ECOSYSTEM ACCOUNTS FOR BRAZIL

Report of the NCAVES Project

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IBGE Instituto Brasileiro de Geografia e Estatística

System of Environmental Economic Accounting

United Nations

UN environment programme

Funded By The European Union

ACRONYMS

ANCA
Advancing Natural Capital Accounting

ANA
National Water and Basic Sanitation Agency

BOD
Biochemical Oxygen Demand

CBD
Convention on Biological Diversity

CICES
Common International Classification of Ecosystem Services

CNAE
National Classification of Economic Activities

CNCFlora
Brazilian National Center for Flora Conservation

CNFP
National Register of Public Forests

CONAC
Department of National Accounts of IBGE

DGC
IBGE Directorate for Geosciences

DO
Dissolved Oxygen

DPE
IBGE Research Board

E.coli
Escherichia Coli

EA
Ecosystem Assets

EAA
Ecosystem Accounting Area

ECLAC
Economic Commission for Latin America and the Caribbean

ECT
Ecosystem Condition Typology

EEA
Environmental-Economic Accounting

EEA-Water
Environmental-Economic Accounting for Water

EFG
Ecosystem Functional Groups

EPANB
National Strategy and Strategic Action Plan for Biodiversity

ES
Ecosystem Services

ET
Ecosystem Types

EU
European Union

GDP
Gross Domestic Product

GPV
Gross Production Value

GVA
Gross Value Added

IBGE
Brazilian Institute of Geography and Statistics

IC
Intermediate Consumption

ICMBio
Chico Mendes Institute for Biodiversity and Conservation

IPEA
Institute of Applied Economic Research

IUCN
International Union for the Conservation of Nature

JBRJ
Botanical Gardens of Rio de Janeiro

MMA
Ministry of the Environment

NCA
Natural Capital Accounting

NCAVES
Natural Capital Accounting and Valuation of Ecosystem Services

NTFP
Non-Timber Forest Products

PAM
Municipal Agricultural Production Survey

PEVS
Vegetal Extraction and Forestry Production Survey

PI
Price Index

QI
Quantity Index

RLI
Red List Index

SDGs
Sustainable Development Goals

SEEA
System of Environmental-Economic Accounting

SEEA – AFF
System of Environmental Economic Accounting for Agriculture, Forestry and Fisheries

SEEA-CF
System of Environmental Economic Accounting - Central Framework

SEEA-EA
System of Environmental-Economic Accounting - Ecosystem Accounting

SEEA-EEA
System of Environmental Economic Accounting - Experimental Ecosystem Accounting

SEEA-Water
System of Environmental Economic Accounting for Water

SFB
Brazilian Forest Service

SNA
System of National Accounts

SNIS
National Sanitation Information System

SUT
Supply and Use Tables

TP
Total Phosphorus

UNEP
United Nations Environment Programme

UNFCCC
United Nations Framework Convention on Climate Change

UNSD
United Nations Statistics Division

PREFACE - DGC and DPE

The Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project, funded by the European Union, was implemented in Brazil under the leadership of the Brazilian Institute of Geography and Statistics (IBGE), with the support of the United Nations Statistics Division (UNSD) and the United Nations Environment Programme (UNEP).

Brazil, together with Mexico, China, Indica and South Africa, were selected as strategic partners for this project, mainly due to the importance of their natural capital, their diverse ecosystems with high biodiversity, along with their adherence to the commitments to the Convention on Biological Diversity (CBD) commitment.

The main objective of the NCAVES project in Brazil was to advance in the development of the Environmental Economic Accounts of Ecosystems, allowing for the proper measurement of the environment, its quality, as well as the benefits generated for the economy, facilitating the use of the accounts for the formulation of public policies.

Therefore, this report outlines the main results achieved, through the NCAVES project, during the period 2017-2021. It includes an overview of the methodologies that were implemented and results obtained, seeking to generate indicators that portray a selected set of primary services provided by Brazilian ecosystems.

The IBGE, as agency responsible for integrating the statistical and geographical perspective, has in its mandate a distinct role to structure and present information on the interrelationship between the environment and the economy, in order to support decision-making for the sustainable management of the territory.

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ANNOTATED OUTLINE

In 2017, the United Nations Statistics Division (UNSD), the United Nations Environment Programme (UNEP), the Secretariat of the Convention on Biological Diversity (CBD) and the European Union (EU) launched the Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project. This project, funded by the EU through its Partnership Instrument, aims to help the five participating partner countries, namely Brazil, China, India, Mexico and South Africa, to advance their knowledge agenda on Environmental Economic Accounting, and in particular Ecosystem Accounting. This report provides an overview of the work carried out in Brazil as part of the NCAVES project.

Section 1 presents the national and international context about the importance of integrating Natural Capital Accounting into the System of National Accounts and highlights the main concepts and foundations of the SEEA-EA manual (UNCEEA, 2021) and considers the relationship between ecosystems and economic and human activities. The chapter also presents the contours of the development of the NCAVES Project in Brazil.

Section 2 develops the methodological advances and results obtained from the publication of the Extent Account – Land Use in Brazilian Biomes from 2000 to 2018 (IBGE 2020a) where spatial analysis of land-use change has been carried out and then presented in a structured accounting format, thereby enabling the measurement of variations in natural and anthropogenic areas by ecosystem type.

Section 3 presents the experimental results of Ecosystem Accounting - Condition of Water Bodies (IBGE 2020), with results of the indicators for the abiotic characteristics in terms of their chemical and physical status as well as their compositional biotic characteristics. Such advances represent an important test of the integration of condition indicators in spatial units common to the Extent Account, namely the Brazilian biomes.

Section 4 highlights the experimental advances for Ecosystem Accounts - Ecosystem Service Accounts (IBGE 2021b,c), which cover the provisioning service of water supply streams, water catchments provision and the provision streams services of extracted and cultivated non-timber forest products (NTFPs). Both analyses were based on the spatial distribution of the biomes. This section also presents the results of the valuation of these services for the national territory.

Section 5 deals with the publication of the Thematic Account on Endangered Species (IBGE 2020b) that groups data from the IUNC global assessment into an accounting structure, that is, a table of stocks by conservation status, as a methodological test, and presents the results through the national assessment of species, sorted by biome and type of environment (terrestrial, freshwater and marine).

Section 6 addresses the Individual Environmental Assets and Resources Accounts, specifically the second edition of the Environmental - Economic Accounts for Water (IBGE 2020e).

Section 7 presents the SDG (Sustainable Development Goals) indicators that can be directly derived or reported by the Environmental-Economic Accounts.

