United Nations Educational, Scientific and Cultural Organization, United Nations Industrial Development Organization, and the Association of Southeast Asian Nations.

21 Forbion (2025).

This multilateral momentum emerges from trends at national and regional levels

THE BIOECONOMY AS AN INTERCONNECTED NATIONAL CLIMATE, NATURE, AND JOBS STRATEGY

At a national level, Brazil has recently elevated the bioeconomy to a strategic pillar of national development, embedding it in key long-term planning instruments. In 2024, the federal government launched its National Bioeconomy Strategy, framing the bioeconomy as a model of economic development that is fair, inclusive, and guided by science and traditional knowledge, with goals around sustainable use of biodiversity, job creation, technology development, and climate mitigation.²² This strategy is integrated into broader frameworks such as the Ecological Transformation Plan and the Multi-Year Plan (2024-2027).²³ The strategy serves as a comprehensive framework to coordinate cross-sectoral policies and unlock the economic potential of the country's vast biodiversity and has formalized implementation through the National Bioeconomy Development Plan (PNDBio), which coordinates across several different federal ministries, aligning agriculture, industry, trade, and science to accelerate the commercialization of bio-based innovations.²⁴ Moreover, the inclusion of the bioeconomy in Brazil's NDC and National Biodiversity Strategies and Action Plans (NBSAPs) offers another instructive model.²⁵ A recent NatureFinance report asserted, "embedding bioeconomy development within international climate and biodiversity commitments, enables Brazil to achieve three objectives simultaneously: (i) to demonstrate practical pathways for meeting climate and nature goals; (ii) to enable cross-governmental collaboration with the bioeconomy as a national priority backed by presidential authority, and (iii) to unlock access to international climate finance that would otherwise remain unavailable for the scaling of the bioeconomy."²⁶ Under the "New Industry Brazil" program, bioeconomy and decarbonization are listed as one of six core missions, which include boosting biofuels, such as bioethanol, and expanding the sustainable use of biodiversity in industry.²⁷ The NDC sets targets such as increasing the share of biofuels in transport energy by 50% and raising the technological use of biodiversity by industry annually.²⁸

Embedding the bioeconomy within the NDC sends a signal to markets and investors that biological innovation and renewable pathways are central to Brazil's climate mitigation and industrial policy, not just niche programs (box 9.1).

²² Lopes, Corleto, and Chiavari (2024).

²³ See more on Brazil's Ecological Transformation Plan at <https://www.gov.br/fazenda/pt-br/aceso-a-informacao/acoes-e-programas/transformacao-ecologica/novo-brasil-ecological-transformation-plan/novobrasilcartilhaingles.pdf>; see more on the Multi-Year Plan (2024-2027) at https://www.gov.br/planejamento/pt-br/assuntos/planejamento/plano-plurianual/arquivos/mensagem-presidencial-ppa-2024-2027/2_mensagem_presidencial_web-1-1.pdf.

²⁴ Bezerra et al. (2026).

²⁵ See more on Brazil's NDCs at <https://ndcpartnership.org/country/bra>; see more on Brazil's NBSAPs at https://app.climatepolicyradar.org/documents/brazil-national-biodiversity-strategy-and-action-plan-nbsap-2025_d2c7?c=UN-submission&at=Party&t=National+Biodiversity+Strategy+and+Action+Plan+%28NBSAP%29&cfn=target.

²⁶ NatureFinance (2026).

²⁷ See more on the "New Industry Brazil" program at <https://www.gov.br/fazenda/pt-br/aceso-a-informacao/acoes-e-programas/transformacao-ecologica/novo-brasil-ecological-transformation-plan/featured-programs/new-industry-brazil-and-the-ecological-transformation-plan>.

²⁸ Federative Republic of Brazil (2024), 17.

