Costa Rican National Bioeconomy Strategy 2020 - 2030

Towards an economy with fossil decarbonization, competitiveness, sustainability and inclusion

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Presentation

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Executive summary

Introduction

“*The bioeconomy is the production, use and conservation of biological resources, including knowledge, science, technology and innovation related to these resources, to provide information, products, processes and services to all economic sectors, with the purpose of advancing towards a sustainable economy* ”. (Global Bioeconomy Summit, 2018)

A. The bioeconomy: a route for the sustainable development of Costa Rica

The definition of bioeconomy agreed at the Second Global Bioeconomy Summit (Berlin, April 2018) highlights three elements:

* The conservation of **biological resources**, as well as their direct use and sustainable transformation to meet the needs of the environment, people and various economic sectors;
* The application of **knowledge** about biological resources, processes and principles in the development of products, processes and services for the benefit of the environment and society;
* The use of applicable **technologies** for the knowledge, transformation and emulation of biological resources, processes and principles.

In the National Strategy of Bioeconomy of Costa Rica 2019 - 2030 we understand by biological resources:

* The biomass that is cultivated to produce food, fodder, fiber and energy;
* The biomass of marine resources and that produced through aquaculture;
* Forest biomass, especially that which is cultivated for use in the forestry and paper industries, and that which is legally extracted from natural ecosystems;
* Residual[[1]](#footnote-2) biomass in the agricultural, fishing and aquaculture, forestry and agro-industrial sectors;
* Biomass that can be recovered from urban residues;
* Liquid waste from livestock and human activities;
* Terrestrial and marine biodiversity, including biodiversity in territorial seas (e.g. biochemical elements[[2]](#footnote-3), genes, proteins and microorganisms of interest for research and commercial applications).

As it is based on the use of biological resources, we consider the bioeconomy provides the basis for a development strategy in which the use of fossil resources is gradually replaced. That is why we postulate that the bioeconomy is a way to advance towards the fossil decarbonization of the economy.

We also recognize that the bioeconomy provides the basis for productive transformation, through the application of knowledge for:

* Increasing value added to the production of the agricultural, aquaculture and fishing, forestry and agro-industrial sectors;
* Valuing waste and residues from the agricultural, aquaculture and fishing, forestry and agro-industrial sectors;
* Diversifying production and encourage the development of new value chains;
* Sophisticating national production, using in a sustainable way the resources of our biodiversity and the application of knowledge in the field of biological sciences.

We believe that the bioeconomy can allow us to make a big leap towards sustainability, reconciling objectives of productive development and protection, knowledge and sustainable use of our biological wealth.

B. The process of elaboration of the National Bioeconomy Strategy

The process for the elaboration of the National Bioeconomy Strategy began in December 2017, with the workshop Bioeconomy, *OECD Recommendations*, in which the OECD recommendations for our innovation policy were presented. The bioeconomy was proposed as the country's response to these recommendations.

The process was resumed during the first months of the Alvarado Administration, with the support of the Regional Technical Cooperation Program ECLAC / Government of Germany. As of December 2018, IICA support was added. Between September 2018 and March 2019, a first phase was completed, in which the following activities were carried out:

* Identification and gathering of information on public policy and research and development initiatives, in areas relevant to the development of the bioeconomy (September - December 2018);
* Consultation with experts in fields relevant for the development of the bioeconomy, in the public, private and science and technology sectors (September 2018 - March 2019);
* Workshop, *Towards a National Bioeconomy Strategy, National project to establish the main lines of work and the relevance of this approach in our country* (CENAT, September 26, 2018).
* Workshop, *The potential of the bioeconomy for agriculture and Rural Development in Costa Rica* (IICA, December 13, 2018).
* Identificación y levantamiento de información sobre iniciativas de políticas públicas y de investigación y desarrollo, en ámbitos relevantes para el desarrollo de la bioeconomía (septiembre – diciembre 2018);

With the inputs derived from the first phase, a first proposal of strategic axes and lines of action was elaborated and submitted for consultation in April-May 2019. The following workshops were held for this purpose:

* Workshop with young bioentrepreneurs, with the collaboration of All Biotech Costa Rica (April 30, 2019);
* Workshop with the academic, science and technology sector, with the collaboration of CENAT (7 May 2019);
* Workshop with the private agricultural sector, in collaboration with IICA (8 May 2019);
* Workshop with the biotechnology sector, with the collaboration of the Biological Sciences Cluster - CR-Biomed (May 9, 2019);
* Workshop with public sector institutions (10 May 2019).

The activities of the first two phases were coordinated by MICITT with the support of an ad-hoc Working Group with representatives from the Ministry of Agriculture and Livestock (MAG), the Ministry of Environment and Energy (MINAE) and the Ministry of Economy, Industry and Trade (MEIC) and technical cooperation from ECLAC GIZ. The group was formalized as the Interministerial Committee on Bioeconomics (CIB) in May 2019.

In a third phase, a regional outreach process was developed with the support of the Ministry of National Planning and Economic Policy (MIDEPLAN) and MAG. To this end, CIB members participated in sessions of the Regional Development Councils (COREDES) and MAG’s Regional Agricultural Sector Committees.

C. Summary of the strategy

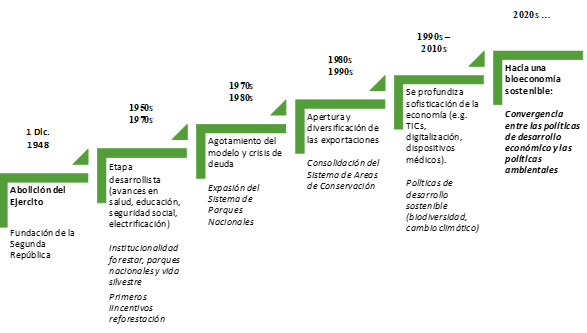
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Background

A. Why a bioeconomy strategy for Costa Rica?

Costa Rica has exceptional conditions to become a world leader in bioeconomy. If we take the Abolition of the Army, in 1948, as the starting point in the construction of today's Costa Rica, we can see that along with the productive development and social development (social security, health and education) policies of the 1950s, 1960s and 1970s, pioneering environmental initiatives also began to be developed. This process has continued since the 1980s, in the economic sphere with policies of trade openness and diversification and productive sophistication, together with internationally recognized initiatives in areas relevant to the development of the bioeconomy, such as biodiversity, forestry, climate change, sustainable agriculture and clean energy, among others.

The bioeconomy in Costa Rica: convergence and coherence between  
productive development and environmental policies



Fuente: Elaboración propia, Estrategia Nacional de Bioeconomía de Costa Rica.

The environmental sector began to be structured in 1988, with the creation of the Ministry of Natural Resources, Energy and Mines (MIRENEM) and was consolidated in 1994 with the Law of the Environment (7554 of 1995), which created the current Ministry of Environment and Energy (MINAE). Other relevant laws passed during the second half of the 1990s are the Forestry Law (7575 of 1996) and the Biodiversity Law (7788 of 1998). This legal framework has been strengthened in recent years by the Law approving the Cartagena Protocol on Biosafety (8537 of 2006), the Law on the Protection of Plant Varieties (8631 of 2008); the Law on Integrated Waste Management (8839 of 2010); and the Approval of the Paris Agreement (Legislative Decree 9405 of 2016). In addition to a series of executive decrees on regulation of biodiversity, regulation and operation of domestic carbon markets, and regulation on liquid biofuels and their mixtures.

There are also public policy initiatives relevant to the development of the bioeconomy, among which the following stand out: National Organic Agriculture Programme (1994); National Biofuels Programme (2008); National Climate Change Strategy (2007); National Climate Change Strategy Action Plan (2010); National Sustainable Tourism Plan 2010-2016 (2010); National Forestry Development Plan 2011-2020 (2011); National Biodiversity Policy (2015); National Biodiversity Strategy 2015-2025 (2015); National REDD+ Strategy Costa Rica (2015); VII National Energy Plan 2015-2030 (2015); National Science, Technology and Innovation Plan 2015-2021 (2015); National Waste Management Plan 2016-2021 (2016); National Wastewater Sanitation Policy, 2016-2030 (2016); National Knowledge-based Society and Economy Policy, 2017-2030 (2016); and National Wetlands Policy, 2017-2030 (2017). In the agricultural sector, the NAMAs in the coffee and livestock sectors stand out, as well as the elaboration of a NAMA energy-biomass, as part of the VII National Energy Plan 2015-2030, with the objective of encouraging the use of organic agricultural residues generated in the agricultural and agro-industrial sector, to generate clean energies.

Therefore, the bioeconomy represents for Costa Rica the possibility of achieving convergence between productive development policies and environmental policies developed over the past seven decades. The bioeconomy can allow us to make a big leap towards sustainability, reconciling objectives of productive development and protection, knowledge and sustainable use of our biological wealth.

The National Bioeconomy Strategy and Policy Articulation



Fuente: Estrategia Nacional de Bioeconomía de Costa Rica ©

The National Bioeconomy Strategy is a framework for integrating public and private initiatives, aligning public incentives and investments, and for orienting private initiative, articulating diverse areas related to production and the environment. The bioeconomy allow us to articulate such initiatives around the great national objective of fossil decarbonization, since we consider that the bioeconomy is an alternative to move towards a post-fossil resource economy.