Finally, **Section 8** seeks to discuss the integration of the different accounts developed under the NCAVES Project, in order to obtain a unified view of the results generated and the efforts undertaken.

Section 1: Introduction

With six biomes, namely the Amazon, Cerrado, Caatinga, Atlantic Forest, Pantanal and Pampa, as well as a broad Coastal-Marine System, Brazil is known for its abundant ecosystems, biodiversity and geodiversity. Used as a productive input and raw material for economic and human activities, such ecosystems are part of the the natural capital, on which societies depend. Abundant but not infinite, natural capital is defined here as any and all assets made available by ecosystems and maintained by their integrated ecological functions.

Such ecological functions contribute to the provision of ecosystem services (ES), usually known in the Brazilian literature as Serviços Ecossistêmicos, which provide many social and economic benefits to humanity. While some of these services can be observed as economic flows in the System of National Accounts (SNA), others remain "hidden", especially when market transactions and ownership are lacking. The latter are the focus of the Ecosystem Accounts methodological approach.

Although the Gross Domestic Product (GDP) is the main macroeconomic indicator widely disseminated in the world today, it does not fully capture the aspects related to the integrity of ecosystems and their relationship with economic actors. Among the ES that are captured by the SNA and internalized in the GDP, the provisioning of fossil fuels, ore, timber and non-timber forest resources and cultivated food are the most common. Regarding the services that remain "hidden", key examples are carbon storage and climate regulation, erosion control, water regulation, water provisioning, pollination and habitat integrity for fauna and flora species.

While some ES generate income and directly contribute to GDP, other ES are not included while they can be affected. For example, the increase in food supply resulting from the expansion of a planted area, and which is at the expense of reduction of native vegetation, contributes to the calculation of the GDP, however its impacts on carbon storage services, erosion control, water regulation and pollination are not considered in the calculation of this indicator. The depletion and degradation of ecosystems resulting from the loss of natural capital are aspects that have not yet been internalized in the GDP, although they interfere in: the conditions of human and economic well-being; the sustainability and resilience of the economic system; and in the stability of the climate resulting in vulnerability to low-income populations.

Therefore, Natural Capital Accounting (NCA) aims to establish a uniform methodology to generate statistics for the accounting of natural assets, recognizing the extent of ecosystems as well as the dependencies of economic actors and their interference with these services. Therefore, and by aiming to represent the integrated dynamics of ecosystems and their relationship with the economic system, the United Nations Statistics Division (UNSD) has prepared the System of Environmental-Economic Accounting - Ecosystem Accounting (SEEA-

EA). This methodology is based on the System of Environmental-Economic Accounting – Central Framework (SEEA-CF), which integrates the physical and monetary flows of individual environmental assets with the accounting rules of the SNA.

SEEA-EA provides a set of terms, concepts, accounting principles and an integrated accounting framework for ecosystem services and the condition of the ecosystem in physical and monetary terms and establishes spatial areas as the base unit for measurement. Therefore, SEEA-CF and SEEA-EA are overlapping methodologies, whose complementarity lies in the use of the same accounting principles to measure the condition and services of ecosystems, through the adoption of a systems approach in the ability to assess the environmental impacts of economic activity, and the use of a strict spatial measurement approach.

Due to its integrated approach and its importance for the formulation of public policies, SEEA-EA contributes to the construction of new economic trajectories that consider the sustainable use of natural resources and the pressures caused by economic actors and which supports a series of global and relevant national initiatives.

This chapter presents the overall context for the importance of NCA, a brief introduction of SEEA-EA explaining the structure and scope of the report and provides an overview of the implementation of the NCAVES project.

1.1 Context for the importance of the System of Environmental-Economic Accounting

The conservation of ecosystems, biodiversity and the maintenance of their ecological functions are fundamental for both life on earth and human well-being and for most economic activities. However, the economic system, which depends on many services that are provided by ecosystems, has been putting pressure on these ecosystems and generating increasing risks to economic and human development.

Considering the ecological crisis that contemporary society is facing, at global, national and local levels, public and private institutions are increasingly incorporating the risks associated with the crisis into their decision-making. Examples of environmental risks include extreme events associated with climate change, the loss of biodiversity and water scarcity, which are also listed in the World Economic Forum's Global Risk Report 2020 (WEF, 2020). New analytical tools, such as NCA, apply the scientific foundations proposed by the field of environmental economics and ecological economics, and help to take such risks into account.

Among the international initiatives that should be mentioned and that can be monitored with the statistics generated in the SEEA are: the 2030 Agenda, which establishes a plan with 17 SDGs to eradicate poverty and promote a decent life for all, within the limits of the planet; the post-2020 biodiversity agenda and the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC). In addition, two important campaigns for the conservation of biodiversity were established in 2021, both of which were promoted by the United Nations (UN): the Decade of Ocean Science for Sustainable Development 2021-2030 and the Decade on Ecosystem Restoration 2021-2030.

Regarding the national political context and the Paris Agreement on combatting climate change, in 2016, Brazil announced its commitment to contribute with 12 million hectares of new forest areas by 2030, an action implemented through the National Policy for Native Vegetation Recovery (Proveg); a policy which was formalized in 2017 to protect and restore forests as provided for in the Forest Code, whose political instrument is the National Plan for the Recovery of Native Vegetation (Planaveg) (IBGE, 2020a).

Another noteworthy initiative is the implementation of the National Strategy for REDD+ (ENREDD+), created with the purpose of formalizing the Brazilian effort to prevent and control deforestation as well as promote sustainable forest management. ENREDD+ is an instrument for the integration of various public policies related to the protection of native vegetation and biodiversity and for the promotion of a low-carbon forest economy (IBGE, 2020a).

It is also worth noting other important instruments of public policies related to biodiversity in Brazil: the identification of Priority Areas and Actions for Conservation, Sustainable Use and Sharing of Biodiversity Benefits which is aimed at planning and implementing measures for the recovery and sustainable use of ecosystems for decision-making (IBGE, 2020a). The instrument includes the identification of measures that are to be locally implemented, providing geospatial information on the action priorities in each area (IBGE, 2020a). The process of identifying the areas is in line with the Convention on Biological Diversity (CBD). The CBD is a UN treaty established during the famous Earth Summit (ECO-92) and ratified by Brazil in 1998 (BRASIL, 1998), and is still in force as a legal and political framework for several other thematic programmes and transversal initiatives, such as the NCAVES project.