BOX 9.1

Brazil's bioethanol sector is a global leader

After decades of intentional policy and investment, Brazil's bioethanol industrial sector is now expanding from sugar-based ethanol into advanced bio-refineries, producing biokerosene and bio-based chemicals. This transition leverages agricultural strength for high-value industrial growth, reducing greenhouse gas emissions while driving industrial competitiveness. The transformation lies not only in emissions reductions but also in the strategic use of biology to rewire industrial competitiveness. Government mandates have long required ethanol blending in gasoline, creating guaranteed demand and a stable market for producers. Moreover, flexible-fuel vehicles (FFVs) account for over 80% of the Brazilian light-duty fleet, translating this into a value web from agriculture and advancing agro-producing into manufacturing and industrialization. The long-standing Brazilian bioethanol industry demonstrates how bio-based systems can substitute fossil fuels and associated emissions from the transport sector at scale, while anchoring domestic industrial value chains and jobs. This example illustrates how policy frameworks (mandates, incentives, institutional coordination) can unlock large-scale markets that align climate goals with economic competitiveness and help convert biological resources and innovation into diversified, low-carbon economic pathways.

SOURCES: IEA Bioenergy (2022); Federative Republic of Brazil (2021); Mark & Spark Solutions (2026).

THE BIOECONOMY AS AN ECONOMIC TRANSITION PATHWAY

Demonstrating the power of economic mainstreaming, the European Union has positioned the bioeconomy as a cornerstone of its industrial and climate strategy, integrating it across agriculture, chemicals, materials, energy, and regional development.²⁹ Countries such as Finland and Germany have invested heavily in bio-based materials, industrial biotechnology, and circular biomanufacturing, explicitly targeting fossil-intensive sectors like plastics, construction, and chemicals.³⁰ What is transformative here is the intent to replace entire value chains, such as steel, cement, and petrochemicals, with bio-based and hybrid alternatives, backed by regulation, public finance, and market creation rather than voluntary sustainability claims. This approach draws lessons from the renewable energy transition and is already helping to create strong and growing markets for bio-based products.

India's bioeconomy approach illustrates the potential of the bioeconomy as an industrial diversification and resilience strategy. From renewable biofuels and industrial enzymes to vaccines and agricultural biotech, India's bioeconomy spans multiple sectors, now representing a solid and exponentially growing share of GDP, supporting jobs and aligning national goals on sustainability, health care, and manufacturing.³¹ India's bioeconomy has grown from about \$10 billion in 2014 to about \$165.7 billion in 2024, marking a roughly 16-fold expansion in a decade, and putting the GDP share at just over 4%.³² The largest areas of national focus are within bio-industrial sectors, which account for nearly half of India's total bioeconomy, with significant emphasis placed on biofuels, industrial enzymes, and other bio-manufactured products. India has grown bioethanol blending to 20% as of 2025, reducing

29 Crowell & Moring (2025).

30 Held (2026); CLIC Innovation (2025).

31 Republic of India (2025).

32 Ibid.

reliance on crude imports, boosting farm incomes, and cutting foreign exchange outflows.³³ It has also grown production of industrial enzymes, which are commonly used in detergents, textiles, and bioplastics.³⁴ This is followed by the growth in India's BioPharma sector, at 35% of the Indian bioeconomy, especially in vaccines and generics.³⁵ India produces 65% of global vaccines—a major export and global health contribution.³⁶ The growth of the Indian bioeconomy is being driven by a number of factors: a strong entrepreneurial environment; a large domestic market with uniform national regulation; highly skilled human capital; and, critically, the Biotechnology for Economy, Environment and Employment Policy (BioE3), a strategic framework designed to shift from traditional manufacturing to high-performance biomanufacturing, directly linking bio-innovation to economic growth, environmental sustainability, and job creation.³⁷

THE BIOECONOMY AT THE INTERSECTION OF POWER, INDUSTRIAL COMPETITIVENESS, AND NATIONAL SECURITY

China offers a different but equally consequential model. Through large-scale investment in industrial biotechnology, biomanufacturing, and synthetic biology, China is increasing bio-based production in pharmaceuticals, food ingredients, materials, and fuels.³⁸ This is framed less as an environmental agenda and more as a strategic industrial pivot, as China strives to become a biotech powerhouse: reducing dependence on imported fossil inputs, securing supply chains, and positioning biotechnology as a future engine of economic growth. The transformation lies in speed and scale—biology is treated as core infrastructure for a post-fossil-fuel industrial system.

