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# OPPORTUNITIES FOR THE DEVELOPMENT OF BIOECONOMY AND BIOTECHNOLOGY CLUSTERS CONNECTED TO BRAZILIAN BIOMES

***Tagore Villarim de Siqueira***
Economist at the Banco Nacional de Desenvolvimento Econômico e Social.
Master's degree in Economic Theory from the Universidade Federal de Pernambuco - UFPE
http://lattes.cnpq.br/0578604562174801

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**Abstract:** In recent decades, advances in biodiversity-based technologies, such as new medicines and solutions to help tackle the ecological transition, have shown that preserving natural environments is not only fundamental to preserving life on the planet and mitigating the effects of climate change, but also plays a decisive role in solving previously unsolvable problems in areas such as human health and climate change. The preservation of biodiversity is fundamental to the discovery of new medicines that could lead to the cure of previously incurable diseases, as well as helping to mitigate the impacts of climate change. In this sense, this article presents some reflections on the opportunities and strategies for the country's sustainable development based on the biodiversity of Brazilian biomes, such as the development of bioeconomy and biotechnology clusters and regional innovation systems.
**Keywords:** Biodiversity. Biomes. Sustainable development. Clusters. Innovation systems.

## INTRODUCTION

The word biodiversity refers to biological diversity, the variety of species and ecosystems that exist in the environment, including all the living beings that exist in every territory on planet Earth. In simple terms, we can say that the biodiversity of the biomes on national territory, including the immense area of the Brazilian Atlantic Ocean, is made up of all forms of life, all fauna and flora in all habitats, in all natural ecosystems.

The biodiversity of each biome, made up of thousands of species, provides an immense number of molecules that represent infinite possibilities for solutions to current and future problems facing humanity in the areas of health and ecological transition. Molecules that can contribute to the production of goods and services produced from scientific studies in university laboratories and research centers and then made available to society through startups. Some of these benefiting sectors are well known, such as medicines, food products, biofuels, biofertilizers and biomaterials.

However, molecules from Brazilian biomes can potentially be used to solve problems in any area of human knowledge.

The potential for economic development based on the biodiversity of each of the country's biomes has become more evident in recent decades as a result of technological developments in various areas of knowledge, such as biotechnology, nanotechnology and information technology. On the scale of molecules, technological advances in biotechnology have boosted the gains from the development of new products related to biodiversity, which offer billions of possible solutions for the production of goods and services and are made available to the population, such as new medicines and potential solutions for diseases that until then had no cure.

At the same time, the limits still presented by new, non-nature-based technologies, such as the electric car, should be highlighted. Although they do not emit polluting gases, they put significant pressure on energy generation systems, which are sometimes dependent on polluting sources such as coal, and face major challenges in increasing the extraction of various ores on a global scale, such as nickel, cobalt, lithium and rare earths (Ni Co Li TR) - for the manufacture of batteries, causing strong environmental and social impacts on several continents. This means that, despite their technological superiority, electric cars still have a strong environmental impact, and could easily be replaced by vehicles with biofuel engines - such as ethanol and biodiesel - with zero emissions of polluting gases, considering the energy balance of the entire value chain.

From this perspective, it is possible to see that the value of a living forest is immense, and it is no exaggeration to say that it could reach several trillion dollars, or even that it is incalculable, given the potential for generating wealth from billions of molecules of its biodiversity, with the production frontier going far beyond the known bioeconomy related to the fauna and flora of each biome.

Thus, it would not be an exaggeration to say that, with the advances made in biotechnology in recent decades, it will be possible to develop applications from molecules to solve problems in crucial areas for humanity, such as health and ecological transition, with the results of scientific research being able to become the basis for new goods and services through innovations carried out by research centers and startups. It is no exaggeration to say that such activities could be the embryo for the development of a new nature-based economy, in line with the concepts of circular economy and sustainable development, and capable of responding to the concerns arising from climate change.

Recent advances in these biodiversity-based technologies have contributed to a more optimistic outlook regarding the cure of many diseases and the ability to mitigate the impacts of climate change. They have expanded the possibilities for producing new goods and services in a more sustainable way, generating fewer environmental impacts. However, it is important to realize that there are several weaknesses and vulnerabilities that limit the pace of development of these new branches of activity based on the bank of molecules that exist in each biome, and it is necessary to define a public policy, a sustainable development strategy for the country capable of stimulating this new industry, capable of strengthening the national innovation system and promoting systemic competitiveness in the various infrastructure, economic and social systems. In this way, the national cluster policy - PNC - adopted by European Union countries could serve as an example for Brazilian *policy makers*.

In this sense, this article presents some reflections on the opportunities for sustainable development in the country based on the biodiversity of the Brazilian biomes, considered to be the most diverse in the world in terms of the number of species of fauna and flora, with the strengthening of bioeconomy and biotechnology clusters in the country, as well as related regional innovation systems. The article is organized into three sections, in addition to the introduction, final considerations and bibliographical references. The first section presents some considerations on the origin and evolution of the concepts of biodiversity and the bioeconomy, as well as clusters and national innovation systems. The second section presents a case study of the National Cluster Policy (NCP) in the European Union, taking the experience of four countries as an example: Portugal, Ireland, Finland and France. Finally, the third section presents Brazilian industrial clusters, specialized industrial agglomerations classified according to their location quotient.

## BIODIVERSITY AND BIOECONOMY OF BRAZILIAN BIOMES

At the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992 (Rio 92), the Climate and Biodiversity Conventions, Agenda 21, the Rio Declaration for Environment and Development and the Declaration of Principles for Forests were signed.

This convention was a defining milestone in the construction of a new model of economic development, sustainable development, based on economic, social and environmental sustainability. Production systems must meet the demands of the present without compromising the well-being of future generations.

The Climate Convention is a treaty that establishes commitments for signatory countries to combat climate change. At COP27 in 2015, for example, the Paris Agreement established a series of actions for signatory countries to follow in order to reduce greenhouse gas emissions, "Intended Nationally Determined Contributions (NDCs)". The overall aim is to prevent the planet's climate from warming by more than 1.5°C compared to pre-industrial era levels.

Brazil's NDC committed it to reducing greenhouse gas emissions by 37% below 2005 levels by 2025, with a subsequent indicative contribution of reducing greenhouse gas emissions by 43% below 2005 levels by 2030. To this end, the country has committed to increasing the share of sustainable bioenergy in its energy matrix to approximately 18% by 2030, restoring and reforesting 12 million hectares of forests, as well as achieving an estimated 45% share of renewable energies in the composition of the energy matrix by 2030 (Ministry of the Environment website).

The Biodiversity Convention is a treaty that defines principles and actions for the protection and use of the planet's biodiversity. Based on these principles, concepts such as sociobiodiversity, sociobiodiversity economy and bioeconomy have been developed.

The Biodiversity Convention is structured around three basic pillars: the conservation of biological diversity, the sustainable use of biodiversity and the fair and equitable sharing of the benefits arising from the utilization of genetic resources. The Convention considers biodiversity at three levels: ecosystems, species and genetic resources.

The concept of socio-biodiversity covers a wide range of products and services resulting from the connection between biological diversity, the practice of sustainable activities such as organic farming, regenerative agriculture and agroforestry systems, and the management of natural ecosystem resources. Socio-biodiversity crops in Brazil include, for example: açaí, babassu, rubber, cocoa, Brazil nuts, cassava, native fruits, fish farming, certified community-managed timber and vegetable oils, among others. Socio-biodiversity thus encompasses various foods from extractivism, agro-forestry systems and family farming. It makes use of natural and social assets to generate new products and services, valuing traditional communities, family farmers and forest peoples. It contributes to keeping the forest alive and therefore to greater absorption of greenhouse gas pollutants, and should therefore be encouraged by public policies, financial support from other countries, companies focused on ESG (Environment, Social and Government) projects and through the carbon credit market.

The concept of bioeconomy, also widespread during this period, is confused with that of sociobiodiversity, but is broader and includes production systems developed from biological products, such as the experience of the Proálcool program in Brazil in the 1970s, with Embrapa as a reference institution for the development of new technologies and production systems based on innovations in agricultural and forestry activities.

For Embrapa, the bioeconomy is an industrial production model based on the use of biological resources, with the aim of "offering solutions for the sustainability of production systems with a view to replacing fossil and non-renewable resources" (Embrapa, www.embrapa.br/tema-bioeconomia).

In this way, we could say that the concept of the bioeconomy is related to activities that depend on the biodiversity of biomes and at the same time contribute to their respective conservation, ranging from simple, low value-added activities, such as collecting seeds, leaves and honey from forests, to activities with higher added value, such as agricultural pro-

duction and forestry in agroforestry systems, and more technology-intensive activities such as biotechnology, through more complex systems, with universities, research centers, laboratories, startups and mature companies linked to the pharmaceutical and biofertilizer industries, for example.

The advances made by genetics and biotechnology in recent decades have strengthened expectations for building a bio-based economy, with biotechnology solutions covering numerous areas of the economy, with emphasis on the sustainable production of renewable resources and their efficient conversion into food, fibers, animal feed, chemicals, pharmaceuticals, cosmetics, biomaterials, biofertilizers and bioenergy. The impacts are truly far-reaching, including benefits for human health and ecological transition, thus justifying the construction of an institutional environment to promote the development of bioeconomy and biotechnology clusters and, respective, regional innovation systems focused on Brazilian biomes.