The National Bioeconomy Strategy complements the country's current initiatives in the areas of circular economy and the so called orange economy (the economy of creativity) and is strategically aligned with a set of policy frameworks that the country has adopted. These include, among other:

* The National Development Plan 2019-2022;
* The National Productive Development Policy 2050;
* The National Policy of Sustainable Production and Consumption 2018-2030;
* The National Decarbonization Plan 2018 – 2050;
* The National Biodiversity Strategy 2015 -2025;
* The National Plan for Integrated Residues Management 2016 – 2021;
* The REDD + Implementation Plan;
* The National Policy of Knowledge-Based Society and Economy;
* The National Science Strategy for Innovation;
* The Bicentennial Digital Transformation Strategy 2018-2022;
* The National Biological Corridors Program;
* The National Entrepreneurship Policy 2030;
* The Namas in the agricultural sector (coffee and livestock);
* The National Forest Development Plan 2010-2020 (under revision and update process, coordinated by MIDEPLAN and MINAE);
* National Policies of Protected Wild Areas.

Tables A.1 - A.X (in the Annex) present a summary of the alignment between legal and policy frameworks in areas related to the bioeconomy.

The National Bioeconomy Strategy is also part of a process of structural change towards a knowledge-based economy, taking advantage of biodiversity resources and the public-private articulation that has begun to be generated in areas related to bioeconomy, with the creation of the Biological Sciences Cluster – CR Biomed.

Finally, the bioeconomy is an alternative to address the regional development gaps between the central region of the country and the peripheral regions. Several of the strategic axes and lines of action point to this.

B. Strengths and opportunities for the development of the bioeconomy in Costa Rica[[3]](#footnote-4)

1. Strengths

Costa Rica has important strengths for the development of the bioeconomy, as a model to move towards an economy less dependent on fossil resources, and more competitive, sustainable and inclusive. The country has a favorable geographic location for integration into value chains in North America and Europe, has a diversified export base, has signed multiple international trade agreements, and has a network of trade promotion offices in 21 countries that can help promote the export of bioeconomy products.

Since the 1970s, the country has developed policies and initiatives in the social, economic and environmental spheres relevant to the development of the bioeconomy, including a National Decarbonization Plan, with goals for 2050. Based on this, it has a strong and well-positioned country brand in areas of relevance for the bioeconomy, including strengths in agro-industry, ecotourism, agricultural biotechnology and medical devices, and digital economy. The country's international leadership in climate action in the agricultural and forestry sectors is widely recognized.

Since the last decades of the 19th century, Costa Rica has shown a strong commitment to investing in education. Today the country is recognized for the quality of its human resources and the existence of internationally recognized laboratories and research centers in fields related to the bioeconomy (OECD). The country has developed a broad concept of innovation, which also includes social innovation.

Costa Rica also stands out internationally for its biodiversity resources and its commitment to environmental protection. Due to its geographical position, it has exceptional conditions for the production of biomass, from which it has developed its export base. Exports from the agricultural sector continue to be an important portion of the country's total exports and provide the basis for various applications in the circular bioeconomy, with the integral use of biomass.

2. Opportunities

There are opportunities, both national and international, that Costa Rica can take advantage of to position itself as a leading country in the bioeconomy. At the national level, efforts have been made to develop research capabilities and qualified personnel in areas related to attracting foreign direct investment. There are recently created mechanisms for the promotion of bio-entrepreneurship and in recent years technology transfer offices have been created in higher education institutions.

In research and development, the country has more than thirty research centers in biological sciences, sustainability and relevant areas for the promotion of the bioeconomy, in several public universities -*Instituto Tecnológico de Costa Rica* (ITCR), *Universidad de Costa Rica* (UCR) and *Universidad Nacional* (UNA). Added to this are shared infrastructures for innovation at the National Center for High Technology (CENAT), with two consolidated laboratories on topics related to biotechnology (CENIBIOT) and biorefining and materials (LANOTEC).

Public-private collaboration is also an opportunity that the country can seize to attract domestic and foreign investment into the bioeconomy. For example, the existence of a diversified life sciences cluster (CR-Biomed), which integrates companies and research centers in agricultural, industrial, environmental, and human and animal health biotechnology. The bioeconomy is an opportunity for the country to take advantage of its research capabilities in biological and environmental sciences.

Also in recent years, new careers have been developed at our public universities, fully aligned with the focus of the bioeconomy; for example, Biosystems Engineering at the UCR and Bioprocess Engineering at the UNA. These careers are oriented to different sectors of the economy: biosystems related to primary sectors, such as agriculture; and bioprocesses more oriented towards biochemistry and industrial chemistry.

The bioeconomy is also an opportunity to consolidate knowledge-intensive industries (e.g. digital industry) and offshore services as part of global value chains. There is a new private sector in the country recognized for its pro-activity in areas of relevance for the development of the bioeconomy (e.g. biotechnologies, renewable energies) and for some years now there has been a National Quality System that can be strengthened and improved for use by national companies. Finally, the bioeconomy is an opportunity to address societal challenges, national and global, in which it can strengthen its leadership position, e.g., in energy efficiency, environment, sustainable agriculture and environment.

In the international arena, the bioeconomy has emerged strongly over the last two decades as a new techno-productive paradigm to face global challenges, such as climate change. Currently there are more than 50 countries around the world with specific or related strategies for the development of the bioeconomy; and Costa Rica's efforts to develop its National Strategy are already recognized (see ilustrative map).

Costa Rica: research centers in biological sciences, sustainable development and relevant areas for the development of the bioeconomy in public universities and CONARE research centers

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| **University of Costa Rica (UCR)** | **National University of Costa Rica (UNA)** | **Costa Rican Institute of Technology (ITCR)** |
| **Ciencias agroalimentarias**   * Centro para Investigaciones en Granos y Semillas * Centro de Investigación en Nutrición Animal * Centro de Investigación en Economía Agrícola y Desarrollo Agroempresarial * Centro de Investigaciones Agronómicas * Centro Nacional de Ciencia y Tecnología de Alimentos * Centro de Investigación en Protección de Cultivos * Instituto de Investigaciones Agrícolas   **Ciencias básicas**   * Centro de Investigación en Electroquímica y Energía Química * Centro en Investigación en Contaminación Ambiental * Centro de Investigación en Ciencia e Ingeniería de Materiales * Centro de Investigación en Estructuras Microscópicas * Centro de Investigaciones en Productos Naturales * Centro de Investigación en Ciencias del Mar y Limnología * Centro de Investigación en Biología Celular y Molecular   **Ciencias de la salud**   * Laboratorio de Ensayos Biológicos * Instituto Clodomiro Picado * Instituto de Investigaciones Farmacéuticas * Centro de Investigación en Enfermedades Tropicales   **Ciencias sociales**   * Centro de Investigaciones en Desarrollo Sostenible * Instituto de Investigaciones en Ciencias Económicas | **Facultad de la Tierra y el Mar**   * Instituto de Investigaciones y Servicios Forestales * Instituto Internacional en Conservación y Manejo de Vida Silvestre * Centro de Investigaciones Apícolas Tropicales * Centro Mesoamericano de Desarrollo Sostenible del Trópico Seco * Centro de Recursos Hídricos para Centroamérica y el Caribe   **Facultad de ciencias sociales**   * Centro Internacional de Política Económica para el Desarrollo Sostenible | **Sede Central, Cartago**   * Centro de Investigación en Administración, Economía y Gestión Tecnológica * Centro de Investigación en Biotecnología * Centro de Investigación y Gestión Agroindustrial * Centro de Investigación en Vivienda y Construcción * Centro de Investigación en Innovación Forestal * Centro de Investigación y Extensión de Ingeniería de los Materiales * Centro de Investigación en Protección Ambiental * Centro de Investigación y de Servicios Químicos y Microbiológicos   **Centro Regional de Santa Clara, San Carlos**   * Centro de Investigación y Desarrollo en Agricultura Sostenible para el Trópico Húmedo |
| **Centros de investigación de CONARE** | |
| **Centro Nacional de Alta Tecnología CENAT**   * Centro Nacional de Innovaciones Biotecnológicas CENIBIOT * Laboratorio Nacional de Nanotecnología LANOTEC | |

Fuente: Elaboración propia, Estrategia Nacional de Bioeconomía de Costa Rica.

There is also a favourable environment, with significant growth in global markets for bio-based products and growing interest in strengthening international cooperation mechanisms for bioeconomy development; for example, support from multilateral financial institutions (e.g., Inter-American Development Bank, World Bank) and international technical cooperation organizations (e.g., ECLAC, FAO, IICA, ILO and UNIDO), as well as a favourable environment for North-South and South-South cooperation among countries with bioeconomy strategies already in the process of implementation or elaboration.