This is demonstrated in China's 14th Five-Year Plan (FYP), which set a target of renminbi (RMB) 22 trillion (around \$3.28 trillion) for the Chinese bioeconomy by 2025.³⁹ The plan shifts focus from broad biotechnology to more specific, scalable high-value production and industrial applications, particularly biomanufacturing. In particular, it calls for accelerating research and development (R&D) and industrialization in areas such as biomedicine, biological breeding, biomaterials, bioenergy, and bioinformatics, while strengthening biosecurity risk prevention, control, and governance systems.⁴⁰ Like many other country case studies mentioned here, China's subsequent 15th FYP views bioeconomy tools as critical to reducing carbon emissions and achieving low-carbon growth, with a key departure point being an emphasis on "conversion, application, and ecosystem shaping," aiming for practical economic results from biotech.⁴¹ In 2025, China's newly approved drugs and R&D pipelines accounted for over 30% of the global total.⁴² China contributes around 70% of global bio-fermentation product output, especially in food additives and industrial enzymes, resulting in more than RMB 400 billion (around \$57 billion) in value.⁴³ This reveals the rapid industrial expansion and integration into core sectors such as medicine, agriculture, and chemicals.

33 ETManufacturing Desk (2025); Mehan (2026); Republic of India (2026).

34 Republic of India (2025).

35 BIRAC (2024).

36 Republic of India (2025).

37 Republic of India (2025); BIRAC (2024).

38 Brown and Groenewegen-Lau (2025).

39 Ouyang and Liu (2022); Global Times (2022).

40 Ouyang and Liu (2022); Global Times (2022); Zhang et al. (2022).

41 Guo (2025).

42 Wu (2025).

43 Sedzro (2026).

China's bioeconomy anchors another striking trend: a broader industrial strategy in which biology and data are dual pillars of competitiveness, not separate sectors, and instead are recognized as fundamental to national security.⁴⁴ China's targets include improvements in fundamental biotech research, biosecurity governance, and the deployment of advanced computational tools like AI to enhance biotechnology's productivity and application scope, from drug discovery to precision agriculture and synthetic biology.⁴⁵ The practical implications are clear. China is investing not just in biological inputs but also in the digital architecture that multiplies their value: AI for genomics, high-performance computing for biological simulation, and integrated data platforms that connect research, industry, and markets. This positions China not only to scale biomanufacturing domestically but also to compete internationally in data-intensive biotech sectors where AI can sharply reduce development costs and time to market. Moreover, China's leadership has signaled that cooperation with technology partners, including neighboring countries like the Republic of Korea, around AI and bio-innovation is a priority, showing that these sectors are viewed as central to future economic diplomacy and global governance discussions.

The Republic of Korea has explicitly targeted AI-bio convergence as a core driver of industrial transformation, embedding this objective in high-level national strategies such as the National AI-Bio Strategy and the broader national innovation ecosystem supported by tens of billions in public and blended finance.⁴⁶ A central pillar of the Republic of Korea's strategy is digital biofoundries, facilities that use AI, automation, and robotics to standardize and automate synthetic biology processes, dramatically shortening experimental cycles and lowering costs. These biofoundries are intended both to spur commercial biotech innovation and to anchor domestic industrial capacity in areas such as biologics, advanced materials, and biomanufacturing.⁴⁷

Recently, the Republic of Korea launched a National Bio Innovation Committee to coordinate biotechnology policy and ministries and drive investment and R&D, signaling the importance of an integrated national agenda that unites AI, biotech, and advanced computing.⁴⁸ Practical measures include plans to build high-performance computing infrastructure, integrate national bio-data systems, and foster public-private partnerships to drive AI-enabled research and industrial applications.⁴⁹ At the same time, the biotech economy in the Republic of Korea is seen as a "next growth engine" alongside semiconductors, backed by ambitious investment funds designed to integrate private capital into long-term innovation projects.⁵⁰

THE BIOECONOMY AS A DRIVER OF GREEN INDUSTRIALIZATION, VALUE ADDITION, AND REDUCED RESOURCE EXTRACTION

There are serious equity challenges to advancing the global and local bioeconomy. African countries have focused on using the biomass innovation-driven bioeconomy to propel them out of resource-extractive patterns into higher-value chains and more sustainable development.