The most recent case that illustrates the rapid rise of biotechnology in the global economy is the experience of the Danish pharmaceutical company Novo Nordisk, with the drug Ozempic for the treatment of diabetes and obesity, whose active ingredient, semaglutide, is derived from a molecule of a desert lizard between Mexico and the United States. The launch of the new drug at the beginning of 2024 caused an exponential increase in global demand for the product, generating a major impact in the city where the company's factory is located, just outside the country's capital Copenhagen. Following the launch of the product, within a few weeks the company reached the top position in Europe in terms of market value (BBC NEWS BRAZIL).

Another example that illustrates the potential of biotechnology to promote Brazilian development can be found here in Brazil, with Embrapa developing a bioinput, in conjunction with a startup, derived from a bacterium that lives in the root of the mandacaru tree in the Caatinga biome in the northeastern hinterland. This bioinput helps to reduce water consumption by plants, thus helping them to cope with water stress in the semi-arid region during long droughts, and its application has already begun in corn crops and is due to be extended to other crops, such as coffee and soybeans (PORTAL AGRO2).

Other evidence that reinforces expectations about the flourishing of the bioeconomy and biotechnology is provided by the study "Accelerating the Global Transition to a Bio--based Economy: The Strategic Role of Policy", published by the World Economic Forum - WEF, which shows the immense potential of the bioeconomy to transform the world economy and meet the challenges of the ecological transition. This study highlights the importance of the bioeconomy in offering solutions to the most pressing challenges facing humanity today, pointing out that effective policies have boosted innovative biotechnologies in the laboratory and that innovations are being widely used by society. A good example is the success of the vaccine to combat COVID-19, which ended the pandemic that hit the entire planet a few years ago. With the WEF advocating continued support for the evolution of these tools, so that we can continue to reliably harness biology and its commercial applications, public policy must remain central to ensuring that innovations deliver a bio-based, resilient and human-centered economy.

Current knowledge about the biodiversity of Brazilian biomes shows some possible ways forward, with potential for structuring production systems based on products from forests and river basins. However, the wealth of biodiversity in these biomes also shows that the road ahead is long and vast, with the potential for developing new value chains being much

broader, with many other goods and services that could be developed from the molecules of the flora and fauna of Brazil's biomes. The possibilities are limitless, with countless applications for concentrates and natural essences being produced from innovations carried out in laboratories at universities, research centers and startups in the country. In this sense, the importance of public policies to promote investment in research, development and innovation (R,D&I), focused on new products and services based on the flora and fauna of each biome (Amazon, Atlantic Forest, Caatinga, Cerrado, Pantanal and Pampa), as well as the area of the Brazilian Atlantic Ocean, stands out. Better knowledge of the fauna and flora of each part of Brazil's territory will contribute to building a new, bio-based Brazilian economy, in line with the concepts of sustainable development, circular economy and the UN's 2030 Sustainable Development Goals (SDGs).

According to Sachs (2008), in his book "The Wealth of All: Building a Sustainable Economy on an Overpopulated, Polluted and Poor Planet", public policies play a key role in providing the technologies the world needs to face the challenges of climate change in the 21st century: *"Markets alone will not develop the sustainable technologies we will need in the 21st century. Scientific discoveries in general, on which sustainable technologies depend, are a public good that cannot be provided by market forces. This is because scientific knowledge is an intangible good that can be used by one person without diminishing its availability to others." P.48*

In this sense, public policies could focus on strengthening the institutions of the regional innovation systems related to each biome, supporting teaching and research networks, as well as research centers, incubators and startups, thus providing the conditions for structuring competitive innovation clusters and ecosystems in each region of the country. The study of the biodiversity of each biome and the identification of molecules with the potential to solve specific problems, such as a drug or an application that can mitigate impacts on ecological transition, could help define the strategy for structuring regional bioeconomy and biotechnology ecosystems in each biome. On the other hand, it is also necessary to promote the development of clusters in each region - also known as specialized agglomerations, competitiveness poles or local productive arrangements, supporting companies participating in the bioeconomy and biotechnology value chains, with an emphasis on small and medium-sized enterprises (SMEs) and stimulating investments in innovation and gains in competitiveness.

It is therefore necessary to focus on scientific research to expand knowledge about each of the country's biomes, thus improving the identification of molecules and potential applications that could represent solutions in the areas of health, energy transition and climate change, for example. It is therefore necessary to build capacity and increase the competitiveness of research infrastructure - such as universities, research centers and laboratories, and investments in education in general and the training and development of researchers.

In addition, it is also necessary to improve the approach to identifying new development opportunities that have not yet been realized, to build a new agenda for sustainable development, with appropriate public incentives, based on the potential offered by the billions of molecules that exist in the biodiversity of Brazilian biomes.

## INNOVATION CLUSTERS AND ECOSYSTEMS

The development of Biotechnology Clusters focused on the biodiversity of Brazilian biomes is directly related to the evolution of regional innovation systems, their organizations, the degree of interaction between their participants and public policies, as well as the expansion of the knowledge base on the biodiversity of these biomes. In this sense, it is important to build capacity in universities and their laboratories to generate knowledge about the biodiversity of national biomes and transfer this knowledge to society through new technologies transformed into goods and services through business incubation processes, startups, and partnerships with mature innovative companies.

According to Freeman (1995), the construction of national innovation systems must take into account the interaction of various actors, institutions and public policies that contribute to innovation and economic development, and it is necessary to adopt a holistic approach that covers all innovation processes, going beyond the focus on companies and/or isolated sectors. In this sense, the role of institutions, government policies, research organizations, universities and industry associations stands out. It is worth remembering that the effectiveness of innovation policies is related to the degree of understanding of the institutional framework of the country or region where the innovation policy is implemented.

From this perspective, policies and strategies to support innovation in industry stand out, as well as the promotion of a culture of innovation in companies participating in the various industrial value chains, through the consolidation of research, development and innovation (R,D&I) centers, technological competition, interdisciplinary collaboration and dynamic interactions between companies.

The approach needs to be systemic and dynamic, taking into account aspects such as the historical, economic and systemic dimensions of innovation; a collaborative academic environment needs to be promoted that encourages interdisciplinarity and the exchange of knowledge, capable of achieving the established objectives and pointing out new research routes for innovation. With innovations being observed in a broader perspective, contributing to a better understanding of their respective impacts, in the regional innovation ecosystems themselves, but also in national terms.

In this sense, the European experience with innovation systems and national cluster policies (NCP) stands out, as well as their respective contributions to regional development in various countries. Initiatives developed on the basis of local potential have contributed to the industrial reconversion of some regions that were experiencing declining economic activity, highlighting concepts such as clusters, specialized agglomerations, competitiveness poles, industrial ecosystems, national innovation systems, and the role of innovation and competitiveness in the process of sustainable development. Many of these production systems started out simple, with just a few participating organizations, but gradually became more complex, transforming themselves into large industrial agglomerations with global operations.

The word cluster can literally be translated as "Set". It is an English term for a group of interconnected objects, a bunch, a bouquet, a clump or even a swarm. The image to remember is that of distinct but interconnected entities. In this way, the term is used to designate a "System" made up of elements that act independently and have connections with each other in order to achieve a goal, a result or a product, which can start out simple and evolve adaptively to high degrees of complexity.

In economic geography, in Anglo-American literature, a cluster is a concentration of activities grouped around a sector, also known as a business agglomeration. This type of grouping, also known as a local productive system (LPS), is dealt with in France and other European Union countries in the policy of competitiveness clusters (Géoconfluences. Glossaire).

## CASE STUDY: NATIONAL CLUSTER POLICY (NCP) IN THE EUROPEAN UNION

This section presents the experience of four European Union (EU) countries with the National Cluster Policy (NCP): Portugal, Ireland, Finland and France. This policy is adopted by the 27 countries of the European Union as part of their respective industrial development strategies. It takes as a reference the 14 most relevant ecosystems for the EU economy, as selected by the European Commission. The experience of these countries illustrates the importance of the CNP on the European continent. It is a policy focused on specialized clusters in territories where large production chains operate, forming regional competitiveness poles and/or economic ecosystems. These clusters are classified as priorities for strengthening the competitiveness of the regions where they are located, as well as the countries and the European Union itself, and it is therefore essential to consolidate their respective positions as locomotives of sustainable economic development. For example, in Portugal the three main economic ecosystems are agri-food (farming and the manufacture of food and drink products), textiles and tourism. In Ireland, the health, digital and electronics ecosystems stand out. In Finland, the digital, electronics, mobility-transport-automotive and tourism ecosystems stand out. And in France, the digital, electronics, health and cultural and creative industries ecosystems stand out.

This strategy offers several examples of the importance of public policies for regional development implemented in recent decades in the EU, with the capacity to contribute to the economic conversion of regions that have fallen into decline, increase competitiveness and employment and reduce inequalities.

The EU's cluster policy focuses on actions aimed at increasing the productivity, quality and efficiency of the most important clusters in each country, and promotes employment and income in less developed regions. In this way, this policy also contributes to greater cohesion, unity, in the development pattern of the various European regions, preventing the risks of fragmentation of the European Union's economic space. These initiatives are focused on strengthening the most relevant regional economic nuclei, clusters and ecosystems with greater economic density, in terms of organizations, companies, jobs and economic production. The public policies established strengthen governance, benefit regional innovation systems and promote the competitiveness gains of clusters. Such clusters can be financed by various European Commission funds, such as the Horizon Fund for innovation, with an allocation of 95.5 billion euros for the period 2021-2027.