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| Policies for the bioeconomy around the world |
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| Fuente: Consejo Alemán para la Bioeconmía |

C. Three guiding concepts: fossil decarbonization, circular economy and industry 4.0

The National Bioeconomy Strategy of Costa Rica also has as reference three guiding conceptual frameworks, which represent new productive approaches: The circular economy, the fossil decarbonization of the economy, and Industry 4.0.

1. Bioeconomy and fossil decarbonization

The central element of the bioeconomy is biological resources. In the bioeconomy, biological resources are the basis for obtaining materials and energy. That is a fundamental difference with respect to the economy that consolidated during the 20th century, which was based on the use of fossil resources, as the main source of energy and many materials; for example, plastics and synthetic textiles. That is why we consider bioeconomy as a production and consumption model for the transition to a post-fossil fuel economy (see ilustration). Moreover, we consider the bioeconomy as an alternative to achieve the goals we have set in our National Decarbonization Plan 2019 - 2050, especially in relation to the integral management of waste (Axis 8) and agriculture, land use and the application of solutions based on nature (axes 8, 9 and 10).

The Bioeconomy in context, 20th century economy vs. 21st century economy



Fuente: Elaboración propia, Estrategia Nacional de Bioeconomía de Costa Rica.

2. Bioeconomy and circular economy

The circular economy refers to how resources are used to reduce input extraction and reuse items that would otherwise had been considered waste. Within its logic, it considers the impact of products on the environment, throughout their life cycle and seeks to efficiently manage stoks, material and energy flows. It promotes reuse, repair, recycling and valuation. In other words, it minimizes the consumption of natural resources. In this way, it contributes to the construction of new businesses, boosting innovation and competitiveness.

The bioeconomy promotes the integral use of biomass, including residual biomass in the agricultural, fishing and aquaculture, forestry and agro-industrial sectors, seeking to eliminate the generation of discharges to the environment. Therefore, it is a way of making circular economy, which seeks the use of biological resources in the most productive and efficient way, developing economic activities friendly to the environment and inclusive, and from that, creating significant social welfare. Bioeconomy also allows us to promote production systems that repair and regenerate ecosystems, optimizing the use of resources and improving natural capital, ensuring that the use of biological resources is made within natural limits that ensure their reproduction and seeking that such use is for the benefit of society as a whole.

So we are talking about a circular bioeconomy[[4]](#footnote-5) that goes beyond making a more efficient use of fossil resources, because it aims to replace them. A circular bioeconomy that contributes to reducing the fossil carbon footprint of production and generates new market niches for concerned consumers who seek to minimize their impact on the environment. A circular bioeconomy with which we seek to reconcile the objectives of competitive fossil decarbonization and efficient sustainability (see ilustration).

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| The circular bioeconomy: balance between competitive decarbonization  and efficient sustainability |
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| Fuente: Elaboración propia, Estrategia Nacional de Bioeconomía de Costa Rica |

3. Bioeconomy and industry 4.0

The World Economic Forum in its report "Harnessing the Fourth Industrial Revolution for the Circular Economy"[[5]](#footnote-6) states that at the heart of this revolution are the combinatorial effects of digital, physical and biological technologies, as artificial intelligence (AI), tissue engineering and 3D printing are combined to design and print an implantable human organ. They emphasize that the power of Industry 4.0 (4RI) can be harnessed to improve the way materials are managed and guide society from old-fashioned models of extraction-production-disposal to sustainable, circular solutions. 4RI solutions do not solve all the challenges and requirements to move to a circular bioeconomy, but offer a tool to make it easier and more economical.

In the same vein, the Swedish Foundation for Strategic Environmental Research in its report Bioeconomics and Digitalisation[[6]](#footnote-7) points out that the fourth industrial revolution captures processes related to a combination of cyber systems, Internet of things (IoT), Internet of services, direct Internet-based communication between humans, between humans and machines, and between machines (M2M). They also point out that it is a new industrial revolution with two driving forces. On the one hand, changes in the socio-economic framework that require shorter development periods, more individualized demands, flexible product development, decentralization and less hierarchical organizations with greater efficiency in the use of resources; and, on the other hand, more technology is required in industrial practice to incorporate solutions to production processes with greater mechanization, automation, digitization and miniaturization. Thus, the transition to a sustainable bioeconomy that integrates the technologies of Industry 4.0 does not mean that traditional facilities will be instantly replaced by new ones, but rather, that new technologies will be integrated into existing facilities in a process of progressive transformation of business models and production itself.

The OECD, in its recommendation on the sustainability of bio-based products[[7]](#footnote-8) ponders that this shift towards bioeconomy, in which industry building blocks and energy feedstocks are derived from bio-based products, depends on consumer choice ("buy green") and supply-side factors, many of which are strongly linked to socio-economic aspects of the appropriation and use of 4IR technologies.

With the National Bioeconomy Strategy 2020 - 2030, then, we seek to direct efforts towards this productive and progressive national transformation towards sustainability, which privileges the incorporation of industry 4.0 technologies into existing production processes. We seek to take advantage of the country's current advances in the bioeconomy and generate new processes and products, with an implementation oriented towards value chains and business models, which must be transformed and renewed to provide flexibility, resilience and adaptability to Costa Rican companies and institutions. Thus, the future national bioeconomy depends, unavoidably, on the improvement in the absorption capacities of the private sector, its growing participation in national R&D, as well as the appropriation of digital technologies as catalysts for business transformation.

Vision, principles, strategic objectives and governance

A. Vision

A Costa Rica with a sustainable production of high added value in all its regions and emerging bio-cities, based on the fair and equitable use of its biodiversity, the circular use of biomass and the biotechnological progress of the country as a knowledge society.

B. Principles

The National Bioeconomy Strategy is grounded in two major global policy frameworks adopted by the country: the Agenda 2030 for Sustainable Development and the Paris Agreement on Climate Change. In this context, the Strategy is guided by the following principles:

* Social inclusion (gender and youth, indigenous population and territorial development)
* Value addition, diversification and productive sophistication
* Sustainable development and climate action

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| The National Bioeconomy Strategy: principles and strategic alignment |
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| Fuente: Elaboración propia, Estrategia Nacional de Bioeconomía de Costa Rica |

1. Social Inclusion

The bioeconomy strategy is proposed as a measure of sustainable and socially inclusive economic development, since it implies sustainability beyond the environmental perspective, seeking to stimulate the creation of jobs and wealth, as well as a more equitable distribution of income and the reduction of gaps between the country's central and peripheral regions.

As a fundamental part of the principle of social inclusion, the strategy will promote territorial development and prioritize gender equity and the creation of opportunities for the country's youth and indigenous communities. All these aspects will be key in the elaboration of the action plans for the implementation of the Strategy.

2. Diversification and productive sophistication

The bioeconomy is based on the application of knowledge, scientific research, technological development and innovation to create products based on bioinputs and that do not harm nature or human health. These aspects increase value addition in the productive sectors and have a direct impact on the productive sophistication of the national economy, including, from a circular economy perspective, the valorization of waste. All of the above promotes the generation of new products, i.e. diversification of production and the creation of value chains, aspects of great importance for the development of new sources of quality employment and an increase in the well-being of the population.

It is important that the incorporation of knowledge promoted by the bioeconomy contributes to business sophistication as new technologies are generated and adopted and new ways of organizing work and new business models are developed that allow companies to enter and exit the market easily. For Costa Rica, it is necessary to have greater competitiveness and productivity, balancing economic, social and environmental objectives.

3. Sustainable development and climate action

We believe that the bioeconomy provides a conceptual framework for addressing the major social challenges and sustainable development concerns addressed in the 2030 Development Agenda for Sustainable Development. Moreover, given that its material and energy base is biological resources, the bioeconomy is a real alternative for the fossil decarbonization of the economy and can play a fundamental role in climate action, in line with Sustainable Development Goal (SDG) No. 13 (combat climate change) and the commitments set out in the Paris Agreement.

The bioeconomy is related to the sustainable production of healthy foods and the sustainable intensification of agricultural production; therefore, it can contribute to SDG 2 (through sustainable food production), SDG 3 (healthy lives) and SDG 15 (protection of terrestrial ecosystems). For example, through biotechnological applications, varieties of crops that are more resistant to biotic and abiotic stresses can be developed, which supports both SDG 2 (in relation to the sustainability of agricultural production) and SDG 13 (in relation to the adaptation of agriculture).

The application of biotechnologies also allows the development of bioremediation alternatives to face environmental pollution problems, for example, for the recovery of degraded or contaminated soils and for the treatment of wastewater and water for human consumption; therefore, it offers alternatives to support SDG 6 (clean water and sanitation for all) and SDG 15 (in relation to the prevention of soil degradation).

A central concept in the bioeconomy is that of biorefinery, a productive model that seeks to close production cycles, through the productive use of residual biomass derived from production and consumption processes. For example, a biorefinery can use residual biomass to produce bioenegy, thus contributing to SDG 12 (responsible production and consumption) and SDG 7 (affordable and non-polluting energy). The biorefinery also allows the development of new products that can be used as inputs by other productive sectors (eg biomaterials for construction, bio-inputs for agriculture), which substitute products derived from petrochemicals (eg bioenergy, biofertilizers, bioplastics), or that satisfy new demands from consumers (eg functional foods, biocosmetics). Therefore, in addition, in addition to contributing to No. 7 and SDG No. 12, it can also do so with SDG 8 (new sources of decent work and sustainable economic development) and the SDG. 9 (industry and innovation).