After the approval of the Strategic Biodiversity Plan 2011-2020 at the CBD, in 2011 Brazil began establishing the 20 Aichi Biodiversity Targets and internalizing them as National Biodiversity Targets for 2020, which also intersect with the 2030 Agenda and the SDGs. In turn, the National Strategy and Strategic Action Plan for Biodiversity (EPANB) (2011-2020), published in 2017, brings an important milestone for the implementation and respective monitoring of the proposed actions and goals (IBGE, 2020a).

The 2020 global environmental agenda presents an important transition, marking the consolidation of the System of Environmental-Economic Accounting - Ecosystem Accounting, so that it meets the growing political demands of the post-2020 CBD framework, and includes the re-discussion of the Aichi Biodiversity Targets (IBGE, 2020a). This entire reflection on the international perspective, and especially on the key national actions and priorities, is essential for the establishment of the ecosystem accounting in Brazil. In this regard, the development of the agenda at the national level requires choices of spatial units, attributes to be evaluated and a proposal of indicators in order to assess the conservation of ecosystems. This step is crucial for the preparation, implementation and monitoring of public policies.

It is important, therefore, to clarify that the results presented herein from the NCAVES project are an important milestone for the development of the Brazilian Natural Capital Accounting System, bringing the first edition of the Ecosystem Extent Accounts, and the first edition of the Threatened Species Accounts for Brazil, based on existing data relevant to environmental analysis and planning. The evolution of the publication of other accounts and other studies is expected, considering that the SEEA-EA methodology is flexible for the adoption of other focuses, or scales, and even subjects, according to the availability of information and the country's priority agenda.

1.2. The System of Environmental - Economic Accounting - Ecosystem Accounting

The SEEA-EA methodology considers that, in the SNA framework, not all environmental resources qualify as economic assets; only those with property rights and that have been recorded in the balance sheet (IBGE, 2020a). Thus, part of the benefits generated by nature, such as ecosystem services are not captured by the SNA since they do not constitute an economic production process. This is the case, for example, of climate regulation and water flow regulation by forest areas (IBGE, 2020a).

The SEEA-EA is an integrated spatially explicit statistical framework that organizes biophysical information about ecosystems, measures ecosystem services, tracks changes in the extent and condition of ecosystems, values ecosystem services and assets, and links information to measures of economic and human activities. SEEA-EA was developed by a multidisciplinary group of experts in order to respond to a series of political demands and challenges, focusing on making nature's contributions to the economy and to people visible, and to better record the dependencies and impacts of economic activity and other human activities on the environment (UN, 2021).

The SEEA-EA framework provides an integrated information system on (a) ecosystem assets, covering ecosystem extent, ecosystem condition, ecosystem services, ecosystem capacity and relevant monetary values; and (b) economic activity and other human activities and their respective beneficiaries (families, businesses and governments). Ecosystem accounting described in the SEEA-EA framework involves recording over an accounting period the: (i) stocks and changes in stock of each ecosystem asset, including entries for ecosystem enhancement and degradation; and (ii) flows from this asset in the form of ecosystem services. Service flows in any accounting period are related to the type of ecosystem, its size or extent, its condition (health or conservation status), as well as factors determining the levels of use by the population directly benefiting from these services (UN et al, 2021).

The ecosystem accounting framework is designed for application at national, sub-national and local levels, enabling the integration of information on various ecosystem types and various ecosystem services with macro-level economic information (e.g. national income measurements, added value, production, consumption and wealth), as well as in individual administrative areas such as, protected areas, cities and environmentally defined areas such as watersheds.

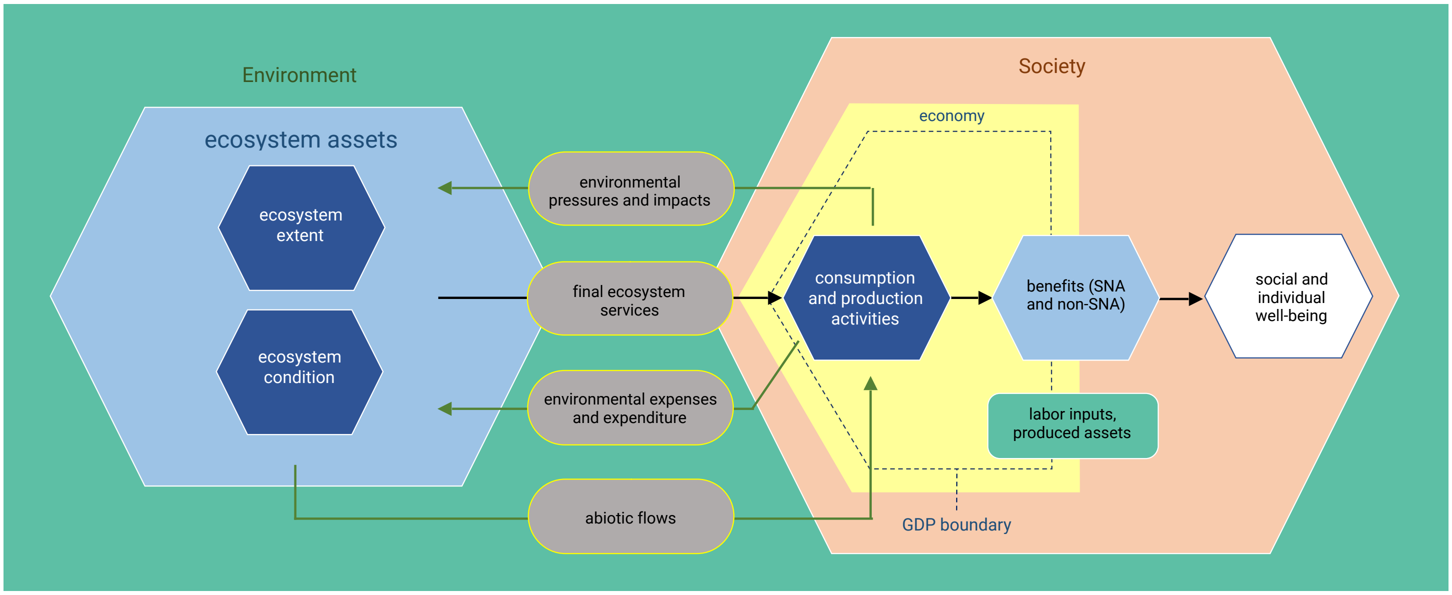
1.2.1. Conceptual approach

The essence of ecosystem accounting lies in the potential to represent the biophysical environment in terms of distinct spatial areas, each representing ecosystem assets such as forests, wetlands, agricultural areas, rivers and coral reefs.