The European Commission has selected 14 ecosystems that are most relevant to the development of the countries of the European Union and, therefore, should receive greater attention from public policies, based on their economic importance and present and future sustainability, based on variables such as employment, income, the environment and innovation: Retail; Construction; Health; Proximity, Social Economy and Civil Security; Tourism; Agri-Food (farming and food industry); Mobility-Transport-Automotive; Culture and Creative Industry; Energy Intensive Industries; Digital; Aerospace and Defense; Textiles; Electronics; and Renewable Energy.

For each EU country, rankings were made for these ecosystems according to their location quotient and relative importance in generating jobs. In Portugal, for example, the top five positions were occupied by: Retail, Tourism, Agri-Food, Construction; and, Proximity, Social Economy and Civil Security. In Ireland, the highlights were Health, Retail, Tourism, Construction; and, Proximity, Social Economy and Civil Security. In Finland, the most relevant ecosystems were Construction; Proximity, Social Economy and Civil Security; Health; Retail; and Tourism. In France, the ranking was led by Health; Retail; Proximity, Social Economy and Civil Security; Construction; and Tourism.

The mission of the Horizon Europe Fund (HORIZON), which supports projects in these ecosystems, is to promote scientific research and innovation in the EU, with a budget of 95.5 billion euros for the period 2021-2027. The general objectives of the Fund are as follows: to strengthen the EU's scientific and technological bases and the European Research Area (ERA); to boost innovation capacity, competitiveness and employment in Europe; and, to meet citizens' priorities and sustain the European socio-economic model and values. Currently, the Fund has a special focus on impact creation, the Europe Green Deal, the digital and sustainability transition and the recovery from the coronavirus crisis.

HORIZON has three pillars:

Pillar 1
Excellence in Science
European Research Council
Marie Skłodowska-Curie's actions
Research infrastructures

Pillar 2
Global Challenges and European Industrial Competitiveness
Clusters: Health; Culture, Creativity and Inclusive Society; Civil Security for Society; Digital, Industry and Space; Climate, Energy and Mobility; Food, Bioeconomy, Natural Resources, Agriculture and Environment.

Pillar 3
Innovative Europe
European Innovation Council
European Innovation Ecosystems
European Institute of Innovation and Technology (EIT)

The Draghi report of September 2024 reinforces the need to promote increased competitiveness, strengthening clusters, innovation systems and funds to finance the development of the European Union. It presents a strategy for the EU to modernize the economy through investments in infrastructure, education and innovation. The report "The future of European competitiveness Part A - A competitiveness strategy for Europe" proposes closing the innovation gap, a plan for decarbonization and competitiveness, and reducing external vulnerabilities by increasing security and strengthening the capacity of the defence and space industries. In addition, it proposes changes to the institutional governance and functioning of the EU to achieve the objectives proposed in the report, bearing in mind that successful industrial policies require comprehensive strategies that include good coordination of various areas, such as: investment, enforcement, education, access to finance, regulation, trade and foreign policy.

He therefore proposes strengthening and modernizing state development policies to promote competitiveness gains in the European production system, with a focus on strategic industries for the EU economy, such as semiconductors, electric vehicles, telecommunications and space, and clean energies.

A proposal focused on efficiency and productivity gains, as adopted by the United States in recent years, through initiatives such as increased tariffs on imports of various industrial products due to Chinese competition, the Chip and Science Act and the Inflation Reduction Act, which supported investments in the semiconductor, electric vehicle and renewable energy industries.

In this sense, it is worth noting that the largest companies in the world today, the only companies with a market value of more than US$1 trillion, have four common characteristics: they are North American, they are in the information technology and artificial intelligence sector and they have been or still are beneficiaries of state policies for innovation and the supply of products and services to the US Defense system, for example.

Thus, in order to meet the objectives presented by the Draghi report, an annual investment of between 750 and 800 billion euros has been proposed, equivalent to 4.4-4.7% of the EU's GDP in 2023. For comparison, the investment made under the Marshall Plan between 1948-51 was equivalent to 1-2% of the EU's GDP.

In this sense, Mazzucato (2014), in his book "O Estado Empreendedor: Desmascarando o mito do setor público vs. setor privado" (The Entrepreneurial State: Debunking the myth of the public sector vs. the private sector), offers several examples of the state's important contribution to the development of innovations that have transformed the world economy, with public policies having been decisive in the various technological revolutions throughout the 20th century and in recent times throughout the world. Among many cases, an emblematic example is offered by the US space program from the 1960s onwards, which led to the emergence and development of various technologies that have influenced our way of life to this day, with innovations such as: rockets, satellites, computing, semiconductors, electronics, solar energy, telecommunications, live broadcasting, cell phones, the Internet, etc.

## CASE STUDIES: NATIONAL CLUSTER POLICY (NCP) IN PORTUGAL, IRELAND, FINLAND AND FRANCE

This section presents the main characteristics of the experience of four European Union countries within the framework of the PNC (Portugal, Ireland, Finland and France), which could serve as a reference for a development strategy for developing countries such as Brazil, based on strengthening specialized clusters and innovation systems.

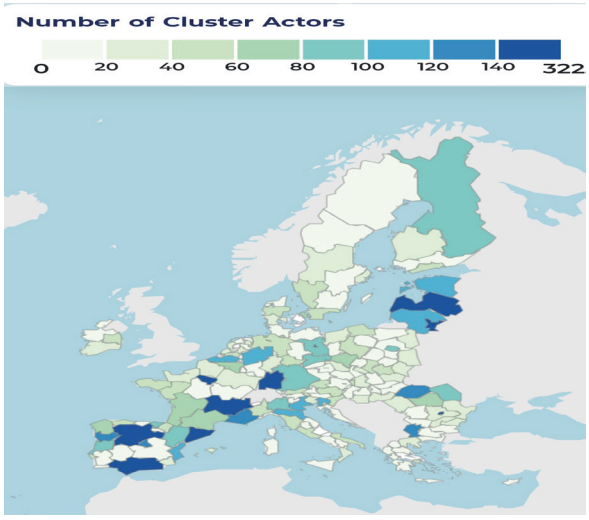
In 2024 there were 1,200 cluster organizations in the European Union, 60% of which were created since 2010 (MAP 1). Among the participants in the clusters, the presence of small and medium-sized enterprises (SMEs) stands out. In terms of economic activity, two activities stand out from the rest, accounting for 45% of all clusters, 27% of which are in the Digital sector and 18% in Renewable Energies. The most significant growth was seen in the Digital, Renewable Energy and Health industrial ecosystems; in terms of employment, GVA - value added management and number of clusters. The evaluation of clusters in the EU identified a positive correlation between the number of clusters and industrial competitiveness indicators (European Cluster Panorama Report 2024).

The National Cluster Policy (NCP) has several common objectives in the 27 countries of the European Union (EU27), among which the following stand out: promoting cooperation between organizations participating in clusters, such as companies, universities, research centers, startups, etc; promoting competitiveness, productivity, quality and efficiency; promoting small and medium-sized enterprises (SMEs); stimulating exports and suppor-

ting the internationalization strategy and connection with global supply chains; promoting R&D activities, technological development and implementation, entrepreneurship, startups and spin-offs; promoting the visibility of clusters and strengthening cluster institutions and innovation ecosystems; promoting employment, professional qualifications and skills, including support for the retention of researchers in companies and the funding of doctorates and post-doctorates; strengthening territorial cohesion and the network of cluster organizations and related activities; promoting the social and sustainable economy and other solidarity-based initiatives. Finally, the MNCs support studies on clusters and carry out periodic evaluations of the initiatives carried out.

The beneficiaries of the PNC are: SMEs, Cluster organizations; Research organizations; Academic institutions; Startups; Large companies; and, Technology centers.

Economic activity and employment are distributed unevenly across the regions of the various EU27 countries, with the degree of specialization being measured by means of Location Quotients (LQ) which reflect the relative specialization of an activity in a given region compared to the EU average. If the LQ for a given activity-region combination is greater than 1.5, it is considered a "specialization node" (specialized agglomeration), and if the activity represents at least 1% of total employment in the region, it is considered regionally relevant. The tables presented for each country show the total number of regionally relevant "specialization nodes" in each region of the country and identify the five most specialized nodes.




Map 1. Clusters in the European Union - 2024

Source: European Cluster Collaboration Platform (ECCP). https://reporting.clustercollaboration.eu/region

## PORTUGAL

Portugal's National Cluster Policy (PNC) is implemented by the Portuguese Agency for Competitiveness and Innovation (IAPMEI) in partnership with the Ministry of Economy and Digital Transition, which is responsible for the policy. This policy began in 2017, when 20 cluster organizations were accredited as Competitiveness Clusters under the Interface Programme, which aims to support actions within academia, research and industry.

TABLE 1 shows 35 "specialized node" activities by region, of which 25 are on the mainland, 5 in the Azores and 5 in Madeira. While Table 2 presents the four most regionally relevant ecosystems, which stand out as the most important for the Portuguese economy: Agri-food, tourism, textiles and energy-intensive industries.

Portugal's PNC currently has 18 active Competitiveness Clusters. These clusters are defined as platforms that aggregate knowledge and skills and play a central role in the country's industrial policy and economy. These clusters contribute to innovation and technology transfer, digitalization, the identification

and training of suppliers, connections between startups and industrial companies, internationalization, the circular economy and energy efficiency. Between 2019 and 2021, the Government and the Competitiveness Clusters signed the Sectoral Pacts for Competitiveness and Internationalization to increase the competitiveness, innovation and internationalization of Portuguese companies.