44 Iuvinale (2026).

45 Ibid.

46 Republic of Korea (2025a); IBBIS (2026).

47 Republic of Korea (2025b); KAIST Graduate School of Engineering Biology (n.d.).

48 Castillo Monagas (2026); The Pharma (2026); Lee (2025).

49 Ibid.

50 Chae (2026).

The East African Community (EAC) developed the first regional bioeconomy strategy in Africa, spanning 2021/22-2031/32, with the goal of transforming natural biological resources into sustainable economic opportunities.⁵¹ The strategy aims to harness abundant agricultural lands and biodiversity to drive inclusive growth, create jobs, and improve resilience to global challenges like climate change. It serves to support the growth of bioindustries, from bioenergy to biochemicals, while promoting value addition and strengthening food and feed production with sustainable, bio-based technologies.⁵² It has facilitated the development of regional platforms for innovation, research, and capacity building, including regional observatories and harmonized policy frameworks, and encouraged scientific and learning institutions, private sector actors, and government to collaborate on bioscience solutions. It also has a focus on clean bioenergy and circular processes that convert waste into useful products, reducing greenhouse gas emissions. By moving beyond exporting raw agricultural produce, the region can generate higher economic returns from bio-based goods, such as food ingredients, pharmaceuticals, biomaterials, bioenergy, among others. An example of putting this regional policy into practice is the International Centre of Insect Physiology and Ecology (icipe) and its flagship program, BioInnovate Africa (box 9.2).

BOX 9.2

The International Centre of Insect Physiology and Ecology (icipe)

The International Centre of Insect Physiology and Ecology (icipe), and its flagship program, BioInnovate Africa, advances “a science- and innovation-driven bioeconomy across Eastern Africa. Supported by the Swedish International Development Cooperation Agency (Sida) and implemented in partnership with over 300 cooperation partners, BioInnovate operates across eight countries: Burundi, Ethiopia, Democratic Republic of Congo, Kenya, Rwanda, South Sudan, Tanzania, and Uganda. The program’s core mission is to translate cutting-edge bioscience into market-ready, biobased solutions, bridging persistent gaps between research, enterprise development, investment, and policy. Working across the full innovation pipeline—from laboratory discovery and early-stage de-risking to industry standards and regulatory support—BioInnovate plays a catalytic role in unlocking Africa’s bioeconomy potential. Innovations span agriculture, health, and waste valorization, including biofertilizers (e.g., Civu Rhizobia), biopesticides and fungicides (Triasper®, fungal biopesticides), Striga-resistant maize and finger millet, tsetse fly repellents, chitin-based wound-care products, biobased malaria supplements (SUPPACT), enzyme applications for leather processing, industrial effluent bioconversion technologies, mushroom substrate blocks, and Black Soldier Fly-based animal feed and insect-enriched foods now supplying markets and schools. BioInnovate Africa demonstrates that with the right enabling finance, partnerships, and policy environment, African scientists can deliver world-class biobased innovations, driving industrial transformation, job creation, and resilient development while reducing dependency on imported inputs and fossil-based systems. The program shows that the primary constraint is not scientific capacity but access to early-stage finance, market linkages, and policy support.”*

*Drawn from NatureFinance (2026).

SOURCES: See more on icipe at <https://www.icipe.org/>; see more on BioInnovate at <https://bioinnovate-africa.org/about-us/>; icipe (n.d.) and knowledge provided by icipe colleagues.