The key concepts of the ecosystem accounting framework related to ecosystem services concern (i) the provision of ecosystem services to users; and (ii) the contribution of ecosystem services to the generation of benefits, that is, the goods and services enjoyed by society that are provided by ecosystems. Following the general framework of ecosystem accounting, each ecosystem asset provides a set or package of ecosystem services (UN et al, 2021).

Ecosystem services are the contributions of the ecosystem to human benefits, including their well-being and economic activities; therefore, they exclude the set of flows usually referred to as supporting or intermediary services that contribute to the intra- and inter-ecosystem processes (IBGE, 2020a). According to accounting logic, each ecosystem asset is understood to provide a flow of ecosystem services. Service flows in any period are related to the extent (such as the area in hectare) and the condition of the ecosystems - see Figure 1. The goal in ecosystem accounting is to record the supply of all ecosystem services over an accounting period for each ecosystem asset within an ecosystem accounting area, as well as the users of the ecosystem services.

Figure 1: General structure of Ecosystem Accounting



Source: IBGE (2020a)

The term "benefits", as used in SEEA-EA, encompasses: (a) System of National Accounts (SNA) benefits, that is, the products (goods and services) produced by economic units as recorded in the standard national accounts; and (b) the non-SNA benefits, which are generated by ecosystems and consumed or absorbed directly by economic and human activities.

SNA benefits are goods or services included in the SNA production boundary. For example, ecosystem services and goods connected to food, water, energy, clothing, shelter and recreation etc. **Non-SNA benefits** are goods and services that are not included in the SNA production boundary. Examples include clean air and flood protection provided by ecosystems. In line with the definition of benefits, the scope of non-SNA benefits for ecosystem accounting purposes is limited to contributions to people and society (UN, 2021).

1.2.2. Ecosystem accounting

The first important concept to be defined for ecosystem accounting is the **ecosystem accounting area (EAA), the geographic space for which an ecosystem account is compiled** (UN 2021). The EAA determines the spatial boundary and ecosystem assets to be included in an account. This area can have the total size of a country, a geopolitical or administrative delimitation, or be chosen along environmental boundaries (watersheds or protected areas), according to their specific purposes, which must consider the scale of analysis, available data and national public policies.

The second important concept defined for ecosystem accounting is **ecosystem assets (EA), which are statistically represented in spatial units, defined by contiguous spaces of different ecosystem types (ET) and characterized by a distinct set of biotic and abiotic components and their interactions.** The definition of an ecosystem asset is a statistical representation common to the Convention on Biological Diversity's general definition of ecosystems (SEEA-EA, p. 43). An ecosystem type, in turn, has specific components that include, for example, animals, plants, fungi, water, soil, and minerals present in ecosystems.

From the definition of the geographical and spatial unit of the EAA and the EA, and the determination of the attributes of the ET, the stages of development of ecosystem accounting are applied, whose composition is given by the Extent Accounts, Condition Accounts, Ecosystem Services Flow Accounts, and Ecosystem Monetary Asset Accounts. Figure 2 summarizes the main types of accounts.

Figure 2: Stylized Integration of Ecosystem Accounting

	Ecosystem Assets	
	Biome X	**Biome Y**
	Ecosystem Types	**Ecosystem Types**
SEEA - Ecosystem Accounting	Forest Cover, Wetland, Cropland, etc.	Forest Cover, Wetland, Cropland, etc.
Extent Accounts	Ecosystem conversion Opening and Closing Stocks	
Condition Accounts	Opening and Closing Condition in relation to reference condition	
Ecosystem Services Flow Accounts (Physical and Monetary)	Supply and Use of Provisioning, Regulating, and Cultural Services Uses: Economic activities, households, other	
Ecosystem Monetary Asset Accounts	Opening and Closing Stocks Enhancement and Degradation of Ecosystems	

Source: Adapted from UN et al. (2021)

i) The **Ecosystem Extent Accounts** are the first stage of SEEA-EA as they account for the extent of the ecosystem, that is, the area, based on the spatial units of the different ecosystem types previously determined. Extent account data underlie the derivation of indicators of the composition and change in ecosystem types and thus provide a common basis to analyse conversions between different ecosystem types and their impacts on ecosystem condition and other accounts. The compilation of these accounts determines the spatial foundation that will support the structure of the other accounts;

ii) **Ecosystem Condition Accounts** consist of organizing biophysical information on the condition, that is, the status or quality, of different types of ecosystems. To this end, a reference condition is established for the analysed parameters and the gap between the current status and the reference values is quantified, indicating the ecological integrity of the ecosystems. It can also organize data to measure an ecosystem's ability to provide services.

iii) **Ecosystem Services Flow Accounts** quantify the biophysical flows of the final ecosystem services provided by ecosystem assets and the use of those services by economic units, including households, businesses and government, constituting one of the central features of ecosystem accounting. Said quantification is presented in a supply and use table for an accounting period. Estimates of ecosystem services in monetary terms are based on estimated prices of individual services multiplied by the quantities recorded in the service flow accounts in physical terms.

iv) **Ecosystem Monetary Asset Accounting** records information on stocks and changes in stocks, that is, consequences of the conversion of ecosystem types as well as in the flows of services provided (for example, additions in case of enhancement and reductions in case of degradation), to asset values.

The main structure of this report is based on these accounts: Extent Accounts; Condition Accounts; Supply and Use of Ecosystem Services (in both physical and monetary terms); and Ecosystem Monetary Asset Accounts.

1.3. Implementation of the NCAVES Project in Brazil

The United Nations Statistics Division, the United Nations Environment Programme, the Secretariat of the Convention on Biological Diversity and the European Union launched the Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES) project. The project, funded by the European Union through its Partnership Instrument (PI), aims to help the five participating partner countries, namely Brazil, China, India, Mexico and South Africa, to advance their knowledge agenda on Environmental-Economic Accounting, particularly Ecosystem Accounting.

Brazil is home to an important portion of the planet's biodiversity, has extensive areas favorable to agriculture and is abundant in water resources. In this context, the country is among the largest suppliers of food and raw materials to the world and every day new studies prove the importance of biomes such as the Amazon to maintain global ecological balance, as well as the risks that deforestation presents for climate regulation. Considering the Brazilian potential for growth in various sectors of the economy from the different uses of ecosystem services, as well as the interference caused by economic activities on biodiversity, it is important that Brazil develops indicators that integrate environment and economy to support sustainable public policy decisions.