The application of biotechnological tools and others that arise from technological convergence (e.g. bioinformatics, biomodelling, biomonitoring) is also essential to increase knowledge of biodiversity; for example, biochemical elements, genes, proteins and microorganisms. This knowledge can be essential to improve biodiversity management (SDG 14 and SDG 15), as well as to improve crops (SDG 2), develop new products (SDG 8 and SDG 9), or replicate principles, processes and systems observed in nature (biomimicry) in the design of new products and solutions to human problems for which "nature" has already developed solutions; for example, self-assembly processes with manufacturing applications (SDG 9), as well a energy efficiency and humidity and temperature control in building design (SDG 11), among many others. In the development of new products, the bioeconomy also promotes the development of agricultural bio-inputs and biopharmaceuticals, which can contribute to the sustainability of agriculture (SDG 2) and to provide alternatives for the treatment of human diseases (SDG3), among others.

C. Strategic objectives

Three strategic objectives of the Strategy are derived from the vision and guiding principles:

* **Strategic Objective 1:** To make Costa Rica a model country in sustainable development, taking advantage of its biological resources to promote social inclusion and equity, balanced territorial development, conservation, knowledge and sustainable use of its biodiversity, and national competitiveness**.**
* **Strategic objective 2:** Make the bioeconomy one of the pillars of the productive transformation of Costa Rica, promoting innovation, adding value, diversification and sophistication of its economy, applying the principles of circular bioeconomy and seeking fossil decarbonization of the productive processes.
* **Strategic Objective 3:** To promote convergence between the country's wealth in biological resources and the use of national capacities in biological sciences for the exploitation of that wealth.

D. Governance

It is widely recognized[[8]](#footnote-9) that obtaining the benefits of the bioeconomy requires intentional policies aimed at the expected goals. This will require leadership, first from governments, but also from leading companies, to set goals and generate structural conditions for success, as well as to obtain regional and international agreements; and to develop mechanisms to ensure that policy can flexibly adapt to new opportunities.

In Costa Rica, the President of the Republic has set a course with the publication of the National Decarbonization Plan 2018-2050, which proposes the country as a leader in achieving climate change objectives. Given that the National Bioeconomy Strategy pursues a balance between sustainability and economic development, an intense national articulation is required, which must be reflected in the established governance for the development of the strategy as well as in its execution and implementation.

In the construction phase, the Ministry of Science, Technology and Telecommunications (MICITT), as coordinator and initial promoter of the Strategy, has set up an Interministerial Bioeconomy Commission (CIB), which consolidates a technical space for exchange between the four participating ministries. This has allowed the articulation with different actors of the rectories of each ministry, as well as with representatives of academia, companies, institutions and entrepreneurs, who have supported this effort since its beginning. In addition, at the regional level, with the support of MIDEPLAN, the Strategy has been shared in the different COREDES of the country, in order to raise awareness and identify specific needs.

This sectoral and regional approach, which has been the basis for the construction of the Strategy, has been particularly effective in identifying key actors, their roles and areas of influence. For this reason, it is considered opportune to continue the sectoral and regional scheme in the governance of the execution of the Strategy.

It is for this reason that it is proposed, as other countries have done, the creation of a high-level National Bioeconomy Council, as the highest decision-making and monitoring body of the Strategy, with the participation of the 4 Ministers or Vice-Ministers of the participating ministries and with representatives from academia, the business sector and entrepreneurs. It is also proposed that the Interministerial Commission on Bioeconomy (CIB) continue as a technical advisory body to the National Council and that it incorporate regional representatives, and become an Interministerial-Interregional Commission on Bioeconomy (CIIB). The organizational and management aspects of the Council and Committees should be regulated in regulations established for this purpose.

Strategic axes and lines of action

A. Strategic axis 1: Bioeconomy for rural development

Justification

The National Bioeconomy Strategy recognizes that agricultural, fishing and forestry activities are fundamental to the development of rural areas and to the country's economy. The Strategy emphasizes that in order to strengthen this contribution, it is essential to diversify productive activities and increase value addition in the zones where production takes place, eliminating regional disparities and promoting synergies. To this end, it is considered important to improve the efficiency and environmental management of production processes, promote linkages with other sectors, create options for the development of new products from primary production, and pay attention to quality management and differentiation of production.

Objective

***Promote sustainable and inclusive rural productive development, based on diversification and value addition in the production of goods and services in agricultural, fisheries and forestry activities, promoting the creation of value networks and better environmental management of their production processes.***

Lines of action

1. Sustainable agriculture with fossil decarbonization...
2. Value-added foods and ingredients.
3. Sustainable fisheries and aquaculture.

1. Sustainable agriculture with fossil decarbonization.

Justification

Agriculture is a pillar sector of the bioeconomy. It is one of the sectors most affected by climate change, climate variability and extreme hydrometeorological events. The sector is an important emitter of greenhouse gases; but it is also the only sector capable of capturing carbon dioxide in its basic production processes (photosynthesis and carbon cycle).

The National Decarbonization Plan foresees actions related to the reduction of greenhouse gases in the agricultural sector (axes 8 and 9) and the consolidation of a territorial management model that incorporates the adoption of solutions based on nature to face environmental problems (Axis 10). This demands a substantial improvement in the use of natural resources and in environmental management in the agricultural sector and other economic activities developed in rural territories. Therefore, the construction of a sustainable bioeconomy in Costa Rica seeks to develop an agriculture that is adapted to the effects of climate change and at the same time generates low greenhouse gas emissions.

Where are we going?

* Promote the application of biological systems to improve the management of agroclimatic risks.
* Reduce the use of synthetic agricultural inputs and substitute with bio-inputs or non-toxic inputs for human health and the environment.
* Increase the adoption of bioremediation solutions in waste and effluent management and in programs for the improvement and recovery of degraded soils and ecosystems.
* Develop evidence-based mechanisms to ensure the effectiveness and quality of agricultural bio-inputs and bioremediation solutions.
* To improve farmers' knowledge about the economic and health and environmental benefits, of the application of quality bio-inputs and bioremediators and of other non-toxic agricultural products for human health and the environment.
* Facilitate the development of a domestic market for bio-inputs and bioremediators (e.g. incentives, regulations, certifications, registrations).
* Promote research, development and innovation in high technology fields to increase the sustainability of agriculture.
* Promote the development of circular economy processes in agricultural, agro-industrial, forestry and fishing activities.
* Promote research and development of precision agriculture applications.

2. Value-added foods and ingredients

Justification

Agriculture must be a pillar of the development of rural economies. The creation of quality jobs, productive diversification and value addition at the local level are essential to this end. Therefore, the development of a bioeconomy with high added value in Costa Rica seeks to promote the development of an agroindustry that produces food and ingredients that generate added value at the local level, promoting the valorization of differentiating attributes, such as their nutritional quality and the origin of production.

Where are we going?

* Encourage high value-added agricultural production.
* Promote the development of a new value-added rural agroindustry, based on innovation, differentiation and valorization of local resources.
* Promote the development of active ingredients for industrial use.
* Develop shared platforms to foster collaboration between the public, private and research and development sectors.
* Promote the development of an innovative Costa Rican gastronomy, based on the use of local products.
* Position Costa Rica globally as a producer of differentiated foods and ingredients with high added value.

3. Sustainable fisheries and aquaculture

Justification

Our country has a marine territory ten times larger than its continental territory, which gives us a wealth of marine - coastal resources. These resources must be used in a sustainable manner, for the benefit of future generations and to ensure food security, especially for the populations of coastal areas, which are among the most backward in the country. Aquaculture is complementary to fishing (mariculture) and agriculture (aquaculture on land). However, in order to achieve the rational use of natural resources and strengthen the development of aquaculture, it is necessary to generate knowledge, research, development and innovation (R&D&I).

Where are we going?

* Strengthen research, development and innovation (R&D&I) in fisheries, aquaculture and mariculture.
* Promote inter-institutional synergy for the exchange of knowledge and project development.
* Develop information systems in the areas of fishing, aquaculture and mariculture.
* Develop technologies and applications for the traceability of fish production, under the concept of "from the sea to the table".
* Promote aquaculture entrepreneurship.
* Promote international cooperation for technology transfer.
* Create options for the development of marine bio-tourism.

B. Strategic axis 2: Biodiversity and development

Justification

Costa Rica is recognized for its high biodiversity, compared to the small size of its territory; and the country's trajectory in the development of institutionality and mechanisms for its protection is recognized internationally. *Costa Rica's National Biodiversity Policy 2015-2030* (Executive Decree No. 39118 MINAE, September 11, 2015) has as its vision "to seek the conservation, sustainable use and resilience of biodiversity, promoting inclusive economic development, broadening social participation for the conservation and management of biodiversity, seeking fair and equitable distribution of the benefits it provides and ensuring and recognizing respect for different forms of knowledge and innovation.” In line with this vision, the National Bioeconomy Strategy recognizes the sustainable use of biodiversity and ecosystem services as a fundamental pillar for the development of the bioeconomy in Costa Rica.