51 East African Community (2022).

52 Ibid.

Complementary to icipe programming, a recent initiative is the African Bioeconomy Finance Hub, which is a strategic intervention to reposition nature as a core driver of jobs, resilience, and industrial transformation across the continent.⁵³ Designed to outlast political cycles, the Hub seeks to translate bioeconomy policy ambitions into finance-ready roadmaps, investment pipelines, and measurable impact frameworks. Anchored in Africa and led by African institutions, the Hub aims to address systemic barriers that limit capital flows into biomanufacturing, regenerative agriculture, nature-based inputs, and circular bio-industries. Its ambition is structural: to shift Africa from exporting raw biological resources to capturing significantly greater value through local processing, innovation, and industrial upgrading. By targeting the capture of up to 50% of the final value of Africa's biomass by 2035 (up from less than 10% today), the Hub positions Africa not merely as a resource base but as a global bioeconomy leader.⁵⁴

Embedding equity in the bioeconomy to ensure its transformative promise

The following case studies (see box 9.3) illustrate not just Africa's institutional capacity to lead in the bioeconomy but the governance principles that must underpin any bioeconomy if it is to avoid reproducing existing extractive economic patterns.

The bioeconomy intersects directly with intellectual property regimes.⁵⁵ Patents on genes, enzymes, and biological processes can concentrate innovation rents in technologically advanced economies. Political economy scholars warn that biotechnology markets often exhibit rent-seeking dynamics under globalized IP regimes.⁵⁶ For developing economies, capacity building in patenting and domestic bio-innovation is therefore essential to avoid structural dependency.

Equity and justice therefore sit at the center of whether the bioeconomy constitutes a true transition. A bio-based economy that reduces carbon emissions but accelerates land concentration, undermines food security, or extracts biological wealth without fair returns will fail its transformative promise. Costa Rica, through its bioeconomy strategy linked to biodiversity governance and payments for ecosystem services, points toward alternative models where conservation, innovation, and local value creation are mutually reinforcing rather than in conflict.⁵⁷

Equity in the bioeconomy is not only a moral consideration but a structural determinant of whether the bioeconomy delivers broad-based development or reinforces existing inequalities. Since the bioeconomy spans agriculture, health, energy, materials, and digital biotechnology, it has the potential to create employment across the entire skills spectrum—from advanced research and AI-enabled bio-design to farm-level biomass production and distributed bioprocessing. The critical question is whether value is concentrated at the top of the innovation chain or intentionally distributed along it.

At the high-skill end, the bioeconomy creates demand for researchers, bioinformaticians, fermentation engineers, regulatory specialists, and advanced manufacturing technicians. These are future-facing, knowledge-intensive

53 ANCA (2025).

54 NatureFinance (2026), 91.

55 Drahos and Braithwaite (2002).

56 Birch and Muniesa (2020).

57 ECLAC (2020); UNFCCC (2020).

roles that anchor domestic innovation systems and attract investment. However, equitable growth requires deliberate investment in education pipelines—technical colleges, vocational biotech training, and university-industry partnerships—so that access to these jobs is not restricted to a narrow urban elite. Building local capacity in bio-manufacturing, quality control, and laboratory services enables countries to retain more value domestically rather than exporting raw biological materials and reimporting finished bio-based products. It also strengthens domestic innovation ecosystems by creating opportunities for highly skilled professionals locally, reducing the risk of brain drain and helping countries build long-term scientific, industrial, and technological competitiveness.

At the mid- and lower-skill levels, the bioeconomy can generate substantial employment in biomass production, feedstock logistics, bio-refinery operations, waste-to-value systems, and decentralized processing facilities. For rural economies in particular, this can mean new income streams from crop residues and agricultural waste, invasive species harvesting, regenerative agriculture, aquaculture, or forest stewardship. If designed inclusively, bio-based value chains can formalize informal work, increase incomes for smallholder producers, and strengthen regional economies rather than concentrating opportunity in metropolitan biotech clusters.

Equity also has a geographic dimension. Many biological resources are located in rural or biodiversity-rich regions, often inhabited by marginalized communities. A just bioeconomy requires benefit-sharing mechanisms, local ownership models, and transparent governance frameworks to ensure communities participate in and profit from commercialization.