The NCAVES Project started pilot tests of ecosystem accounting with the following objectives:

- Improve the measurement of ecosystems and their services, in physical and monetary terms, at national and sub-national levels;
- Integrate accounting indicators of natural capital related to the protection of biodiversity and ecosystems in the planning and implementation of policies at national and subnational levels;
- Contribute to the development of internationally agreed methodology and its use in partner countries.

1.3.1. NCAVES lines of work

The project has different lines of work, selected according to the needs of global improvement of the integration of ecosystem accounting in the political processes of the countries. They are:

i. **Ecosystem Accounting** - compile ecosystem accounting in physical and monetary terms in project countries;

ii. **Scenario Analysis** - apply a scenario analysis to the accounts based on national policy priorities;

iii. **Methodological developmen**t - develop guidelines and methodologies to contribute to the national and global implementation of the NCA;

iv. **Development of indicators** - contribute to the development and testing of indicators in the context of the post-2020 Biodiversity Agenda and other international initiatives;

v. **Business Accounts** - contribute to the alignment between SEEA and corporate sustainability reporting;

vi. **Communication Products** - Raise awareness of NCA through the development of a range of communication products.

vii. **Enhanced Training and Knowledge Sharing** - Enlarge the community of professional NCA experts through e-Learning and training workshops (nationally and regionally).

viii. **Interinstitutional Strengthening** - establish or strengthen interinstitutional mechanisms related to the NCA through the preparation of a national roadmap.

This report focuses on summarizing the results of the lines of work i, iii and iv.

1.3.2. National implementation

In Brazil, the NCAVES Project was launched in May 2017, on the occasion of an international institutional mission with the participation of the Brazilian Institute of Geography and Statistics (IBGE), the Ministry of the Environment (MMA), the United Nations Statistics Division (UNSD), the United Nations Environment Programme (UNEP), the Economic Commission for Latin America and the Caribbean (ECLAC), the Institute for Applied Economic Research (IPEA), the Ministry of Planning, the European Union Delegation and the German cooperation agency GIZ.

Among the factors that have driven Brazil to carry out the piloting of the SEEA Experimental Ecosystem Accounting methodology, is the national commitment to monitoring the related global SDG indicators. This national commitment will allow for methodological development, specification of data and metadata, and policy applications for ecosystem accounting, including mapping the supply and use of ecosystem services and ecosystem accounts at national and regional/municipal levels (UNSD and UNEP, 2017).

At this launch, the proposal was to carry out a wide consultation with different key actors interested in the criteria that would support the preparation of the scope of the SEEA pilot project on ecosystem accounting. Among the listed criteria are the: i) existence of environmental pressures, for example, water scarcity, deforestation, major change in land use, loss of biodiversity etc.; ii) generation of statistics on the condition of the ecosystem and ecosystem services for monitoring specific public policies for biodiversity, water, forest and agriculture; iii) availability of data for ecosystem accounting (e.g. digital maps on land cover/use, vegetation, ecosystem types, soil and geology, hydrology, elevation and urban infrastructure) at appropriate scales and resolutions, which can be integrated at a common scale; and iv) ability to link maps and data on ecosystems and the economy, either to the economic activities of companies or to household consumption (UNSD and UNEP, 2017).

The project's implementation planning in Brazil therefore included: i) an evaluation mission; ii) a report containing a national plan on how to advance the application of experimental accounts, mapping of existing projects and stakeholders; iii) a work plan for compiling the accounts and their use in policy formulation; iv) a national forum to discuss the national plan, including the establishment of a coordination mechanism, and its implementation; v) a training workshop to provide technical guidance on implementing the various ecosystem accounts as prioritized in the national plan; vi) research to test a proposed list of indicators related to ecosystems and their relationship to the economy in support of various processes, including SDG indicators (Ministry of Environment, 2017).

Under the coordination of the Directorate for Geosciences, which has been leading the implementation of significant improvements in the development of SEEA in recent years, the NCAVES project therefore made it possible for IBGE to coordinate its own resources, strategic partnerships and technical and financial support from different organizations for the development of several products related to SEEA.

In 2018, a second visit by the project team took place in Brasília and Rio de Janeiro. In Brasília, several meetings were held with interested parties, including a Plenary Consultation Meeting with Stakeholders, at the National School of Public Administration

(ENAP), summoned by the Civil House of the Presidency of the Republic. In November 2018, IBGE hosted the Regional Training Workshop on the SEEA EEA for Latin American and Caribbean Countries, which was co-organized by ECLAC, UNSD and UNEP, with around 60 participants from 20 countries. The activities involving the NCAVES project in Brazil were boosted in early 2019 when IBGE restructured its teams and a manager and two technical consultants were hired to assist in the preparation of project products, taking into account local needs and global objectives.

The consolidation of the management structure implemented by IBGE for the development of SEEA-EA was notably influenced by the NCAVES project. IBGE's institutional arrangement includes a manager in the Research Directorate (DPE) and a manager in the Directorate of Geosciences (DGC), which work together under the coordination of the National Accounts Coordination (CONAC). The Institute has both the Directorate for Research, which produces a large part of the Brazilian social and economic statistics, such as the demographic census and the National Accounts (which includes the GDP), and the Directorate for Geosciences, responsible for environmental studies, including geospatial information such as vegetation maps, geology, geomorphology, land use, among others.

This type of management structure has been exceptionally efficient for the development of EEAs, as most of the necessary information is produced in the same institution helping to streamline data collection and analysis. Also, the more frequent interaction between specialists in geo-technology and the environment with economists and specialists in social and economic sciences is a great institutional advantage for the development of EEAs in Brazil. In this context, IBGE leads the development of EEAs in Brazil with the support and partnership of institutions specialized in specific themes. Specific partnerships were identified for each product line. Table 1 summarizes the accounts and studies that were produced by IBGE and partners in Brazil under the NCAVES Project.

The Ecosystem Extent Accounting, the Threatened Species Accounting and the Environmental Water Accounting were published as official statistics by IBGE, reflecting that the methodology was fully implemented

In publication categories whose statistics were produced in an experimental manner, that is, subject to future improvements, are the Water Supply Ecosystem Service Accounting and the Blue Water Valuation Study of the "Water Abstraction, Treatment and Distribution" sector for Brazil, the Extracted and Cultivated Non-Timber Forest Products Provision Ecosystem Services Accounting (NTFP) and the NTFP Valuation Study.