Objective

***Enhance ecosystem services and the sustainable use of terrestrial and marine biodiversity resources as a new engine for sustainable, inclusive, high value-added and low greenhouse gas emissions development.***

Lines of action

1. Sustainable production and bioturism in biological corridors.
2. Promotion of ecosystem services.
3. Bioprospecting and economic use of genetic and biochemical[[9]](#footnote-10) resources of biodiversity.
4. Development of applications of digital technologies (APPs) about conservation areas and the natural scenic beauty of the country.

1. Sustainable production and bioturism in biological corridors.

Justification

Costa Rica is renowned for its history in the development of protected areas, which currently cover more than a quarter of its land territory and about three per cent of it marine territory (which in turn is about 10 times the size of the land territory). There is also a system of biological corridors, which provide physical connectivity between the different types of protected wilderness areas. To strengthen this system, the National Plan of Biological Corridors was developed, created by Executive Decree No. 33106 (May 30, 2006) and reformed by Executive Decree No. 40043 (January 2017). There are 44 biological corridors and 128 connectivity routes with protected areas; together, protected wild areas and biological corridors cover approximately 50% of the national terrestrial territory. Because they are adjacent to conservation areas, biological corridors play important buffering functions. And because they are privately owned areas, they can be the target of significant productive pressures. Therefore, the construction of a sustainable bioeconomy with high added value in Costa Rica seeks to promote the development of productive and sustainable tourism activities in biological corridors, consistent with rural development objectives and the conservation and protection of biodiversity.

Where are we going?

* Take advantage of the connectivity provided by the biological corridors (128 routes) to promote the development of sustainable ecotourism trails between conservation areas.
* Ensure the sustainability of productive activities that are currently developed in biological corridors.
* Identify new products with potential for sustainable use, especially by indigenous communities, small producers, youth and women.
* Encourage the creation of enterprises oriented to the development of products and services originated in biological corridors.
* Develop mechanisms to value products and services originated in biological corridors.

2. Promotion of ecosystem services

Justification

The Forestry Law (7575 of 1996) recognizes environmental services related to forests and forest plantations, among which are the mitigation of greenhouse gas emissions, protection of water, protection of biodiversity and natural scenic beauty. Costa Rica has been a pioneer in the development of mechanisms for the protection and sustainable use of such services; for example, the country developed the first National Payment System for Environmental Services (PES), based on a percentage of the fuels tax. Subsequently, resources were added to the PES systems from the Water Use Fee, from cooperation projects, and from the private sector.

In May 2018, through Executive Decree 41124-Minae, the Regulation for the Management and Recognition of Ecosystem services is created, with the objectives of establishing the norms for the management and recognition of the ecosystem services provided by the Natural Heritage of the Country (PNE – Patrimonio Natural del Estado) and private lands of importance for conservation, and developing the economic and non-economic mechanisms established by the Biodiversity Law in order to contribute to the financial sustainability of the Protected Wild Areas (ASP) and management of SINAC. Ecosystem services are defined as the “benefits that people obtain from ecosystems: provision services (also known as goods) such as food and water; regulatory services such as floods, pests, disease control; cultural services such as spiritual and recreational benefits; and support services, such as nutrient cycles, that maintain the conditions for life on Earth, among others ” (MINAE, 2018).

Currently, there is a SINAC Institutional Strategy for the Recognition and Valuation of Ecosystem Services provided by biodiversity and natural resources, which has already been presented and approved by the National Council of Conservation Areas (CONAC). The new framework seeks to strengthen the mechanisms that the country has already developed for the management of such services, especially in the areas of forestry, biodiversity and ecotourism.

There are ecosystem services of importance to agriculture that are also relevant to the development of a sustainable bioeconomy. For example, support services such as nutrient cycling and soil formation; and regulatory services such as pollination, biological pest control and erosion control. Therefore, the construction of a sustainable bioeconomy with high added value in Costa Rica seeks to promote the sustainable use and protection of ecosystem services, includig those that are important for agricultural production.

Where are we going?

* Encourage the development of agroforestry systems and other innovative agri-environmental practices.
* Take advantage of ecosystem services for the development of recreational activities aimed at increasing people's physical and spiritual well-being (e.g. bioacoustics, bird watching, yoga, hot springs).
* Develop proposals and studies to support the design and implementation of economic and non-economic mechanisms and instruments to promote the bioeconomy, through the sustainable use and conservation of biodiversity and the management of ecosystem services.
* Design economic and non-economic mechanisms for the promotion of relevant ecosystem services in productive sectors (e.g. pollination in agriculture, erosion control, water cycle).

3. Bioprospecting and economic use of genetic and biochemical resources of biodiversity

Justification

The Biodiversity Law (No. 7788 of 1998) establishes that the biochemical and genetic properties of wild or domesticated elements of biodiversity are in the public domain; and indicates that the State will authorize the exploration, research, bioprospecting[[10]](#footnote-11) use and exploitation of the elements of biodiversity that constitute public domain assets, as well as the use of all genetic and biochemical resources. These resources are an asset that the country can use, in a sustainable way, to promote the diversification and productive sophistication of the country, based on the development of new products with high aggregation of knowledge; for example, agricultural varieties with resistance to biotic (e.g. pathogenic) and abiotic stresses (e.g. soils with salinity and minerals, excess heat and humidity) in crops of economic interest; agricultural varieties with improved nutritional qualities, in crops of importance for food security; agricultural bio-inputs; bioremediation solutions; biopharmaceutical and cosmetic products, among others.

Therefore, the construction of a sustainable bioeconomy with high added value in Costa Rica seeks to promote bioprospecting and other advanced strategies for the search of biochemical and genetic elements of interest for commercial research and commercial applications.

Where are we going?

* Encourage the development of enterprises and innovations, based on the sustainable use of biochemical and genetic elements of the country's biodiversity, in research and commercial applications.
* Improve information technology tools to simplify the granting of access permits and disseminate related information.
* Implement incentives that promote the enhancement of biological diversity, giving a commercial advantage to products that comply with the corresponding regulations and provide relevant information to consumers.
* Create mechanisms that contribute to financing different stages of the production chain and that facilitate the placement of products in the market.
* Develop tools that support the articulation between key actors (suppliers, academia, companies, institutions, marketing entities, sources of financing, others) throughout the value chain of biodiversity products.
* Create tools to systematize and disseminate success stories and model initiatives related to access to genetic and biochemical resources and benefit sharing.
* Strengthen the mechanisms for the protection of knowledge about biochemical and genetic properties of the elements of wild, marine and terrestrial biodiversity.
* Update the legislation and institutions to promote the sustainable use of biodiversity, considering developments during the last decades in the field of biological sciences.

4. Development of applications of digital technologies (APPs) about conservation areas and the natural scenic beauty of the country

Justification

Since the late 1980s Costa Rica has managed to position itself internationally as a high quality destination for ecotourism (i.e. tourism associated with the use of the country's scenic resources). At the same time, an important cluster of information and communication technologies has been developed and consolidated, which in recent years has achieved significant advances in the field of digital animation. Recent advances in the development of digital applications (APPs) open new opportunities for environmental education and the use of scenic beauty, especially in areas of conversion and rural landscapes, creating synergies between the bioeconomy and the economy of creativity (the so-called orange economy).

Therefore, the construction of a sustainable bioeconomy with high added value seeks to position Costa Rica as a leading country in digital ecotourism through the development of applications that enhance the knowledge of the country's landscape wealth (e.g. rural landscapes, urban recreational parks), without generating environmental impact.

Where are we going?

* Facilitate knowledge of the natural wealth and natural scenic beauty of the country.
* Expand opportunities for tourism promotion in the country.
* Take advantage of digital technologies in environmental education.
* Develop local digital animation enterprises, especially by young people and women.
* Develop regional virtual tourism platforms.

C. Strategic Axis 3: Residual biomass biorefinery

Justification

Nanotechnology was declared of public interest by the MICITT and the Presidency of the Republic of Costa Rica in 2011, by Executive Decree No. 36567, considering that in the country there are different research processes in the fields of bio and nanotechnology, as branches of human knowledge for the development of the country that provide new and better options to solve problems in essential areas such as agriculture, nutrition, health, energy, environment, water for human consumption and industrialization processes.

On the other hand, agricultural, agro-industrial, forestry and small-scale activities generate significant volumes of biomass residues, which often are considered environmental pollution problems. Residual biomass can be of animal or plant origin, and can be found in liquid and solid states, with varying degrees of moisture. The most common examples are manure in livestock activtities (from cattle, pigs and chicken), stubble in crops, husks in agro-industrialization and forest residues. This biomass can be used to obtain energy and a wide range of products. In Costa Rica, for example, during the process of agroindustrialization of pineapple for export, are generated hundreds of tons of shells and crowns of pineapple, a source rich in lignins and cellulose, which can be used as raw material for the synthesis of active ingredients and excipients for various industries such as pharmaceuticals and food. In the LANOTEC of CENAT, studies are being carried out with this and other substrates, which have been obtained from nanocelluloses of wide industrial use, to nanomaterials such as nanostructured silica with great potential for the catalyst industry..