These Pacts aim to promote the implementation of a broad set of initiatives related to the circular economy and the energy and ecological transitions, as well as improving the institutional and regulatory conditions of the business ecosystem, promoting Industry 4.0, training human resources, increasing exports and internationalization and promoting innovation.

These Pacts include six key actions, which are adjusted according to the different organizations in the cluster, namely: provision for training, retaining and attracting talent; increasing the added value of products and promoting the circular economy; innovation; promoting internationalization and attracting foreign investment; promoting the national start-up ecosystem; and, financing.

The policy focuses on the following sectors: aerospace, railways, petrochemicals, fashion and footwear, the sea, raw materials, sustainable living, smart cities, textiles, agri-food, health, construction, automobiles, ICT, production technologies and wine.

In addition to implementing the PNC, IAPMEI is responsible for following up, monitoring and evaluating the Competitiveness Clusters and their progress towards achieving the objectives set out in the approved program. The Monitoring Committee, chaired by the Assistant Secretary of State for the Economy, monitors the PNC.

The PNC has financial instruments, technical assistance and promotion. It provides funding for R&D projects, including testing, proof of concept, prototyping, demonstration projects, vouchers, doctorates and technical cooperation.

Within the scope of technical assistance, PNC supports the development of technical skills, such as knowledge transfer, intellectual property, entrepreneurship, export advice and market intelligence. PNC's support includes the development of interpersonal skills, such as coaching, management, retraining, networking and building partnerships at home and abroad.

The PNC to promote the activities of Competitiveness Clusters contributes to strengthening the culture of innovation in the country, networks and other forms of partnerships and cooperation. The PNC supports R&D strategies aimed at fostering innovation, thus creating the conditions to expand the launch of new products, processes and/or services with a high technological content.

The policy to support Competitiveness Clusters began in 2017, and IAPMEI has already carried out three monitoring assessments (2017, 2018 and 2019). In 2020, a more comprehensive evaluation was carried out for the 3 years (2017, 2018 and 2019). The first results were positive. Small and medium-sized enterprises (SMEs) accounted for around 50% of participants. Evaluations of cluster performance showed positive results in terms of various indicators, number of clusters, participating members, projects and I7D, innovation, turnover and gross value added (GVA) (ECCP Portugal.org, 2023).

| Region | Number of nodes | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 |
|---|---|---|---|---|---|---|
| PT11: North (Portugal) | 11 | C15 - Manuf. of leather products | C14 - Manuf. of wearing apparel | C13 - Manuf. of textiles | N82 - Business support activities | C31 - Manuf. of furniture |
| PT15: Algarve | 9 | A03 - Fishing & aquaculture | I55 - Accommodation | I56 - Food & beverage services | N82 - Business support activities | F41 - Construction of buildings |
| PT16: Centre (Portugal) | 8 | A02 - Forestry & logging | C23 - Manuf. of other non-metal mineral products | A01 - Crop & animal production | N82 - Business support activities | C25 - Manuf. of fabricated metal products |
| PT17: Lisbon Metropolitan Area | 9 | N82 - Business support activities | N80 - Security, investigation activities | N78 - Employment activities | T97 - Households as employers act. | I55 - Accommodation |
| PT18: Alentejo | 6 | A02 - Forestry & logging | A01 - Crop & animal production | N82 - Business support activities | O84 - Public adm., defence, soc. security | C10 - Manuf. of food products |
| PT20: Azores | 8 | A03 - Fishing & aquaculture | T97 - Households as employers act. | I55 - Accommodation | A01 - Crop & animal production | N82 - Business support activities |
| PT30: Madeira | 10 | A03 - Fishing & aquaculture | I55 - Accommodation | N82 - Business support activities | A01 - Crop & animal production | T97 - Households as employers act. |

Table 1. Portugal. Regionally Relevant Sector Clusters

Source: European Cluster Collaboration Platform (ECCP). ECCP Portugal.org, 2023.

| Region | Number of nodes | Node 1 | Node 2 | Node 3 |
|---|---|---|---|---|
| PT11: North (Portugal) | 1 | Textile | - | - |
| PT15: Algarve | 1 | Tourism | - | - |
| PT16: Centre (Portugal) | 3 | Agri-Food | Textile | Energy-intensive industries |
| PT17: Lisbon Metropolitan Area | 1 | Tourism | - | - |
| PT18: Alentejo | 1 | Agri-Food | - | - |
| PT20: Azores | 1 | Agri-Food | - | - |
| PT30: Madeira | 2 | Tourism | Agri-Food | - |

Table 2. Portugal. Ecosystems Regionally Relevant Clusters

Source: European Cluster Collaboration Platform (ECCP). ECCP Portugal.org, 2023.

## IRELAND

The institution responsible for cluster policy in Ireland is Science Foundation Ireland (SFI), whose main objective is to fund research in the fields of science, technology, engineering and mathematics (STEM). SFI focuses on STEM research, scientific research and engineering innovation to promote competitiveness, foster innovation and increase employment in the country. SFI's initiatives are carried out through partnerships and collaboration with national and international companies, funding for research centers, and the provision of subsidies and infrastructure to higher education institutes. In addition, the institution supports events to promote STEM areas, such as "Science Week". Between 2012 and 2017, the SFI accounted for 23.4% of central government spending on R&D.

TABLE 3 shows 15 "specialized node" activities by region. While Table 4 shows the three most regionally relevant ecosystems in the country, namely: Health, Electronics and Digital.

The IFC is responsible for implementing the policy, providing funding and overseeing the implementation of projects. The institution relies on the leadership of board members and an executive team responsible for overseeing the implementation of the NHP. SFI was originally created in 2000 as a sub-council of Forfás to administer the Ireland Technology Foresight Fund. In 2003, SFI was established as a separate entity with the Industrial Development Act (Science Foundation Ireland) approved by the government. In 2013 the Act was amended to include targeted basic research and applied research.

| Region | Number of nodes | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 |
|---|---|---|---|---|---|---|
| IE04: Northern and Western (Ireland) | 5 | C32 - Other manufacturing | C21 - Manuf. of pharmaceuticals | I55 - Accommodation | A01 - Crop & animal production | Q88 - Social work without accommodation |
| IE05: Southern (Ireland) | 5 | C21 - Manuf. of pharmaceuticals | C32 - Other manufacturing | I55 - Accommodation | C26 - Manuf. of electronic & optical products | A01 - Crop & animal production |
| IE06: Eastern and Midland (Ireland) | 8 | C21 - Manuf. of pharmaceuticals | K65 - Insurance, pension funding | K64 - Financial services | J62 - Computer programming, consultancy | I55 - Accommodation |

Table 3. Ireland. Regionally Relevant Sector Clusters

Source: European Cluster Collaboration Platform (ECCP). ECCP Ireland.org, 2023.

| Region | Number of nodes | Node 1 |
|---|---|---|
| IE04: Northern and Western (Ireland) | 1 | Health |
| IE05: Southern (Ireland) | 1 | Electronics |
| IE06: Eastern and Midland (Ireland) | 1 | Digital |

Table 4. Ireland. Regionally Relevant Clustered Ecosystems

Source: European Cluster Collaboration Platform (ECCP). ECCP Ireland.org, 2023.

Beneficiaries of the policy include: SMEs, research organizations, academic institutions, start-ups, large companies, technology centers, and the general public.

The SFI funds researchers in higher education institutes who collaborate with multinational companies, small and medium-sized enterprises (SMEs) and start-ups. The SFI establishes "SFI research centers" throughout Ireland and awards grants to higher education institutions to improve their infrastructure. SFI also supports TV programs that promote STEM areas. SFI provides financial support for R&D projects of SMEs that become members of clusters and networking events.

The IFC promotes cluster development by supporting the development of technical and transversal skills. Technical skills include: knowledge transfer, intellectual property, entrepreneurship, export consultancy and market intelligence. In terms of transversal skills, the institution supports activities such as coaching, management training and skills upgrading. The SFI also offers support for networking and building partnerships (at home and abroad). The SFI also supports marketing activities, including advertising, communication, events and fairs; and infrastructure-related activities, such as coworking spaces, offices, incubation spaces and accelerators, research centers and technology parks (ECCP Ireland.org, 2023).

## FINLAND

Finland's cluster policy is among the national priorities for regional development and is aligned with two European Union priorities "Digitalization" and "Social Inclusion". The Ministry of Economy is responsible for drawing up, financing and supervising the plan, helping to define the objectives and focal points for regional and national development. The regional implementation of the policy includes the participation of local authorities. The Ministry oversees regional development and promotes sectoral funding focused on EU priority areas.