Table 1: EEA and related studies developed in Brazil under the NCAVES Project

System of Environmental - Economic Accounting - Ecosystem Accounting	Institutions involved	Methodology
Ecosystem Accounting		
Extent Account: Land Use by Biome	IBGE	SEEA-EEA
Experimental Condition of Water Bodies Account	ANA IBGE	SEEA-EEA
Experimental Ecosystem Service Account: Water Supply by Biome	IBGE ANA	SEEA-EEA SEEA-Water SEEA-CF
Experimental Study on the Valuation of the Blue Water Provisioning Service in the "Abstraction, treatment and distribution of water" sector for Brazil	IBGE ANA	
Experimental Ecosystem Service Account: Benefits of Provisioning of Non-Timber Forest Products Extracted and Cultivated by Biome	IBGE	SEEA-EEA SEEA-AAF SEEA-CF
Experimental Study on the Valuation of the Service for the Provision of Non-Timber Forest Products Extracted and Cultivated for Brazil	IBGE	
Thematic Account		
Threatened Species Accounts 2014	IBGE ICMBio JBRJ	SEEA-EEA
Individual Environmental Assets and Resources Accounts		
Environmental Economic Account of Water by Macro-region 2013-2017	IBGE ANA	SEEA-CF SEEA-Water

The current publication summarizes the main results achieved during the 2017-2020 period. Worthy of noting is that during this period, the IBGE and ANA also published, within the scope of SEEA, the first Environmental Economic Accounts for water: Brazil 2013-2015. However, and as this publication is the result of a separate partnership linked to the Regional-Local TEEB Project which was financed by the German Cooperation Agency GIZ, it will not be presented in this report.

Section 2:
Ecosystem Extent Account: Land Use by Biome

2.1. Introduction

The preparation of ecosystem extent accounts follows the reverse process compared to conventional economic analysis, as it uses the spatial unit of the ecosystem as the starting point of observation, instead of the economic actors. As the first step in the development of SEEA-EA, extent accounting aims to present the spatial dimension of ecosystems from a continuous assessment of their extension and variation across accounting periods, both of which are relevant for several reasons:.

- First, ecosystem extent provides a common basis for deriving indicators of deforestation, agricultural conversion, urban expansion, landscape fragmentation, and other forms of ecosystem change that dynamically and complexly, often non-linearly, affect the status of the landscape. The analysis of ecosystem area conversion, therefore, enables discussion between interested parties and related economic actors that depend on and interfere in the composition of ecosystem types in a country.

- The second aspect is that the organization of ecosystem extent data provides a common structure, through which other ecosystem data can be linked, such as ecosystem condition, conservation or degradation maps, and ecosystem service flows, using a common classification by ecosystem type.

- Thirdly, the ecosystem extent account framework intuitively demonstrates the ability of accounting to provide a time series narrative of spatial variables, in this case by estimating opening and closing stocks for an accounting period to reveal the degree to which the extent of ecosystem types varies over time.

- The fourth aspect to be highlighted is the possibility of spatial data to provide an underlying framework to measure the ecosystem status and to measure and model several ecosystem services that can vary by ecosystem type and will depend on location and configuration (spatial arrangement) of ecosystem types.

The publication Ecosystem Accounting: Land use in Brazilian Biomes 2000-2018 (IBGE, 2020a), provides the extent of natural and anthropized areas of ecosystems in the Brazilian territory, as well as the conversion variations of each ecosystem type from 2000 to 2018. In order to do this, the official environmental profile compatible with the ecological concept was adopted, as addressed in the spatial units provided in the Ecosystem Accounts Methodology and the Brazilian terrestrial biomes ((UN et al., 2021; IBGE, 2019b; IBGE, 2020a).

2.2. Methodology and Database

2.3.1 Definition of Ecosystem Accounting Area and Spatial Units of Ecosystem Assets and Ecosystem Types

As previously described in this report, to prepare the Ecosystem Extent Accounts, it is necessary to define the boundaries of the Ecosystem Accounting Area (EAA), the Ecosystem Assets (EA) and the Ecosystem

Types (ET), to then apply the extent analysis to those areas, and the associated conversions over time. Table 2 presents how the main concepts, namely, EAA, EA and ET, have been operationalized for the implementation of extent accounting in Brazil.

The overall accounting area is determined as the Brazilian territory, enabling an analysis at national territory level. In order to apply an official ecological focus that can be adopted as a statistical unit, Brazilian biomes were considered as the EAA, reflecting the ecological specificity that is distributed in the national territory and that interferes in the composition of resource flows and uses of services of ecosystems, and considering that the biomes remain stable units at the time scales used for accounting.

Table 2: Ecosystem Accounting Area, Ecosystem Assets and Ecosystem Types adopted in Extent Accounts

Ecosystem Accounting Area	Ecosystem Types	Ecosystem Assets
EAA	ET	EA
Amazon Biome	Artificial surfaces	1 km grid cells
Cerrado Biome	Cropland	
Caatinga Biome	Managed pasture	
Atlantic Forest Biome	Mosaic in forest area	
Pantanal Biome	Silviculture	
Pampa Biome	Forest tree cover	
	Wetland	
	Savanna, grassland, shrubland	
	Mosaic in non-forest area	
	Inland water bodies	
	Coastal water bodies	
	Barren land	

In order for the extent accounts to assess the changes in the conversion of ET, information from the Monitoring of Land Cover and Use in Brazil, prepared by the IBGE (IBGE, 2020c) was used to support the analysis of land-use conversions in the six biomes. To this end, the spatial arrangement of the natural and anthropized areas in the national territory was depicted, using the spatial analysis unit of the biome and the information from the Monitoring of Coverage and Land Use in Brazil (IBGE, 2020a). This also helps to understand the main use conversions in the Brazilian ecosystems from 2000 to 2018, according to the Monitoring history series, and shows the environmental territory activities of the country in the past two decades (IBGE, 2020a).

In addition, an analysis of the intensity of changes in the coverage and most recent land use verified in the Brazilian geographic space during two years of reference was developed - in this present assessment, the years of 2016 and 2018 - to highlight the areas of the country where the main current conversion processes have occurred (IBGE, 2020a).

2.3.2 Spatial distribution of Brazilian biomes for Ecosystem Types

The Map of Biomes and Coastal-Marine System of Brazil: compatible with the 1:250,000 scale (IBGE, 2019) refers to the physical-biotic representation of the country, which was guided by the Map of Biomes of Brazil: first approximation (IBGE, 2004) and its main contribution is towards the sustainable management of natural resources.

The biome has always been associated with the concept of preservation, and its visualization has been sought by the aggregation of ecosystems by proximity and regionalization. At IBGE, the representation of biomes follows very specific criteria, based on the definition of the biome (IBGE, 2020a):

> "a set of life forms (plant and animal) constituted by the grouping of contiguous vegetation types identifiable at a regional scale, with similar geoclimatic conditions and a shared history of changes, resulting in their own biological diversity" (IBGE, 2004).