The productive model to achieve such use of biomass is that of the biorefinery. Therefore, the construction of a sustainable bioeconomy with high added value seeks to position Costa Rica as a leading country in the integral use and recovery of residual biomass in primary production, through biorefining processes, to generate new value chains and networks.

Objective

***Encourage the development of new productive activities based on the full use and valorization of residual biomass from agricultural, agro-industrial, forestry and fishing processes.***

Lines of action

1. Knowledge of residual biomass.
2. Bioenergy production.
3. Production of bio-inputs and bionanomaterials.
4. Production of food, biomolecules and advanced bio-products of high value.

1. Knowledge of residual biomass

Justification

The principle of cascading use of biomass exhibits an inverse relationship between the volume of biomass used and the value generated by its use: uses that involve more volume, such as bioenergy, generally generate less value; uses that demand less volume, such as the production of enzymes, biopolymers and other biomolecules, are what add more value. However, the use is conditioned by the characteristics of the biomass available and the technological requirements for its transformation: the use of greater volume and less value are the most immediate and require less sophisticated technologies; uses of lesser volume and greater value require sophisticated technologies and knowledge.

Where are we going?

* Update national regulations and institutions to promote the use of residual biomass in agricultural, agro-industrial, forestry, fishing and aquaculture activities.
* Improve the management of agricultural, agro-industrial, forestry and fishing residues.
* Develop inventories of agricultural, agro-industrial and forestry residues, considering the needs of biomass residues that must remain in the field to maintain the carbon balance.
* Elaborate exploitation profiles of the different types of residual biomass.
* Identify initiatives underway to use residual biomass.
* Promote the use of biomass to obtain materials with greater added value and that occupy international market niches.

2. Bioenergy production

Justification

Residual biomass is an important potential source of renewable energy. Depending on its moisture content, it can be transformed into different types of energy through physical/chemical processes (e.g. oils and biodiesel), biochemical (e.g. ethanol and biogas) or thermochemical (synthetic gas, charcoal) processes, as well as thermal, mechanical and electrical energy through a combination of biochemical and thermochemical processes. Bioenergy production represents the most direct use of residual biomass, especially in agriculture, agro-industrial activities and residues from wood processing industries. It is an alternative for the production of bioenergies for self-consumption in farms and rural households.

Where are we going?

* Facilitate the production of energy in agricultural and agroindustrial activities to be used to replace fossil fuels in these same productive activities.
* Update national regulations and institutions to boost energy production from waste from agricultural, agroindustrial and forestry activities, and allow the sale of surpluses to the national distribution network.
* Diversify the economic fabric of the peripheral areas of the country.
* Contribute to the National Decarbonization Plan.

3. Production of bio-inputs and bionanomaterials

Justification

A second level in the use of residual biomass, under the biorefinery productive model, is the production of bioinputs and bionanomaterials. Bioinputs include the recovery of nutrients for the production of biofertilizers, to be used back in agricultural and forestry production, as well as the production of vegetable protein for animal feed. Biomaterials include the production of intermediate inputs, such as cartons, fibers and biomaterials for construction, to replace similar fossil-based products or with high environmental impact.

Where are we going?

* Promote I & D & I to study and obtain biofertilizers and biomaterials for use as intermediate inputs in other industries.
* Support the development of startups oriented to the production of biofertilizers and biomaterials for use as intermediate inputs in other industries.
* Promote associativity and linkages between startups and companies oriented to the production of biofertilizers and biomaterials.
* Develop evidence-based mechanisms to ensure the effectiveness and quality of biofertilizers.
* Diversify the economic fabric of the peripheral areas of the country.
* Implement public procurement mechanisms for biofertilizers and biomaterials.
* Contribute to the National Decarbonization Plan.

4. Production of food, biomolecules and advanced bio-products of high value

Justification

The most advanced technological level and greater knowledge integration in the use of residual biomass is the production of food, biomolecules and bio and advanced nanoproducts. For example, biopolymers to produce bioplastics, recovery of proteins for animal and human consumption, enzymes for industrial uses, micro and nanocellulose, lignins and in general biomolecules of industrial uses.

To the extent that residual biomass generated in agricultural activities and in the agri-food industry is perceived as a resource, this opens up countless opportunities for its use to create products with high value added. Perhaps this is one of the greatest potentials that Costa Rica has for the development of the bioeconomy and that requires special dedication so that the potential can be revealed. Taking into account that the country has a strong scientific base, it is important to reconsider the need to formalize and professionalize technology transfer activities that promote the valorization of R&D&I. To this end, the bioeconomy strategy proposes working at the country level to foster links within value chains and work in an integrated manner to attract foreign investment.

Where are we going?

* Promote R & D & I for the study and production of high value-added products from agricultural, agro-industrial, forestry fishing and aquaculture residues.
* Develop enterprises oriented to the elaboration of products of high added value from agricultural, agro-industrial, forestry fishing and aquaculture residues.
* Promote the use of biomass to obtain materials with greater added value and that occupy international niche markets.
* Promote association and linkages between startups and companies oriented to the production of high value-added products from agricultural, agro-industrial, forestry fishing and aquaculture residues.
* Implement public procurement mechanisms for high value-added products from agricultural, agro-industrial, forestry fishing and aquaculture residues.
* Attract foreign investment to the green (agricultural), blue (aquatic resources), gray (bioremediation) and white (industrial) biotechnology sectors.
* Diversify and sophisticate the country's exportable supply.

D. Strategic Axis 4: Advanced bioeconomy

Justification

Biotechnologies, together with nanotechnology and digital technologies (as well as the convergence among them) are essential to foster the development of the bioeconomy, as they make it possible to increase the frontiers for the sustainable use of the whole range of available biological resources. The range of applications is wide and includes industrial processes (white biotechnology), bioremediation (grey biotechnology), agriculture (green biotechnology), aquatic resources (blue biotechnology) and health (red biotechnology).

The range of fields relevant to the bioeconomy includes disciplines such as genomics and omics (e.g. proteomics, lipidomics, glycomics), synthetic biology, biochemical engineering and green chemistry, as well as tools arising from interdisciplinarity and technological convergence, such as bioinformatics, biodiagnostics and biomonitoring.

On the other hand, it is recognized that the main scientific capacities of the country are precisely in the field of biological and environmental sciences, with the greatest strengths of academic research in biochemistry, genetics and medical sciences[[11]](#footnote-12). The country's main research centers are also in the field of biological sciences. And the country is recognized for the richness of its biological resources and attention to environmental protection.

The National Bioeconomy Strategy seeks to promote synergies and alignment between the country's scientific capabilities in the field of biological sciences and the sustainable use of the country's biological wealth to develop new products, applications and biotechnological platforms.

Objective

***Encourage the creation of new productive activities based on the development of new biotechnological and bionanotechnological products, applications and platforms, promoting synergies and alignment between the country's scientific capacities in biological sciences and the sustainable use of biodiversity resources.***

Lines of action

1. Foster a favorable business climate for the development of new biotechnological and bio-nanotechnological products, applications and platforms.
2. Promotion of entrepreneurship in nano and biotechnologies and related fields.
3. Support to startups in the piloting and escalation phases.
4. Access to international markets for new bioproducts, platforms and biotechnological applications and in related fields.

1. Foster a favorable business climate for the development of new biotechnological and bio-nanotechnological products, applications and platforms

Justification

The development of the bioeconomy can be limited by a wide variety of factors; for example, regulatory barriers, financing limitations, barriers to market access, lack of human resources and support services, absence of a culture of knowledge protection through intellectual property mechanisms, poor culture of collaboration to leverage scarce resources (between institutions of the public sector, in the academic and science and technology community, in the business sector, and among them), and the lack of knowledge on the part of the population about the benefits of biologically based products, especially those that substitute products bosed on fossil resources. In addition, it is recognized that entrepreneurship in the field of biological sciences has specificities that it is important to recognize, especially since the times of basic research are longer.

Where are we going?