Finally, inclusion within the bioeconomy must address both gender and generational participation. In many emerging markets, women play central roles in agriculture, health care delivery, and community-level natural resource management, yet they remain underrepresented in biotechnology leadership, advanced STEM fields, and high-value innovation ecosystems. At the same time, high levels of youth unemployment across many developing economies present both a challenge and an opportunity. Targeted entrepreneurship support, incubation funding, and skills development programs can help position the bioeconomy as a major source of employment and enterprise creation, particularly in areas such as digital biology, circular economy enterprises, and green manufacturing.

In more developed markets, inclusion must also address age-related barriers to participation in emerging industries. As the bioeconomy increasingly converges with AI, advanced computing, and automation, there is a growing need to support mid- and late-career professionals in transitioning into these new fields. Many highly skilled workers already possess deep technical and industrial expertise that remains highly relevant to the evolving bioeconomy. Supporting reskilling and lifelong learning can therefore help retain valuable knowledge, strengthen innovation systems, and ensure that technological transitions remain inclusive across generations.

Case study: Valorizing African Indigenous knowledge⁵⁸ at the University of the Free State's Indigenous Knowledge-based Medicines and Innovations Centre in South Africa

The University of the Free State's Indigenous Knowledge-based Medicines and Innovations Centre in South Africa focuses on translating Indigenous knowledge systems (IKS) into scientifically validated, safe, and commercially viable health products. Unlike many purely laboratory-centric biotech projects, the Indigenous Knowledge-based Medicines and Innovations Centre engages directly with traditional health practitioners and Indigenous communities from across the continent to co-create research priorities and product development pathways, ensuring that the holders of knowledge are part of the value chain from discovery through to commercialization. For example, the platform recently received a grant from the World Health Organization to help develop equitable IP and benefit-sharing frameworks for traditional medicines—a vital step in ensuring that communities benefit economically from their knowledge rather than being sidelined when commercial products are developed. The Centre also actively trains postgraduate students, technologists, and researchers, creating pathways into biomanufacturing, pharmacology, and regulatory science, while simultaneously supporting community-level entrepreneurs in cultivating and processing Indigenous botanicals. This dual emphasis on high-level science and grassroots engagement helps broaden participation in the bioeconomy and creates jobs at many skill levels, from community producers and technicians to research fellows and knowledge managers. An illustrative example from South Africa on how to avoid biopiracy is that of the Rooibos Benefit Sharing Agreement, which was a constitutional court ruling which allowed for an annual levy of 1.5% of the profits of rooibos at “farm gate price” to go toward the Indigenous San and Khoi, recognizing their Indigenous knowledge and formative cultivation of the plant and its properties.

SOURCES: AMITD (n.d.); Damons (2025); Schroeder et al. (2020).

The above examples illustrate core principles that help avoid common equity pitfalls in rapidly developing bioindustries, including localized value creation and addition, inclusive knowledge systems and valorization, multilevel job creation and value web thinking, policy and institutional support, and the importance of regional collaboration and capacity building.

By combining scientific rigor, respect for and valorization of traditional knowledge, equitable benefit-sharing, and broad skills development, these initiatives illustrate how a bioeconomy can be both innovative and socially inclusive. They show that it is possible to create jobs, build shared prosperity, and drive technological advancement while ensuring that communities are meaningfully included and not left behind. However, equity requires intentional policy design: skills development across tiers, support for small, micro, and medium enterprises (SMMEs) and co-operatives, regional clustering strategies, and mechanisms that ensure value addition happens close to where biological resources originate. When structured this way, the bioeconomy becomes more than simply a technological transition. It evolves into a socially inclusive development pathway capable of driving innovation, creating shared prosperity, and supporting more equitable and resilient economies.

⁵⁸ Indigenous valorization is the active process of validating, elevating, and integrating Indigenous knowledge, cultures, and practices into modern socioeconomic, political, or scientific frameworks. It ensures Indigenous communities benefit from their own heritage rather than having their resources or traditions extracted or exploited by others, without due remuneration and recognition.