TABLE 5 shows 25 "specialized node" activities by region. While Table 6 shows the five most regionally relevant ecosystems, which stand out as the most important in the country: Digital, Electronics, Mobility-Transport--Automotive and Tourism.

| Region | Number of nodes | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 |
|---|---|---|---|---|---|---|
| FI19: West Finland | 8 | C17 - Manuf. of paper products | C28 - Manuf. of machinery & equipment | C33 - Repair, installation of machinery | P85 - Education | R93 - Sports, amusement, recreation |
| FI1B: Helsinki-Uusimaa | 10 | J58 - Publishing activities | Q88 - Social work without accommodation | J62 - Computer programming, consultancy | C26 - Manuf. of electronic & optical products | N78 - Employment activities |
| FI1C: South Finland | 6 | C17 - Manuf. of paper products | Q87 - Residential care | S94 - Membership organisations | F41 - Construction of buildings | O84 - Public adm., defence, soc. security |
| FI1D: North and East Finland | 9 | A02 - Forestry & logging | C16 - Manuf. of wood products | P85 - Education | C24 - Manuf. of basic metals | C26 - Manuf. of electronic & optical products |
| FI20: Åland Islands | 7 | H50 - Water transport | R92 - Gambling & betting | Q87 - Residential care | H53 - Postal & courier activities | F41 - Construction of buildings |

Table 5. Ireland. Regionally Relevant Sector Clusters

Source: European Cluster Collaboration Platform (ECCP). ECCP Finland.org, 2023.

| Region | Number of nodes | Node 1 | Node 2 |
|---|---|---|---|
| FI19: West Finland | 0 | - | - |
| FI1B: Helsinki-Uusimaa | 2 | Digital | Electronics |
| FI1C: South Finland | 0 | - | - |
| FI1D: North and East Finland | 1 | Electronics | - |
| FI20: Åland Islands | 2 | Mobility-Transport-Automotive | Tourism |

Table 6. Finland. Regionally Relevant Agglomerated Ecosystems

Source: European Cluster Collaboration Platform (ECCP). ECCP Finland.org, 2023.

The plan also takes an intersectoral approach, highlighting the need for intersectoral collaboration between the clusters. Clusters are seen as network organizations with a thematic focus. However, cluster organizations should not focus on building their own in-depth knowledge, for example on digitalization or green technologies, but rather on ensuring that they have basic knowledge and good connections to experts in specific fields. The main competence and capacity of managers, cluster organizations (institutions managing specialized clusters), should be the ability to build networks, facilitate growth and interact with SMEs, raise awareness, share good practices and be intermediaries.

Among the beneficiaries of the PNC are: SMEs, cluster organizations, research organizations, academic institutions, startups, business associations, large companies, NGOs and technology centers. The program is a holistic entrepreneurship strategy that considers different companies, from micro-enterprises to large multinationals. It is supported by the active participation of other stakeholders, including civil society organizations, public administration, the church, etc.

The PNC relies on financial and communication instruments to achieve its objectives. Financial instruments include: funding for cluster participants; innovation vouchers, support for hiring PhDs, and cooperation with innovation players. Communication: the strategy uses the following national financial instruments to support regional development: entrepreneurship funds, employment funds, R&D-focused funds, different investment and development funds divided into sectors and EU funding. The use of these instruments is not described in detail at strategy level.

The financing of Finland's MNC is carried out with the support of EU funds, with emphasis on the following national financial instruments to support regional development:

entrepreneurship funds, employment funds, R&D funds, and other EU sectoral investment and development funds.

The PNC is made up of six distinct areas, namely: environment, community development, innovation and R&D, skills and education, participation and well-being, and regional development. Each of these areas is evaluated in terms of economic, social and environmental impacts. The initiatives carried out by the program are estimated to have positive impacts in all areas (ECCP Finland. org, 2023).

**FRANCE**

France has several Competitiveness Clusters (Pôles de compétivité), relevant agglomerations of companies and institutions specializing in specific activities, in terms of the number of companies, organizations related to the activities, job creation and production value. However, four ecosystems stand out as the most important for the national economy: health, digital, electronics and culture and creative industries (TABLES 7 and 8). TABLE 7 shows 98 "specialized nodes", 88 of which are on the continent, while TABLE 8 shows 14 of the most relevant ecosystems, 11 of which are on the continent.

France has had a national cluster policy since 2004. The current French PNC, in its fifth edition (2023-2026), is aligned with three European Union priorities: Green Economy, Digitalization and Resilience. The main target group of this policy is innovative SMEs, and its focus is on supporting innovation and industrialization. The policy focuses on supporting clusters, involvement in European projects (Horizon Europe) and support for the twin transitions, green and digital, as well as industrial sovereignty through innovation.

Since 2009, the French PNC has prioritized the promotion of competitiveness, with a focus on SMEs in sectors with low investment in R&D&I activities and limited participation in clusters, especially in segments such as the food industry, textiles, metallurgy and shipbuilding.

The Ministry of Economy and Finance is responsible for drawing up and implementing the national cluster policy. Funding is provided by the state through a special national fund (FUI) and regional funds (DIRECCTE), by the regions and local authorities, and by the private sector. Other institutions supporting this initiative are: Bpifrance and Caísse des Dépots, public investment banks; ANR, the state research agency; and, Regional agencies.

France Clusters is an umbrella organization that supports the other French cluster organizations in implementing their projects. Among the services offered by this organization, the following stand out: training and advice, mentoring, help with internationalization, organization of events and forums for the exchange of practices. It is co-financed by the French state, public investment banks (Caisse des Dépots and Banque des Territories), the European Union and some French regions, such as Nouvelle Aquitaine and Provence Alpes Côte d'Azur.

The PNC is implemented differently between the various French regions, with the experience of the Auvergne-Rhône-Alpes region serving as an example of decentralization in the management of this policy, efficiency and results achieved. The French PNC is drawn up and overseen by the Ministry of Economy and Financing, but partnerships are promoted with regional and local authorities to improve the volume of funding and the implementation of projects in each locality.

In this way, the Auvergne-Rhône-Alpes regional agency takes on the management and coordination of initiatives in its area of influence, such as: the creation of new financial instruments for different parts of the region, such as public-private capital funds in the

| Region | Number of nodes | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 |
|---|---|---|---|---|---|---|
| FR1: Île-de-France | 12 | J61 - Telecommunications | N78 - Employment activities | N77 - Rental & leasing | J58 - Publishing activities | R90 - Arts & entertainment |
| FRB: Centre-Val de Loire | 4 | C22 - Manuf. of rubber & plastic products | N82 - Business support activities | N78 - Employment activities | Q88 - Social work without accommodation | |
| FRC: Burgundy-Franche-Comté | 5 | Q88 - Social work without accommodation | C26 - Manuf. of electronic & optical products | M71 - Architecture, engineering | Q87 - Residential care | C22 - Manuf. of rubber & plastic products |
| FRD: Normandy | 5 | Q88 - Social work without accommodation | M71 - Architecture, engineering | C10 - Manuf. of food products | C20 - Manuf. of chemical products | Q87 - Residential care |
| FRE: Hauts-de-France | 5 | M73 - Advertising & market research | Q88 - Social work without accommodation | Q87 - Residential care | N82 - Business support activities | N80 - Security, investigation activities |
| FRF: Grand Est | 2 | Q88 - Social work without accommodation | N78 - Employment activities | | | |
| FRG: Loire Region | 6 | C10 - Manuf. of food products | Q88 - Social work without accommodation | M71 - Architecture, engineering | N78 - Employment activities | Q87 - Residential care |
| FRH: Brittany | 4 | C10 - Manuf. of food products | N81-Buildings services and landscaping | Q88 - Social work without accommodation | F43 - Specialised construction act. | |
| FRI: New Aquitaine | 3 | Q88 - Social work without accommodation | Q87 - Residential care | H53 - Postal & courier activities | | |
| FRJ: Occitania | 4 | M72 - Scientific research & development | C30 - Manuf. of other transport equipment | M71 - Architecture, engineering | Q88 - Social work without accommodation | |
| FRK: Auvergne-Rhône-Alpes | 3 | N78 - Employment activities | Q88 - Social work without accommodation | F43 - Specialised construction act. | | |
| FRL: Provence-Alpes-Côte d'Azur | 4 | Q88 - Social work without accommodation | N81-Buildings services and landscaping | L68 - Real estate | N78 - Employment activities | |
| FRM: Corsica | 6 | N81-Buildings services and landscaping | Q88 - Social work without accommodation | F43 - Specialised construction act. | O84 - Public adm., defence, soc. security | I55 - Accommodation |
| FRY1: Guadeloupe | 5 | O84 - Public adm., defence, soc. security | Q88 - Social work without accommodation | N80 - Security, investigation activities | Q87 - Residential care | P85 - Education |
| FRY2: Martinique | 6 | N80 - Security, investigation activities | G45-Trade & repair of motor vehicles | Q88 - Social work without accommodation | O84 - Public adm., defence, soc. security | N81-Buildings services and landscaping |
| FRY3: French Guiana | 6 | E38 - Waste activities | N80 - Security, investigation activities | Q88 - Social work without accommodation | P85 - Education | O84 - Public adm., defence, soc. security |
| FRY4: Réunion | 6 | Q88 - Social work without accommodation | P85 - Education | T97 - Households as employers act. | O84 - Public adm., defence, soc. security | Q87 - Residential care |
| FRY5: Mayotte | 12 | Q88 - Social work without accommodation | R90 - Arts & entertainment | F43 - Specialised construction act. | R93 - Sports, amusement, recreation | O84 - Public adm., defence, soc. security |

Table 7. France. Regionally Relevant Sector Clusters

Source: European Cluster Collaboration Platform (ECCP). ECCP France.org, 2023.

form of venture capital for startups and seed capital funds that support industrial clusters through the metropolises of Lyon and Saint--Étienne.

Another strategic institution in the French PNC is the Association française des pôles de compétitivité (AFPC), with most of the competitiveness clusters being members of it. The AFPC supports the excellence of competitiveness clusters and the European visibility of the policy. It is mainly financed by the members of the clusters, the Ministry of the Economy and participants in the French financial system.