* Improve existing mechanisms of access to genetic resources for research and commercial applications, considering the needs of national researchers, companies and biotechnological-based enterprises (also Axis No. 3).
* Strengthen working mechanisms between the public, private and research and development sectors to seek solutions to regulatory and other bottlenecks and prioritize recommendations.
* Coordinate the actions of governmental institutions and entities related to the development of research, development and commercialization activities of biotechnological and bio-nanotechnological technologies and products.
* Develop abbreviated mechanisms for importing reagents and transferring samples for research and commercial applications.
* Promote partnerships and linkages between national biotechnology and nanotechnology-based companies.
* Develop platforms to foster collaboration for innovation between the private and research and development sectors (e.g., for prototyping), as a complement to research laboratories.
* Develop innovative financing mechanisms to promote the national productive development of biotechnology and its insertion in global value chains.
* Create technological surveillance mechanisms on the development of new products with a biological basis and / or derived from biotechnological and bio-nanotechnological applications (including the development of patents).
* Establish collaboration agreements with leading international public and private entities in research and development in biotechnology, nanotechnology and related fields.
* Promote a culture of knowledge protection, in which patenting and other intellectual property mechanisms are valued, as much as the publication of scientific articles.
* Increase national capacities in intellectual property, licensing agreements and other knowledge protection mechanisms.
* Develop capacities on new biotechnology-based products in public institutions, especially those in charge of regulation, registration and certification of new products obtained from advanced biotechnology applications.
* Create incentives for the development and obtaining of patents related to the development of new biotechnological and nanotechnological-based molecules and products.
* Develop a platform to disseminate information on companies, products and services based on biotechnology and nanotechnology (e.g. biotechnologies, bioproducts, biomolecules, nanomaterials).
* Develop a database with Costa Rican professionals in biotechnology and related fields residing abroad.
* Attract foreign investment to the green (agricultural), blue (aquatic resources), gray (bioremediation) and white (industrial) biotechnology sectors.

2. Promotion of entrepreneurship in nano and biotechnologies and related fields

Justification

Many bioeconomy strategies around the world recognize that startups and technology-based small businesses are pioneers and drivers of innovation in the bioeconomy. In addition, recognizing that many of these initiatives are driven by young people, the importance of promoting innovation and entrepreneurship among them is highlighted. In Costa Rica, the mechanisms to support entrepreneurship based on biological sciences are incipient and disjointed, partly because of the lack of knowledge of an industry characterized by a higher level of risk than other industries, in the early stages of entrepreneurship development. It is necessary to recognize the characteristics that differentiate projects and startups in biotechnological and related fields, in the regulations of the institutions called to support entrepreneurship in Costa Rica.

Where are we going?

* Develop contests, fairs and similar activities to identify innovative ideas.
* Create internship programs with companies and centers of excellence, in Costa Rica and abroad, and strengthen existing mentoring programs for young people interested in bio-entrepreneurship.
* Strengthen the articulation of existing support mechanisms for entrepreneurship in national universities, in relation to enterprises based on biological sciences (for example, in AUGE at the UCR, the Laboratory of Entrepreneurship of the ITCR, and UNAIncuba at the UNA).
* Promote the articulation between the initial activities of support to entrepreneurship based on biological sciences (pre-incubation, incubation and acceleration), in order to avoid duplication and encourage a smooth transition between the different stages.
* Create innovative financing mechanisms, articulating public and private resources, to support the transition from incubation to piloting and scaling phases.
* Encourage cooperation among young bioinnovators.
* Develop capacities in intellectual property mechanisms and their business models.
* Develop mentoring programs for young people and women interested in bio-entrepreneurship.
* Recognize in the regulation a type of research and development company in biotechnology and areas related to life sciences, which allows to design processes and models adapted to their characteristics.

3. Support to startups in the piloting and escalation phases

Justification

In Costa Rica, mechanisms have begun to be developed to encourage entrepreneurship in areas related to the bioeconomy. There are financing mechanisms, which are generally restricted to the initial incubation phases and to the provision of seed capital to projects with commercial development potential; however, such support is not sufficient for the next critical stages to bring innovations to market. Public policy is important to increase the success rate in the consolidation of startups and ventures in advanced stages of development, especially in a context of risk-adverse financial institutions and poor development of venture capital mechanisms, as is the case in Costa Rica.

Where are we going?

* Develop mechanisms to support startups in phases of piloting and escalation in complying with procedures and regulations required for market access.
* Support formalization, certification and registration processes for startups in the scaling stage with a view to a successful market entry.
* Strengthen public-private financing mechanisms and incentives to facilitate market access to startups in pilotng and scaling phases.
* Develop a portfolio of projects in piloting and scaling phases.
* Consolidate the development of venture capital funds co-financed by the public sector.
* Support the participation of science-based businesses in international trade fairs.

4. Access to international markets for new bioproducts, platforms and biotechnological applications and in related fields.

Justification

Biotechnology ventures face high investments to develop their products and access markets, their success critically depends on achieving economies of scale that allow them to face the high costs of their R&D activities, and their corresponding management of intellectual property.

Access to international markets in a small economy, as is the case of Costa Rica, is the ideal vehicle to enable the investment and reinvestment processes of technological innovation, indispensable in a bioeconomy project.

The facilitation for market access is a key element of importance for all sectors present in this Strategy and for this reason, the issue is addressed again in the cross-cutting axes section.

Where are we going?

* Support the internationalization of national biotechnology-based companies.
* Monitor the development of regulations and requirements for entry of new technology-based products in the main potential markets.
* Homologize the regulations on the classification of new biotechnology-based products with those of the country's main commercial partners.
* Support the certification of national laboratories in Good Laboratory Practices, for the certification of new biotechnology-based products.
* Support the processes for obtaining all those certifications and accreditations, for laboratories, products and manufacturing plants, necessary for entry into international markets.

E. Strategic axis 5: Urban bioeconomy and green and intelligent cities

Justification

Latin America is the most urbanized developing region in the world. And Costa Rica is no exception, with an urban population of around 60%, according to the latest National Population Census. Unplanned and fast urban growth has resulted, among many others, in problems of mobility and traffic congestion, waste management, urban river pollution, poor air quality, waterproofing of the soil, depletion of drinking water sources, pressure on borders of protected areas, and lack of recreational spaces, among others, which cause economic losses for the country and detriment in the quality of life of the population. This situation occurs not only in the Greater Metropolitan Area (GAM), but also in intermediate cities (e.g., Ciudad Quesada and San Isidro del General).

The urban bioeconomy is an emerging area of the bioeconomy, to face the challenges posed by a rapid and disorderly urbanization. Central to the urban bioeconomy are the concepts of biocity, or city based on biological principles, the application of biological principles in urban design, and the application of circular economy principles in the management of urban “waste”. The National Bioeconomy Strategy recognizes the relevance of urban bioeconomy approaches and promotes them through initiatives aimed at sustainable waste management and valorization, development of interurban biological corridors and the promotion of an urban design inspired by biological principles, processes and systems.

Objective

***Promote the application of bio-based urban development principles in urban development policies and initiatives related to solid waste management, the development of spaces for recreation and the construction of buildings.***

Lines of action

1. Sustainable management and valuation of solid urban residues
2. Interurban biological corridors,
3. Urban design inspired by biological principles, processes and systems.

1. Sustainable management and valuation of solid urban residues

The Law for Integral Residues Management (2013) considers a fundamental principle of Environmental Law, establishing that the generation of residues must be prevented at the source. Likewise, shared responsibility is established, that is, that the integral management of residues is a social co-responsibility, which requires the joint, coordinated and differentiated participation of all producers, importers, distributors, consumers, waste managers, both public and private.

Inadequate residues management is one of the main environmental problems facing Costa Rican society. For the year 2006 it was estimated that 3,784 tons of ordinary (or municipal) residues were generated per day in Costa Rica, which is equivalent to an increase of 2.7 times what was produced in 1991. In urban cantons, approximately 1.1 kilograms of residues is generated per person per day. Of these residues approximately 55% are organic, 15.5% are paper and cardboard and 11.5% are plastics. According to estimates by the Ministry of Health, residues generation increased from approximately 3955 tonnes per day in 2011 to around 4000 tonnes per day in 2014.

¿Hacia dónde vamos?

* Promote residues separation at the source (in the same place where they are produced) and sorting by households, the private sector as well as public sector institutions.
* Generate new sources of employment through residue separation and valuation actions.
* Encourage the development of markets for products and materials from residues, in such a way as to create material flows and linkages between companies.
* Generate markets for recycled, recyclable and biodegradable products, so that they are more accessible to the population.

2. Interurban biological corridors

Justification

In Costa Rica, Biological Corridors are the second most important conservation strategy in terms of territory and scope. They are promoted by SINAC, through the National Program of Biological Corridors. An important innovation has been the creation of interurban biological corridors, defined as "*an urban territorial extension that provides connectivity between landscapes, ecosystems and modified or natural habitat, interconnecting micro-watersheds, green sections of cities (urban parks, green areas, tree-lined streets and avenues, railway line, islets and forest on the river bank, among others) or protected wild areas*". Interurban biological corridors contribute to the maintenance of biodiversity, enabling migration, dispersion of species of flora and fauna; and also provide spaces for the recreation of the urban population.

Where are we going?

* Increase recreation options for the urban population.
* Promote the conservation and recovery of biodiversity in urban environments.
* Improve the quality of life of urban populations, especially in the most disadvantaged communities.

3. Urban design inspired by biological principles, processes and systems

Justification

In order to face the problems derived from accelerated and unplanned urbanization, the bioeconomy proposes the concept of "city based on biological principles", or *biocity*, a concept that emphasizes the integration of biological principles in urban planning and life in cities, as a central element to achieve greener cities with high levels of self-sufficiency and quality of life.