Intellectual property and asymmetry: Emerging debates around digital sequence information (DSI)

Digital sequence information (DSI) is increasingly emerging as a foundational asset within the global bioeconomy, underpinning innovation across biotechnology, pharmaceuticals, agriculture, synthetic biology, industrial biomanufacturing, health care, and nature-based industries. As advances in genomics, artificial intelligence, and bioinformatics accelerate, it is becoming central to the next generation of economic growth and scientific discovery. Globally, discussions around DSI have largely been shaped by priorities linked to innovation, open science, technological competitiveness, and the rapid sharing of scientific data. Many developed-country actors and scientific institutions have advocated for maintaining open access to DSI, arguing that open data supports scientific collaboration and innovation, reduces barriers to research, and enables advances in areas such as biodiversity conservation, food security, and health.⁵⁹

The 1992 Convention on Biological Diversity (CBD) and the 2010 Nagoya Protocol established foundational principles on genetic resource sovereignty and benefit-sharing. Yet the rapid rise and expansion of DSI infrastructure have exposed governance gaps.⁶⁰ DSI challenges traditional access and benefit-sharing frameworks because, through bioinformatics, genetic sequence information can be accessed and utilized without the physical transfer of the underlying genetic resources or necessarily establishing an access and benefit-sharing agreement with their providers.⁶¹

Ongoing negotiations under the CBD Kunming-Montreal Global Biodiversity Framework reflect attempts to address this structural asymmetry. Without reform, biodiversity-rich nations risk becoming data providers in a global bioeconomy governed by Northern intellectual property systems.⁶² Further, without deliberate policy choices around access, benefit-sharing, intellectual property, and domestic value addition, the bioeconomy could reproduce the extractive logic of the fossil economy under a greener label.

Increasingly, African policymakers, financiers, scientists, and development institutions are framing DSI not as a scientific or conservation issue but as a broader question of economic transformation, industrialization, nature finance, and sovereignty. Recent African-led dialogues have highlighted the need to move beyond narrow compliance-oriented access and benefit-sharing discussions toward systems that enable domestic value retention, local innovation ecosystems, and participation across the full DSI value chain.

⁵⁹ Laird and Wynberg (2018).

⁶⁰ Ibid.

⁶¹ Akpoviri et al. (2023).

⁶² Birch (2017).

Importantly, emerging African dialogues on DSI are not positioning themselves in opposition to the Cali Fund or broader multilateral benefit-sharing efforts.⁶³ Rather, they seek to build on these foundations while reflecting African realities, aspirations, and concerns. African stakeholders increasingly recognize the Cali Fund as an important and potentially catalytic step toward acknowledging the value of biodiversity and the need for more equitable benefit-sharing in the DSI era.⁶⁴ At the same time, there is growing recognition that the voluntary nature of the Fund, uncertainties around scale, and questions around how value will ultimately flow back to biodiversity custodians mean that Africa cannot rely solely on external redistribution mechanisms.⁶⁵ In this framing, sovereignty is not understood as isolationism or resistance to global collaboration, but rather as the ability for African countries to participate in global DSI systems from a position of greater agency, capability, and value capture. The debates that have surrounded and given rise to the Cali Fund have previously been present in other areas such as critical minerals—namely that beneficiation or value addition must occur at the source of extraction.

A central theme emerging from African discussions is the importance of ensuring that Indigenous Peoples and Local Communities (IPLCs) are recognized not merely as passive beneficiaries but as active co-creators, custodians, and rights-holders within DSI-linked value chains. This reflects a growing recognition that biodiversity stewardship, traditional knowledge systems, and community governance structures form a critical foundation for the bioeconomy itself. Unsurprisingly, this mirrors concerns around IPLCs with respect to carbon and biodiversity credit schemes in relation to co-creation, benefit-sharing, and co-ownership. As such, equitable benefit-sharing mechanisms must go beyond symbolic inclusion and instead create meaningful pathways for communities to participate in and benefit from emerging bio-based industries.