The support for clusters provided by the French PNC takes the form of three basic instruments to achieve its objectives: Financial, Technical Assistance and Communication.

The PNC offers financial support for the R&D projects of SME cluster members, including funding for hiring staff to improve infrastructure such as offices and equipment.

| Region | Number of nodes | Node 1 | Node 2 |
|---|---|---|---|
| FR1: Île-de-France | 2 | Digital | Cultural and creative industries |
| FRB: Centre-Val de Loire | 0 | - | - |
| FRC: Burgundy-Franche-Comté | 2 | Electronics | Health |
| FRD: Normandy | 0 | - | - |
| FRE: Hauts-de-France | 1 | Health | - |
| FRF: Grand Est | 0 | - | - |
| FRG: Loire Region | 0 | - | - |
| FRH: Brittany | 0 | - | - |
| FRI: New Aquitaine | 0 | - | - |
| FRJ: Occitania | 0 | - | - |
| FRK: Auvergne-Rhône-Alpes | 0 | - | - |
| FRL: Provence-Alpes-Côte d'Azur | 0 | - | - |
| FRM: Corsica | 2 | Construction | Proximity, Social economy and Civil Security |
| FRY1: Guadeloupe | 0 | - | - |
| FRY2: Martinique | 1 | Aeroespace & Defense | - |
| FRY3: French Guiana | 0 | - | - |
| FRY4: Réunion | 1 | Proximity, Social economy and Civil Security | - |
| FRY5: Mayotte | 2 | Health | Proximity, Social economy and Civil Security |

Table 8. France. Regionally Relevant Agglomerated Ecosystems

Source: European Cluster Collaboration Platform (ECCP). ECCP France.org, 2023.

In the field of technical assistance, PNC supports the development of technical skills, knowledge transfer, intellectual property, entrepreneurship, export consultancy, market intelligence; soft skills development, coaching, management training, networking and partnership building at home and abroad.

The funding covers administrative expenses, related to staff, office space and office supplies, and project funding. Since 2018, cluster organizations have been able to apply for a quality seal from the Ministry of Economy. The Ministry carries out training to strengthen basic and social skills, such as cybersecurity, cluster professionalization and excellence, as well as providing support for internationalization.

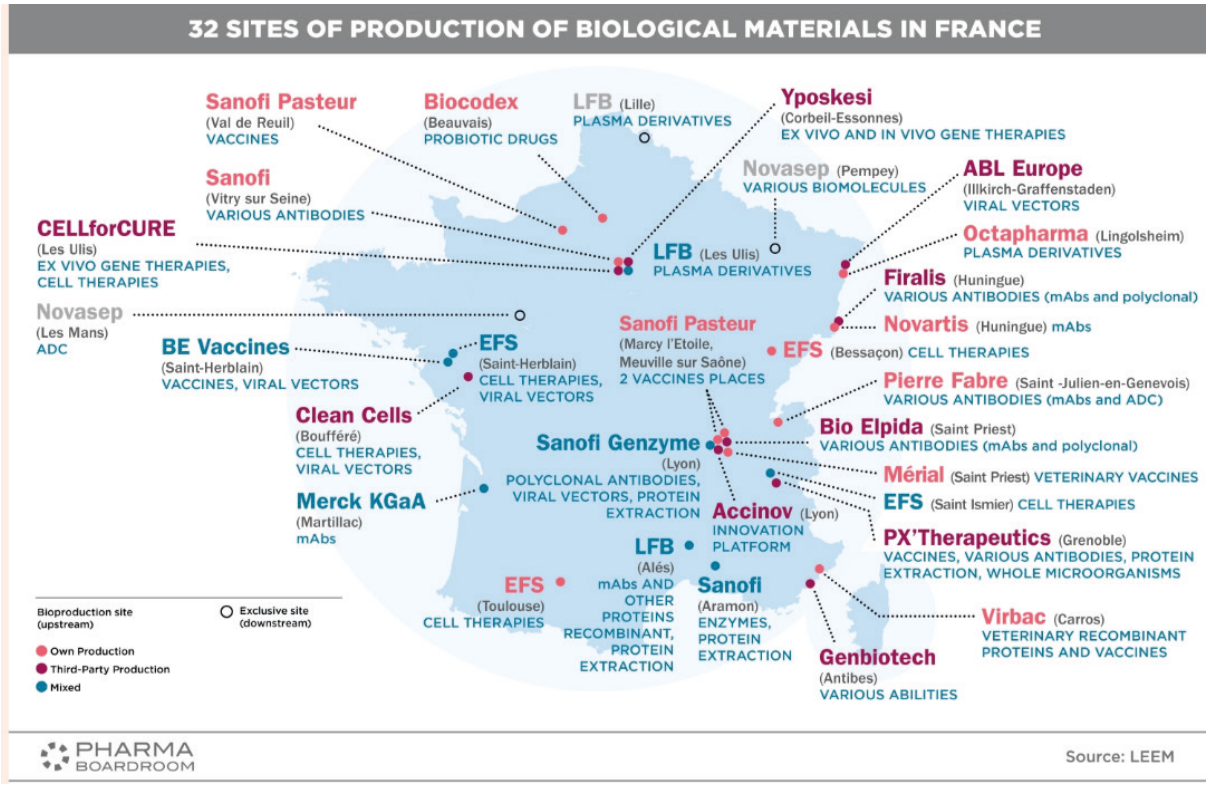
In 2022 there were 55 competitiveness cluster organizations in France, with membership per cluster ranging from 100 to 800, including companies and research organizations such as academic institutions, technology-focused institutions and technology centers. SMEs joining clusters is associated with an increase in private investment in innovation, with such investments even exceeding the amount of financial support received by almost three times (ECCP France.org, 2023).

Maps 2 and 3 below on the French pharmaceutical industry illustrate the importance of one of the country's four main industrial ecosystems, as well as the importance of national cluster and innovation system policy strategies. The French pharmaceutical industry ranks among the top five pharmaceutical industries in Europe, based on 2021 data relating to variables such as market size, R&D spending and production. According to this data, France ranks fourth in Europe in terms of pharmaceutical production, with 20.981 billion euros, behind Switzerland, Germany and Italy, and ahead of Ireland, the United Kingdom and Spain. In terms of R&D spending, France also ranks fourth, with 4.451 billion euros, behind Germany, Switzerland and the United Kingdom and ahead of Belgium (PHARMA BOARDROOM.COM https://pharmaboardroom.com/facts/mapping-french-pharma/).

The ranking of the ten largest pharmaceutical companies in France in 2021 was led by Sanofi with 2.367 billion euros in turnover, followed by Servier with 2.284 billion euros and Janssen with 1.175 billion euros (PHARMA BOARDROOM.COM https://pharmaboardroom.com/facts/top-10-pharma-companies-in-france-2021/).

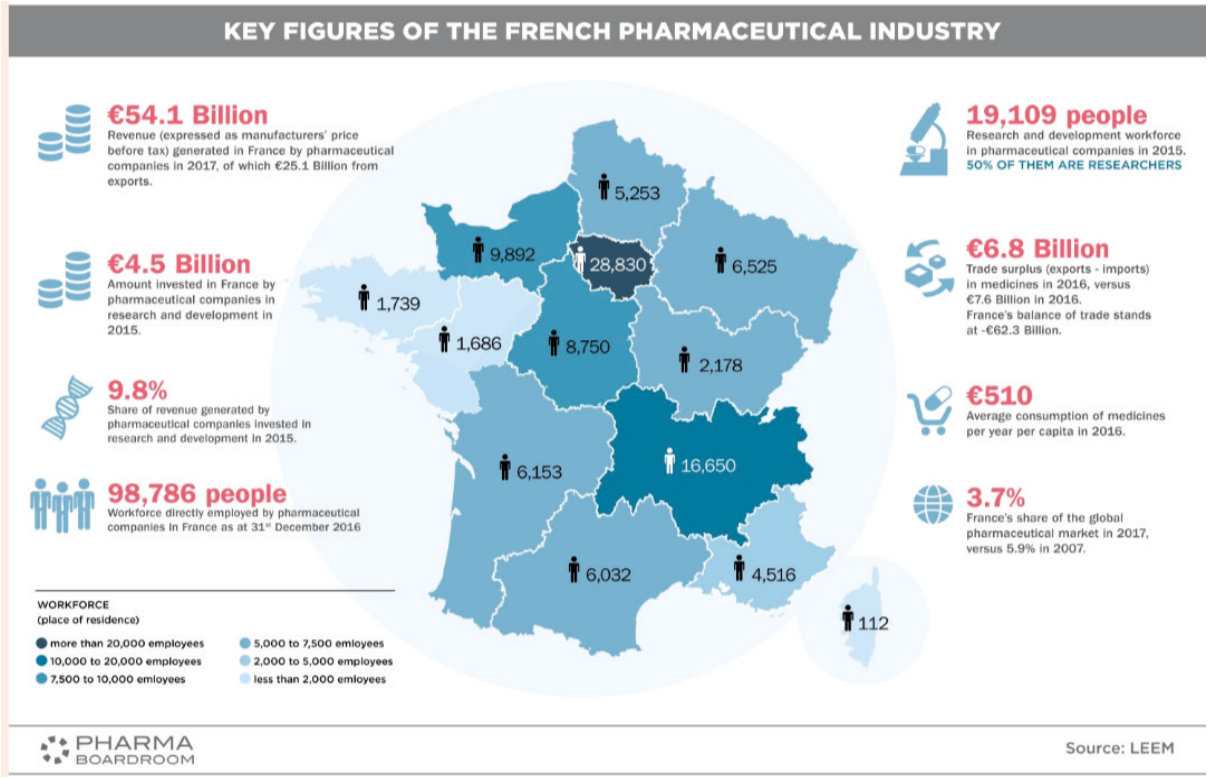
Map 2 shows the 32 sites for the production of biological materials in France, including the location of companies and the production of biological materials, with an emphasis on plasma derivatives, biological inputs for various medicines, in the Il-de-France region, where Paris is located.