The concept of biocity[[12]](#footnote-13) promotes, among others: a) the integration of production, provision, use and recycling systems that promote circular economy processes in the use of materials and energy; b) the minimization of emissions, wastes and losses; c) the integration of production, housing, recreation and service provision spaces; d) the application of biological principles and the use of biological resources in the design and construction of buildings; and e) the development of biological corridors that, among others, contribute to recreation, biodiversity, water regulation and filtration, air cleanliness, erosion control, and the mitigation of extreme temperatures.

The National Bioeconomy Strategy recognizes the relevance of the concept of biocity, especially to bring order to the growth of intermediate cities in the process of expansion.

Where are we going?

* Increase the population's knowledge about the concept of biocity.
* Identify intermediate and small cities whose municipalities may be interested in applying the concept of biocity in their urban development plans.
* Identify the existence of design elements inspired by biological principles in existing urban development policies and actions in the country (e.g. green roofs, energy efficiency, air circulation).
* Develop incentives for construction using biological principles (e.g. to increase energy efficiency, temperature control and waste management).
* Encourage the use of biomaterials that contribute to carbon sequestration in the construction of houses and buildings (e.g. wood and other biomaterials).
* Promote the application of bio-based urban development principles in urban development policies and initiatives related to urban solid waste management, the development of spaces for recreation and construction, and the promotion of green cities.

F. Transversal axes

1. Communication with society

The bioeconomy proposes a paradigm shift in production and consumption processes, which must be properly communicated to highlight its economic, social and environmental benefits. This is why the process of constructing the Strategy has been carried out considering the input of expert consultations and intersectoral and interministerial workshops, with the participation of representatives of the academic and science and innovation sectors, the public and private sectors and young bioentrepreneurs, among others. In addition, interregional communication processes were carried out with the support of MIDEPLAN, through the Regional Development Counciles[[13]](#footnote-14) (COREDES), and MAG, through the Regional Agricultural Sectoral Committees.

In line with the vision set forth by the Knowledge-Based Economy and Society Policy (MICITT 2017), the bioeconomy communication processes seek to make the subject known to the entire society, inviting the participation, involvement and empowerment of the population, so that they can be part of the active and dynamic construction of solutions through support networks from the local and regional level to the national and international level.

2. Education and capacity development

One of the main strengths of our country in the strong commitment it has historically shown to the empowerment of human talent through education. Education is an element that energizes human capabilities and the creation of knowledge, and therefore plays a fundamental role in improving living conditions and in the course given to the country; therefore, it is one of the essential tools to promote the productive transformation of the country towards a bio-economy.

Costa Rica has focused on building a knowledge-based society and economy (MICITT (2017), as have the nations with the highest levels of development, with a view to build more resilient, inclusive communities in harmony with the environment. In line with this vision, the bioeconomy is directly linked to productive activities based on science, technology and innovation, for which it is essential to have a quality education system and universal access to the entire population.

3. Research, development and innovation

Scientific research, development and innovation are essential for the generation and dissemination of scientific and technological knowledge, necessary to expand the frontier of possibilities of a nation, increasing the opportunities for improving the quality of life of people living in the country.

The country has an important critical mass of researchers and academics in fields related to the bioeconomy. It is a valuable input for the implementation and development of the projects that are to be enhanced in this Strategy. The Strategy seeks to promote the articulation of these resources that the country has in terms of research, development and innovation, so that economies of scale can be generated and duplication reduced, increasing access capacity and knowledge generation, under intellectual property schemes , promoting access and dissemination of information for the disposition of the business, academic, student, public sector, among others, with a view to generating the country's well-being.

4. Incentives, financing and attraction of foreign investment

The National Bioeconomy Strategy recognizes the need for new incentive and financing options, both nationally and internationally, as well as for strengthening and articulating the existing support mechanisms for business development. It seeks to avoid duplication and strengthen business initiatives at all stages, for the generation of innovative goods and services with high added value, as well as the diversification of the supply of national products and services with scientific and technological base, both locally as international.

Political stability and social cohesion, among other strengths mentioned in this document, are part of the elements that make the country attractive to foreign investment. These factors enable the development of the sectors associated with the bioeconomy. The agility and facilities for access to technology licenses, co-development agreements, the participation of national researchers in international R & D & I projects, and the recruitment of human and financial resources, among others, are topics that are sought promote as part of this Strategy.

5. Market access

Stimulation of the local market and support for access to international markets for bioeconomy goods and services is a priority measure for the development of the National Bioeconomic Strategy. Market access for bio-economy products may be limited by a variety of factors. Some of the most relevant are: a) lack of regulatory frameworks, especially in the areas of rapid development of knowledge and application of new technologies; b) complexity of regulatory processes; c) lack of capacities to comply with the regulations of export destination markets and/or little knowledge of such requirements; d) lack of compatibility of regulations between conventional and similar biologically based products; e) lack of uniformity in the classification criteria of new products; f) absence of technical capacity or infrastructure to carry out laboratory or field analysis under the standards of the country of export destination; g) there are no laboratories certified under the standards required by the country to which exports go; h) there is no homologation between sanitary and phytosanitary protocols between the country of origin and the country of destination; and i) the cost to the producer (e.g. cost of certifications, seals, homologations).

In addition to the efforts made by individual companies and national consortia to increase access to markets, it is necessary to join forces with the public and academic sectors. It is also important to specify the main differentiating points of the country in terms of bioeconomics. This includes the identification of capacities and development needs of the national R&D&I system. As part of the market access strategy, the participation of companies or academia in international R&D&I subsidies, the participation of companies in investor rounds, and the promotion of the country as a destination for clinical trials, among others, should also be considered.

Roadmap

1. The Law for Integral Residues Management (2013) changes the concept of "garbage" or "waste" to that of "residue", with the objective of recognizing that residues have an intrinsic value and therefore should not be wasted by society. [↑](#footnote-ref-2)
2. Article 7 of the Biodiversity Law No. 7788 defines a biochemical element as "any material derived from plants, animals, fungi or microorganisms that contains specific characteristics, special molecules or clues to design them". [↑](#footnote-ref-3)
3. See also, OECD (2017), OECD Reviews of Innovation Policy: Costa Rica 2017, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264271654-en [↑](#footnote-ref-4)
4. See, for example, OECD (2018), Realizing the circular bioeconomy. OECD Science, Technology and Industry Policy Papers No. 60, OECD Publishing, Paris. [↑](#footnote-ref-5)
5. WEF (2019), Harnessing the Fourth Industrial Revolution for the Circular Economy Consumer Electronics and Plastics Packaging, World Economic Forum, Geneva, Switzerland. [↑](#footnote-ref-6)
6. Antje Klitkou, Joe Bozell, Calliope Panoutsou, Michael Kuhndt, Jaakko Kuusisaari y Jan Peter Beckmann (2017). Bioeconomy and digitalisation, Background Paper, The Swedish Foundation for Strategic Environmental Research, Stockholm, Sweden. [↑](#footnote-ref-7)
7. OECD, Recommendation of the Council on Assessing the Sustainability of Bio-Based Products, OECD/LEGAL/0395 [↑](#footnote-ref-8)
8. See, for example: (i) OECD (2009), The Bioeconomy to 2030, designing a policy agenda, Secretary General of the OECD, OECD Publishing, París; (ii) German Bioeconomy Council (2018), Bioeconomy Policy (Part III), Update report of National Strategies Around the World, German Bioeconomy Council, Berlin, Germany, Retrieved from <http://gbs2018.com/resources/>; (iii) Rodríguez, Adrián; Rodrigues, Mónica y Sotomayor, Octavio (2019), Hacia una bioeconomía sostenible, elementos para una visión regional, Serie Recursos Naturales y Desarrollo No. 191, División de Recursos Naturales, CEPAL, Santiago de Chile, retrieved from <https://repositorio.cepal.org/handle/11362/44640>. [↑](#footnote-ref-9)
9. Biodiversity Law No. 7788, in its article 7 defines biochemical element as "any material derived from plants, animals, fungi or microorganisms, containing specific characteristics, special molecules or clues to design them". [↑](#footnote-ref-10)
10. . The Biodiversity Law (No. 7788 of 1998) defines bioprospecting as "the systematic search, classification and research for commercial purposes of new sources of chemical compounds, genes, proteins, microorganisms and other products with actual or potential economic value, which are found in biodiversity". [↑](#footnote-ref-11)
11. See for example the OECD Innovation Policy Assessment (OECD, 2017). [↑](#footnote-ref-12)
12. Biocities, or cities based on biological principles were identified as a future global bioeconomy flagship project in the delphi study of GBS2015 (German Bioeconomy Council, 2015, Global Vision for the Bioeconomy, an International Delphi Stydy, Berlin, Germany), retrieved from <https://biooekonomierat.de/fileadmin/Publikationen/berichte/Delphi-Study.pdf> [↑](#footnote-ref-13)
13. The Regional Development Councils (COREDES), are regional bodies that coordinate and articulate institutional and inter-institutional policies, plans, programs and projects, through the active participation of the different segments involved in the development of the regional space. (Executive Decree No. 39453-MP-PLAN of October 14, 2015). [↑](#footnote-ref-14)