It is, therefore, derived from the Vegetation Map of Brazil: scale 1:250,000 (IBGE, 2019a), a criterion justified by the fact that this mapping corresponds to the land cover resulting from the interaction of environmental components (rock, relief, soil and climate). The Biomes and Coastal-Marine System Map of Brazil was worked on in stages, and, as a method, the following assumptions were adopted: (i) each biome covers large continuous areas, subject to their 'mappability' conditions; (ii) vegetation disjunctions are incorporated into the dominant biome; (iii) the contact areas are attached to one of the confronting biomes, having as a criterion the dominant plant typology of each one of them (IBGE, 2020a).

In summary, these six groupings of vegetation types with similar physiognomy gave rise, in general terms, to the Brazilian biomes, which received names linked to Brazilian phytogeography, as specified above, namely: Amazon Biome, Atlantic Forest Biome, Caatinga Biome, Cerrado Biome, Pantanal Biome and Pampa Biome (IBGE, 2020a).

2.3.3 Monitoring of land cover and use from 2000 to 2018

The land cover and land-use data used for this study came from information released by the Monitoring of Land Cover and Land Use in Brazil from 2000 to 2018. IBGE's latest methodological report on this (IBGE, 2020c) provides details on this compilation. Monitoring is based on the interpretation of satellite images, together with complementary official information and field surveys conducted throughout the country. The data is published in the IBGE Statistical Grid, which divides the Brazilian territory into cells of 1 km².

To disaggregate land cover and land-use data by biome, some methodological procedures were carried out. The polygons of the Brazilian terrestrial biomes at the 1:250,000 scale (IBGE, 2019a) were incorporated into the statistical grid with 1 km² cells through the union of polygons (IBGE, 2020a). Thus, with the biome attached to the grid, a method to define the boundary was necessary. In order to maintain the format of biomes in cells of 1 km², the boundary criterion already used for federation units in the publication of Monitoring was used (IBGE, 2020a). This criterion consists of the inclusion of all the internal cells of the biome and also those that, when reaching their boundaries, had more than 50 per cent of their area included in the biome (IBGE, 2020a).

2.3. Results

The assessment of the extent of ecosystems, specifically the National Territory biomes, is presented in the form of two analyses compatible with the purpose of ecosystem accounting. The first, more aggregated analysis, shows the statistics in an accounting framework of the variations of natural and anthropized areas, as well as their spatialization. The second analysis is more detailed and shows, for each biome – that is, for each accounting area - the main conversions between land-use categories. Variations in the ecosystem types can, therefore, be interpreted as the main drivers of changes in Brazilian territorial dynamics for the period analysed, namely, from 2000 to 2018.

2.3.1. Table of additions and reductions of natural and anthropized areas of Brazilian biomes

Extent accounts show that natural areas in all Brazilian terrestrial biomes had a negative balance in the period 2000 to 2018. This indicates, therefore, a loss of these coverages in various parts of the country, totaling 489 877 km² of its various ecosystems, representing a loss of 8.34 per cent of the total natural areas in 2000. In turn, the anthropized areas had an increase of 19.51 per cent, with an increase of 489,724 km² (IBGE, 2020a).

Table 3 shows the additions and reductions of natural and anthropized areas, by biome, from 2000 to 2018 in the accounting framework. It is observed that the greatest absolute quantitative reductions in natural areas were concentrated in the Amazon and Cerrado Biomes, totaling a loss of 269,801 km² and 152 706 km² respectively, with year-to-year fluctuations. These natural areas of decline in the Amazon and Cerrado biomes represent a percentage loss of 7.32 per cent and 12.88 per cent respectively, in relation to the natural areas of these regions in 2000 (IBGE, 2020a).

The greatest percentage loss occurred in the Pampa Biome, where 16.8 per cent of its natural area as of 2000 was converted to anthropic uses, representing a loss of 16,161 km2, followed by the Cerrado, with a loss of 12.88 per cent as aforementioned (IBGE, 2020a).

On the other hand, Pantanal was the biome experiencing the smallest decrease in natural areas, both in absolute (2109 km²) and in relative terms (1.6 per cent), which depicts lower conversions of land use in that region of the country (IBGE, 2020a).

Following this trend, the Amazon and Cerrado Biomes also showed the highest percentage values (118.6 per cent and 44.3 per cent, respectively) regarding the total increases in anthropized areas in relation to the extent in 2000. On the other hand, the biomes with the smallest relative changes in the analysed period, thus evidencing the least transformations in the Brazilian space, and therefore, being the most stable throughout the period from 2000 to 2018, were Pantanal, with only 5.8 per cent of its analyzed area, and the Atlantic Forest and Caatinga, with 13.6 per cent and 12.2 per cent respectively, of movement in natural and anthropized areas; these same regions were also the ones recording the smallest relative balance values of changes (IBGE, 2020a).