Map 3 presents the main data on the French pharmaceutical industry, key statistics on the workforce, revenues, investment levels, R&D spending and consumption in the French pharmaceutical industry. In 2017, revenues reached 54.1 billion euros, of which 25.1 billion came from exports. The workforce totaled 98,786 people in 2016, of which 19,109 thousand people (19.3%) were in R&D, 9,500 of them researchers. Although the industry is present in all French regions, the Il-de-France region led the way in terms of job creation with 28,830 people (29.2%), followed by the Auvergne-Rhône-Alpes region with 16,650 people (16.8%).




Map 2. France. 32 Biological Materials Industry Production Sites - 2024

Source: PHARMA Boardroom.com




Map 3. France. Pharmaceutical Industry - 2024

Source: PHARMA Boardroom.com

## BRAZILIAN INDUSTRIAL CLUSTERS

This section presents the most relevant industrial clusters/agglomerations in each federal unit by region of the country, based on the Locational Quotient (LQ) calculated from employment data from the IBGE's Annual Industrial Survey - PIA (2022), with a seven--digit National Classification of Economic Activity - CNAE. These clusters could receive greater attention from public policies focused on supporting industry, with the aim of promoting gains in competitiveness, productivity and quality, thus making industrial production chains more efficient and competitive. In this sense, policies to strengthen clusters and their respective innovation systems stand out, in order to promote improved governance and innovation in the most relevant industrial clusters, as well as helping to expand export capacity and internationalization strategies.

The degree of specialization was measured by the Location Quotient (LQ), which reflects the relative specialization of an activity in a given federation unit (FU) in a region compared to the average for each major region in the country. If the LQ for a given activity-FU combination is greater than 1.0, it is considered a specialized cluster/agglomeration, and if the activity represents at least 1% of total employment in the region, the activity is considered regionally relevant. The figures below show the total number of relevant industrial clusters for each UF in each of the country's major regions. These clusters should be prioritized in the country's industrial development policies.

In this sense, several branches of industrial activity related to farming and cattle-raising and to Brazil's biomes stand out as strategic sectors for the country's sustainable development: Manufacture of food products; Manufacture of beverages; Manufacture of tobacco

products; Manufacture of textile products; Manufacture of clothing and accessories; Preparation of leather and manufacture of leather goods, travel goods and footwear; Manufacture of wood products; Manufacture of pulp, paper and paper products; Manufacture of coke, petroleum products and biofuels; Manufacture of chemical products; Manufacture of pharmaceutical and pharmaceutical products; and Manufacture of rubber and plastic products.

A locational quotient greater than 1 indicates that a region's share of job creation in a specific sector i is greater than its respective percentage contribution to the region's total job creation. In other words, the region specializes in that specific sector. When the locational quotient is below one, the region does not specialize in a particular activity. These results help to identify the main specialized industrial clusters per federation unit in each region of the country and thus help to build a strategy for strengthening clusters and their respective innovation systems as instruments for promoting regional development in Brazil.

In the study for the countries of the European Union, the following criterion was adopted for identifying clusters: if the location quotient was greater than 1.5, it was considered a specialized agglomeration and if this activity accounted for at least 1% of total employment in the region, it was considered a relevant agglomeration in the region.

The main results for Brazil are presented below, the main industrial clusters by federation unit in each major region of the country, according to their respective LQ in descending order.

**NORTHERN REGION**

Amazonas (11 Clusters): Support activities for mineral extraction (2.6); Manufacture of computer equipment, electronic and optical products (2.6); Manufacture of machinery, appliances and electrical materials (2.5); Manufacture of machinery and equipment (2.4); Manufacture of other transportation equipment, except motor vehicles (2.4); Manufacture of rubber and plastic products (2.1); Manufacture of motor vehicles, trailers and bodies (2.1); Manufacture of miscellaneous products (2.0); Manufacture of pulp, paper and paper products (1.6); Manufacture of metal products, except machinery and equipment (1.2); and, Manufacture of chemical products (1.1).

Pará (9 Clusters): Extraction of metallic minerals (2.6); Manufacture of tobacco products (2.6); Manufacture of coke, petroleum products and biofuels (2.1); Metallurgy (2.0); Maintenance, repair and installation of machinery and equipment (1.7); Manufacture of wood products (1.6); Manufacture of textile products (1.4); Preparation of leather and manufacture of leather goods, travel goods and footwear (1.4); Manufacture of non-metallic mineral products (1.2); and Manufacture of food products (1.2).

Rondônia (10 Clusters): Preparation of leather and manufacture of leather goods, travel goods and footwear (2.7); Manufacture of wearing apparel and accessories (2.2); Manufacture of food products (2.0); Manufacture of wood products (2.0); , Manufacture of furniture (1.8); Printing and reproduction of engravings (1.7); Mining of non-metallic minerals (1.5); Manufacture of non-metallic mineral products (1.4); Manufacture of beverages (1.3); and Manufacture of metal products, except machinery and equipment (1.1).

Acre (7 Clusters): Manufacture of food products (2.2); Manufacture of beverages (2.1); Manufacture of wood products (1.9); Manufacture of non-metallic mineral pro-

ducts (1.9); Manufacture of wearing apparel and accessories (1.8); Printing and reproduction of engravings (1.2); and, Manufacture of furniture (1.1).

Roraima (6 Clusters): Manufacture of wearing apparel and accessories (2.9); Manufacture of non-metallic mineral products (1.8); Manufacture of food products (1.5); Manufacture of metal products, except machinery and equipment (1.4); Printing and reproduction of engravings (1.3); and, Manufacture of miscellaneous products (1.3).

Amapá (6 Clusters): Manufacture of wood products (3.6); Printing and reproduction of engravings (3.6); Manufacture of non-metallic mineral products (3.3); Manufacture of wearing apparel and accessories (2.1); Manufacture of furniture (2.1); and, Manufacture of food products (1.1).

Tocantins (6 Clusters): Extraction of non-metallic minerals (6.0); Manufacture of food products (2.0); Manufacture of clothing and accessories (2.0); Manufacture of non-metallic mineral products (2.4); Manufacture of chemical products (2.1); and, Preparation of leather and manufacture of leather goods, travel goods and footwear (1.8).

**NORTHEAST REGION**

Maranhão (10 Clusters): Metallurgy (5.3); Maintenance, repair and installation of machinery and equipment (2.2); Manufacture of non-metallic mineral products (2.0); Manufacture of pulp, paper and paper products (2.0); Manufacture of furniture (1.8); Manufacture of coke, petroleum products and biofuels (1.7); Printing and reproduction of recordings (1.4); Manufacture of chemical products (1.3); Mining of non-metallic minerals (1.2); and Manufacture of metal products, except machinery and equipment (1.2).

Piauí (10 Clusters): Printing and reproduction of recordings (3.1); Manufacture of non-metallic mineral products (2.0); Manufacture of furniture (1.9); Metallurgy (1.6); Manufacture of beverages (1.4); Manufacture of metal products, except machinery and equipment (1.4); Manufacture of miscellaneous products (1.4); Manufacture of food products (1.3); Manufacture of pharmochemical and pharmaceutical products (1.1); and, Maintenance, repair and installation of machinery and equipment (1.1).

Ceará (9 Clusters): Manufacture of pharmochemical and pharmaceutical products (2.3); Preparation of leather and manufacture of leather goods, travel goods and footwear (2.1); Manufacture of clothing and accessories (1.8); Manufacture of machinery, equipment and electrical materials (1.7); Manufacture of other transportation equipment, except motor vehicles (1.6); Metallurgy (1.3); Manufacture of computer, electronic and optical products (1.3); Manufacture of textile products (1.2); and Printing and reproduction of recordings (1.1).

Rio Grande do Norte (10 Clusters): Extraction of petroleum and natural gas (5.1); Support activities for mineral extraction (4.2); Extraction of non-metallic minerals (4.2); Manufacture of textile products (1.6); Manufacture of wearing apparel and accessories (2.5); Manufacture of coke, petroleum products and biofuels (1.9); Manufacture of furniture (1.5); Manufacture of non-metallic mineral products (1.3); Manufacture of machinery and equipment (1.6); and Extraction of metallic minerals (1.1).

Paraíba (7 Clusters): Manufacture of coke, petroleum products and biofuels (4.1); Manufacture of textile products (2.3); Preparation of leather and manufacture of leather goods, travel goods and footwear (1.6); Printing and reproduction of engravings (1.4); Manufacture of non-metallic mineral products (1.2); Manufacture of rubber and plastic products (1.1); and, Manufacture of miscellaneous products (1.1).

Pernambuco (12 Clusters): Manufacture of motor vehicles, trailers and bodies (3.7); Manufacture of other transportation equipment, except motor vehicles (2.1); Manufacture of machinery and equipment (1.6); Manufacture of coke, petroleum products and biofuels (1.4); Manufacture of food products (1.3); Manufacture of beverages (1.3); Manufacture of chemical products (1.2); Manufacture of pharmaceutical and pharmaceutical products (1.1); Manufacture of rubber and plastic products (1.1); Manufacture of metal products, except machinery and equipment (1.1); Manufacture of machinery and electrical equipment (1.3); and, Maintenance, repair and installation of machinery and equipment (1.1).