As a result, African-led discussions are increasingly focused on developing complementary “no-regrets” approaches that strengthen domestic readiness to participate competitively and strategically within the emerging bioeconomy.⁶⁶ Recent initiatives have emphasized the need to invest in sequencing infrastructure, regional bioinformatics hubs, talent pipelines, data sovereignty systems, and fit-for-purpose financing mechanisms that can support African-led biodiscovery, biotechnology, and nature-positive enterprises. There is also growing recognition that concessional and blended finance may play a critical role in de-risking early-stage DSI-related opportunities and enabling investable business models to emerge. More broadly, African bioeconomy dialogues increasingly frame DSI within a wider green industrialization agenda aimed at enabling the continent to retain a greater share of the value derived from its biodiversity and biomass resources.

While global perspectives often prioritize openness, data sharing, and innovation speed, African perspectives place greater emphasis on value retention, fairness, local ownership, and ensuring that biodiversity-rich countries are not once again excluded from the highest-value segments of this emerging industrial revolution.

63 See more on the Cali Fund at <https://thecalifund.org/>.

64 Singh (2026); Republic of South Africa (2026).

65 Shema, Sinyangwe, and Ayodele (2026).

66 Cox (2026).

The bioeconomy as the leapfrog imperative

The global bioeconomy is no longer a peripheral sustainability narrative; it is becoming a defining arena of industrial strategy, economic resilience, and geopolitical positioning. From Brazil's integration of the bioeconomy into climate commitments, China's and the Republic of Korea's AI-enabled biomanufacturing ecosystems and biosecurity approaches, to Africa's emerging stance on data sovereignty, countries are repositioning biology as core infrastructure for a post-fossil-fuel future. What is unfolding is not incremental sectoral change but a reordering of value chains, innovation systems, and competitive advantage. Furthermore, the bioeconomy presents a pathway toward a more sustainable economic model in which decarbonization and biodiversity loss can be addressed while delivering on jobs, livelihoods, and development—a viable economic model for embedding the Sustainable Development Goals (SDGs).

Yet the rapid expansion of bio-based industries does not automatically translate into regenerative development. Without intentional governance, the bioeconomy risks reproducing extractive patterns under greener branding. Data-rich and capital-rich economies may consolidate control over intellectual property, digital sequence information, and synthetic biology platforms, while biodiversity-rich regions remain upstream suppliers of genetic material and biomass. In this scenario, the bioeconomy would merely substitute fossil extraction with biological extraction, leaving structural asymmetries intact.

Equity is therefore not a moral afterthought but a structural determinant of success. Access and benefit-sharing mechanisms must evolve to address digital biology, digital sequence information, and AI-enabled bio-design. Intellectual property regimes must balance innovation incentives with fair value capture. Localized value addition, whether through bio-refineries, industrial biotechnology clusters, or regional innovation ecosystems, must become a central design principle. The much-needed technical capacity must evolve at the same pace. Finance must move beyond pilot projects toward scaled, strategic investment aligned with national and continental development priorities.

For Africa and other biodiversity-rich regions, the bioeconomy represents perhaps the most credible leapfrog pathway beyond fossil-dependent development. Rather than replicating carbon-intensive industrialization, countries can align biodiversity assets with industrial upgrading, digital innovation, and blended finance. The result could be diversified economies, resilient supply chains, job creation across skill tiers and multiple generations, and strengthened economic sovereignty rooted in ecological regeneration. The emergence of continental frameworks and finance platforms signals that this shift is no longer theoretical but institutionally underway.

The bioeconomy, by integrating renewable inputs, circular metabolism, and biological regeneration, offers one of the few systemic pathways capable of aligning economic stability with planetary boundaries.

The choice before policymakers is therefore not whether to pursue a bioeconomy but how to shape it. Built on regeneration, inclusion, and shared and localized value, it can underpin a just and durable economic transition that has the potential for global competitiveness. Left to market forces alone, it risks becoming a biological extension of the model it seeks to replace.

The fossil age has been defined by extraction, exclusion, and inequity. The bioeconomy must be defined by regeneration, circularity, and inclusion. Its expansion is inevitable, and its potential is vast. Whether it becomes transformative will depend on governance, finance, and the courage to embed justice and equity at its core.

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