Alagoas (3 Clusters): Manufacture of food products (2.8); Manufacture of textile products (2.0); and, Manufacture of rubber and plastic products (1.2).

Sergipe (12 Clusters): Extraction of petroleum and natural gas (3.2); Manufacture of textile products (2.0); Manufacture of tobacco products (1.8); Manufacture of non-metallic mineral products (1.6); Manufacture of wood products (1.5); Manufacture of machinery, appliances and electrical materials (1.5); Manufacture of motor vehicles, trailers and bodies (1.4); Manufacture of miscellaneous products (1.4); Manufacture of chemical products (1.3); Manufacture of furniture (1.2); Manufacture of food products (1.1); and, Manufacture of beverages (1.1).

Bahia (15 Clusters): Extraction of metallic minerals (3.7); Manufacture of tobacco products (3.4); Support activities for mineral extraction (2.5); Extraction of petroleum and natural gas (2.2); Manufacture of computer, electronic and optical products (2.2); Manufacture of pulp, paper and paper products (1.9); Manufacture of chemical products (1.6); Manufacture of rubber and plastic products (1.6); Manufacture of wood products (1.5); Maintenance, repair and installation of machinery and equipment (1.4); Manufacture of metal products, except machinery and equipment (1.3); Mining of non-metallic minerals (1.3); Preparation of leather and manufacture of leather goods, travel goods and footwear (1.3); Manufacture of miscellaneous products (1.3); Metallurgy (1.1); and, Manufacture of motor vehicles, trailers and bodies; Manufacture of furniture (1.1).

**SOUTHEAST REGION**

Minas Gerais (10 Clusters): Mining of metallic minerals (3.9); Mining of non-metallic minerals (1.8); Preparation of leather and manufacture of leather goods, travel goods and footwear (1.8); Metallurgy (1.8); Manufacture of tobacco products (1.6); Manufacture of furniture (1.5); Manufacture of food products (1.2); Manufacture of wood products (1.2); Manufacture of wearing apparel and accessories (1.1); and Manufacture of non-metallic mineral products (1.1),

Espírito Santo (9 Clusters): Extraction of non-metallic minerals (4.1); Manufacture of non-metallic mineral products (2.9); Extraction of metallic minerals (2.8); Manufacture of wood products (2.8); Maintenance, repair and installation of machinery and equipment (2.5); Metallurgy (1.5); Manufacture of furniture (1.2); Support activities for the extraction of minerals (1.1); and, Manufacture of clothing and accessories (1.1).

Rio de Janeiro (10 Clusters): Support activities for mineral extraction (10.2); Extraction of petroleum and natural gas (8.8); Manufacture of coke, petroleum products and biofuels (3.1); Manufacture of beverages (2.4); Manufacture of tobacco products (2.4); Maintenance, repair and installation of machinery and equipment (2.4); Manufacture of other transport equipment, except motor vehicles (1.9); Printing and reproduction of recordings (1.7); Metallurgy (1.7); and, Manufacture of wearing apparel and accessories (1.6).

São Paulo (11 Clusters): Manufacture of machinery and equipment (1.3); Manufacture of pulp, paper and paper products (1.2); Manufacture of chemical products (1.2); Manufacture of pharmaceutical and pharmaceutical products (1.2); Manufacture of rubber and plastic products (1.2); Manufacture of computer, electronic and optical products (1.2); Manufacture of electrical machinery, appliances and materials (1.2); Manufacture of motor vehicles, trailers and bodies (1.2); Manufacture of other transport equipment, except motor vehicles (1.2); and, Manufacture of textile products (1.1); and, Manufacture of miscellaneous products (1.1).

**SOUTHERN REGION**

Paraná (10 Clusters): Manufacture of coke, petroleum products and biofuels (2.2); Manufacture of pharmochemical and pharmaceutical products (2.0); Manufacture of chemical products (1.4); Manufacture of food products (1.3); Manufacture of pulp, paper and paper products (1.3); Printing and reproduction of recordings (1.3); Manufacture of wood products (1.2); Mining of non-metallic minerals (1.1); Manufacture of motor vehicles, trailers and bodies (1.1); and, Manufacture of furniture (1.1).

Santa Catarina (8 Clusters): Manufacture of textile products (2.1); Manufacture of wearing apparel and accessories (1.8); Manufacture of machinery, appliances and electrical equipment (1.6); Metallurgy (1.4); Manufacture of wood products (1.3); Manufacture of rubber and plastic products (1.2); Manufacture of non-metallic mineral products (1.2); and, Manufacture of pulp, paper and paper products (1.1).

Rio Grande do Sul (12 Clusters): Support activities for mineral extraction (3.1); Preparation of leather and manufacture of leather goods, travel goods and footwear (2.6); Manufacture of tobacco products (2.5); Manufacture of beverages (1.5); Manufacture of metal products, except machinery and equipment (1.4); Manufacture of machinery and equipment (1.4); Manufacture of computer, electronic and optical equipment (1.3); Manufacture of miscellaneous products (1.3); Manufacture of motor vehicles, trailers and bodies (1.1); Manufacture of other transportation equipment, except motor vehicles (1.1); Manufacture of furniture (1.1); and, Maintenance, repair and installation of machinery and equipment (1.1).

**CENTRAL-WEST REGION**

Mato Grosso do Sul (7 Clusters): Manufacture of pulp, paper and paper products (3.4); Preparation of leather and manufacture of leather goods, travel goods and footwear (1.6); Manufacture of coke, petroleum products and biofuels (1.5); Manufacture of miscellaneous products (1.5); Manufacture of machinery and equipment (1.2); Manufacture of food products (1.1); and, Metallurgy (1.1).

Mato Grosso (10 Clusters): Manufacture of wood products (3.4); Support activities for mineral extraction (3.1); Extraction of metallic minerals (2.4); Extraction of non-metallic minerals (1.5); Manufacture of machinery, equipment and electrical materials (1.4); Manufacture of textile products (1.3); Manufacture of non-metallic mineral products (1.3); Manufacture of beverages (1.2); Manufacture of food products (1.1); and, Metallurgy (1.1).

Goiás (10 Clusters): Manufacture of pharmochemical and pharmaceutical products (1.7); Manufacture of wearing apparel and accessories (1.6); Manufacture of motor vehicles, trailers and bodies (1.6); Manufacture of chemical products (1.4); Manufacture of computer, electronic and optical products (1.2); Manufacture of rubber and plastic products (1.1); Manufacture of metal products, except machinery and equipment (1.1); Manufacture of other transport equipment, except motor

vehicles (1.1); Manufacture of furniture (1.1); and, Maintenance, repair and installation of machinery and equipment (1.1).

Federal District (11 Clusters): Manufacture of tobacco products (5.8); Printing and reproduction of recordings (4.3); Manufacture of computer, electronic and optical products (3.9); Manufacture of beverages (2.9); Manufacture of pharmochemical and pharmaceutical products (2.3); Manufacture of non-metallic mineral products (2.1); Manufacture of other transport equipment, except motor vehicles (1.7); Manufacture of furniture (1.7); Manufacture of metal products, except machinery and equipment (1.6); Manufacture of miscellaneous products (1.4); and, Maintenance, repair and installation of machinery and equipment (1.3).

## FINAL CONSIDERATIONS

In recent decades, advances in biodiversity-based technologies have shown that the conservation of natural environments and, in particular, species of fauna and flora, as well as being fundamental to preserving life on the planet and mitigating the effects of climate change, is the cornerstone of a new 21st century economy, an economy based on biology, which will play an increasingly important role in solving the biggest problems of our time, in areas such as health and ecological transition.

Thus, preserving biodiversity is fundamental to mitigating the effects of climate change and promoting the development of the new biology-based economy of the 21st century. A new economy in which Brazil is emerging with the potential to become a major *global player*, given its large biomes, such as the Amazon, and the richness of its biodiversity, considered the most diverse in the world in terms of the number of species of fauna and flora.

Scientific research based on the biodiversity of natural environments is the path to discovering new medicines that can lead to the cure of previously incurable diseases, bio-inputs for agriculture and applications in the most varied sectors of the economy.

In this way, it can be said that Brazil has a great opportunity to become a world leader in sustainable development and the bio-based economy and transform the 21st century into the Brazilian century, due to the rich biodiversity of the biomes on national territory. The preservation of its biomes, such as the Amazon, Atlantic Forest, Cerrado, Caatinga, Pantanal and Pampa, as well as the area of the Atlantic Ocean in Brazilian territory, places Brazil as one of the main countries that can contribute to reducing emissions and capturing polluting gases and thus help mitigate the effects of climate change. On the other hand, Brazil's rich biodiversity puts the country in a unique position to implement a strategy for developing bioeconomy and biotechnology clusters associated with strengthening regional innovation systems and linked to Brazilian biomes, a strategy with the potential to take the country to the forefront of a new world economy based on biology.

Finally, the study made it possible to identify the most relevant industrial clusters in each region of the country, based on the location quotient. These clusters could receive greater support from public policies to promote innovation and competitiveness, with emphasis on strengthening innovation systems, improving governance, supporting innovative SMEs, export capacity and internationalization strategies.

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