Table 3: Ecosystem Extent Accounts of the Brazilian Biomes 2000-2018

Variables	Total		Biome											
			Amazon		Cerrado		Atlantic Forest		Caatinga		Pantanal		Pampa	
	Natural areas	Anthropized areas	Natural areas	Anthropized areas	Natural areas	Anthropized areas	Natural areas	Anthropized areas	Natural areas	Anthropized areas	Natural areas	Anthropized areas	Natural areas	Anthropized areas
2000														
Opening extent (km²)	**5,877,298**	**2,510,306**	**3,684,512**	**450,865**	**1,185,192**	**790,693**	**195,614**	**896,686**	**581,581**	**274,213**	**134,205**	**15,358**	**96,194**	**82,491**
Additions	2,955	460,530	1,282	248,427	509	135,983	257	43,490	519	21,477	378	1,707	10	9,446
Reductions	326,066	137,419	193,539	56,170	96,274	40,218	8,793	34,954	17,165	4,831	1,649	436	8,646	810
2010														
Extent (km²)	5,554,187	2,833,417	3,492,255	643,122	1,089,427	886,458	187,078	905,222	564,935	290,859	132,934	16,629	87,558	91,127
Additions	1,509	107,787	385	39,064	284	37,357	248	13,515	293	15,285	290	134	9	2,432
Reductions	69,316	39,980	27,376	12,073	23,068	14,573	3,083	10,680	13,375	2,203	189	235	2,225	216
2012														
Extent (km²)	5,486,380	2,901,224	3,465,264	670,113	1,066,643	909,242	184,243	908,057	551,853	303,941	133,035	16,528	85,342	93,343
Additions	3,592	93,615	2,043	39,654	320	35,913	44	7,362	1,000	6,895	101	243	84	3,548
Reductions	49,030	48,177	21,123	20,574	18,392	17,841	735	6,671	5,327	2,568	216	128	3,237	395
2014														
Extent (km²)	5,440,942	2,946,662	3,446,184	689,193	1,048,571	927,314	183,552	908,748	547,526	308,268	132,920	16,643	82,189	96,496
Additions	2,118	60,715	644	36,413	314	16,599	213	4,428	648	2,264	278	74	21	937
Reductions	36,435	26,398	23,541	13,516	8,417	8,496	1,509	3,132	1,801	1,111	326	26	841	117
2016														
Extent (km²)	5,406,625	2,980,979	3,423,287	712,090	1,040,468	935,417	182,256	910,044	546,373	309,421	132,872	16,691	81,369	97,316
Additions	12,894	74,296	8,185	38,566	2,706	25,583	102	4,513	1,545	2,376	123	1,026	233	2,232
Reductions	32,098	55,245	16,761	30,057	10,688	17,671	577	4,039	1,604	2,328	899	254	1,569	896
2018														
Final extent	**5,387,421**	**5,387,421**	**3,414,711**	**720,599**	**1,032,486**	**943,329**	**181,781**	**910,518**	**546,314**	**309,469**	**132,096**	**17,463**	**80,033**	**98,652**
Net changes														
Absolute (km²)	(-) 489,877	(-) 489,877	(-) 269,801	269,734	(-) 152,706	152,636	(-) 13,833	13,832	(-) 35,267	35,256	(-) 2,109	2,105	(-) 16,161	16,161
Percentage (%)	(-) 8.34	(-) 8.34	(-) 7.32	59.83	(-) 12.88	19.30	(-) 7.07	1.54	(-) 6.06	12.86	(-) 1.57	13.71	(-) 16,80	19.59
Turnover														
Absolute (km²)	536,013	536,013	294,879	534,514	160,972	350,234	15,561	132,784	43,277	61,338	4,449	4,263	16,875	21,029
Percentage (%)	9.12	9.12	8.00	118.55	13.58	44.29	7.95	14.81	7.44	22.37	3.32	27.76	17.54	25.49

Source: IBGE (2020a)

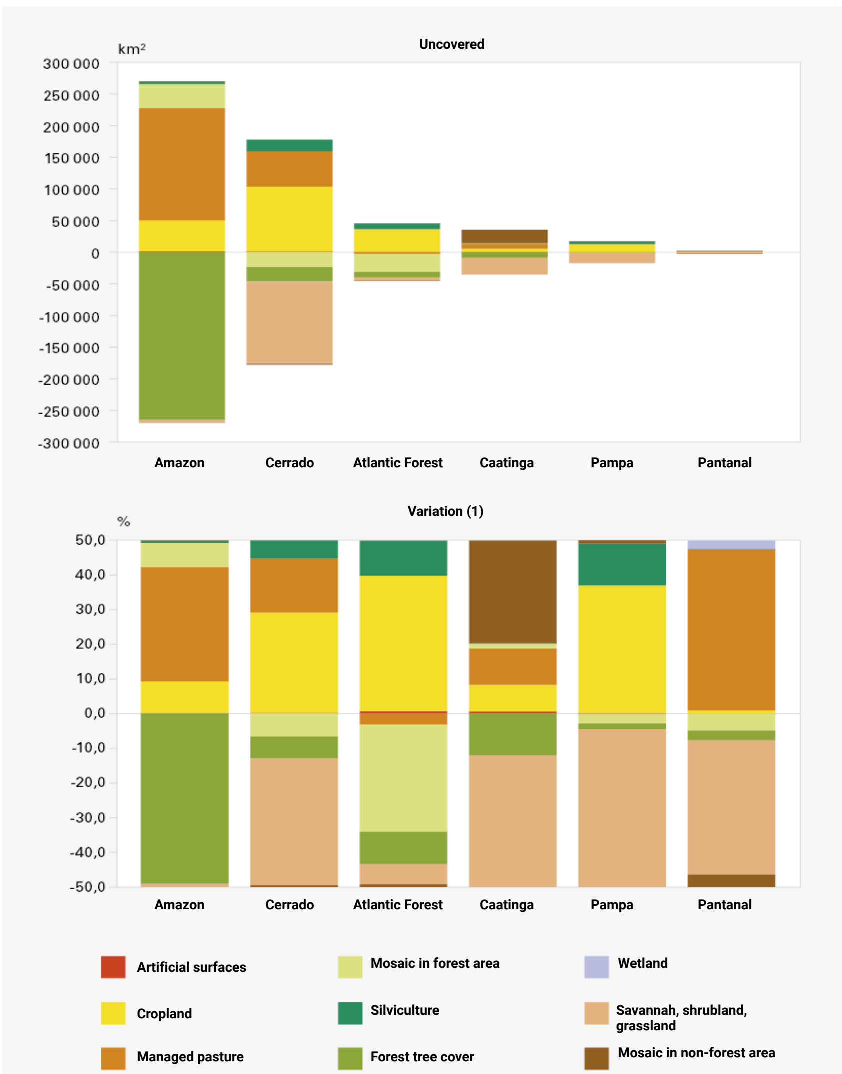
It is interesting to note that, throughout the accounting period, both the Atlantic Forest and Caatinga Biomes were the ones that recorded significant decreases in the rate of the loss of natural areas, from 8793 km² in the initial period (2000-2010) to 577 km² in the present period (2016-2018) for the Atlantic Forest, and from 17,165 km² to 1604 km², in the Caatinga, in the same periods (IBGE, 2020a).

However, considering the relative amount of original vegetation within these biomes, the situation is quite different: while the Atlantic Forest, with the longest and most intense historical territory occupation of Brazil, presents the lowest value, with only 16.6 per cent of natural areas currently, Caatinga emerges as the third most preserved biome in the country, with only 36.2 per cent of its territory currently under anthropic influence (IBGE, 2020A).

2.3.2. Dynamics of conversion of use and land coverage in Brazilian biomes

Figure 4 shows the dynamics of land cover and land-use conversions by biome, with the main conversions of land use. The figure corroborates the results already pointed out, where it stands out that in absolute terms the Amazon and Cerrado biomes were those with the greatest loss of forest tree cover vegetation and savannah, shrubland and grassland vegetation (IBGE, 2020A).

Figure 4 - Dynamics of conversion of land use and coverage in Brazilian biomes, 2000-2018

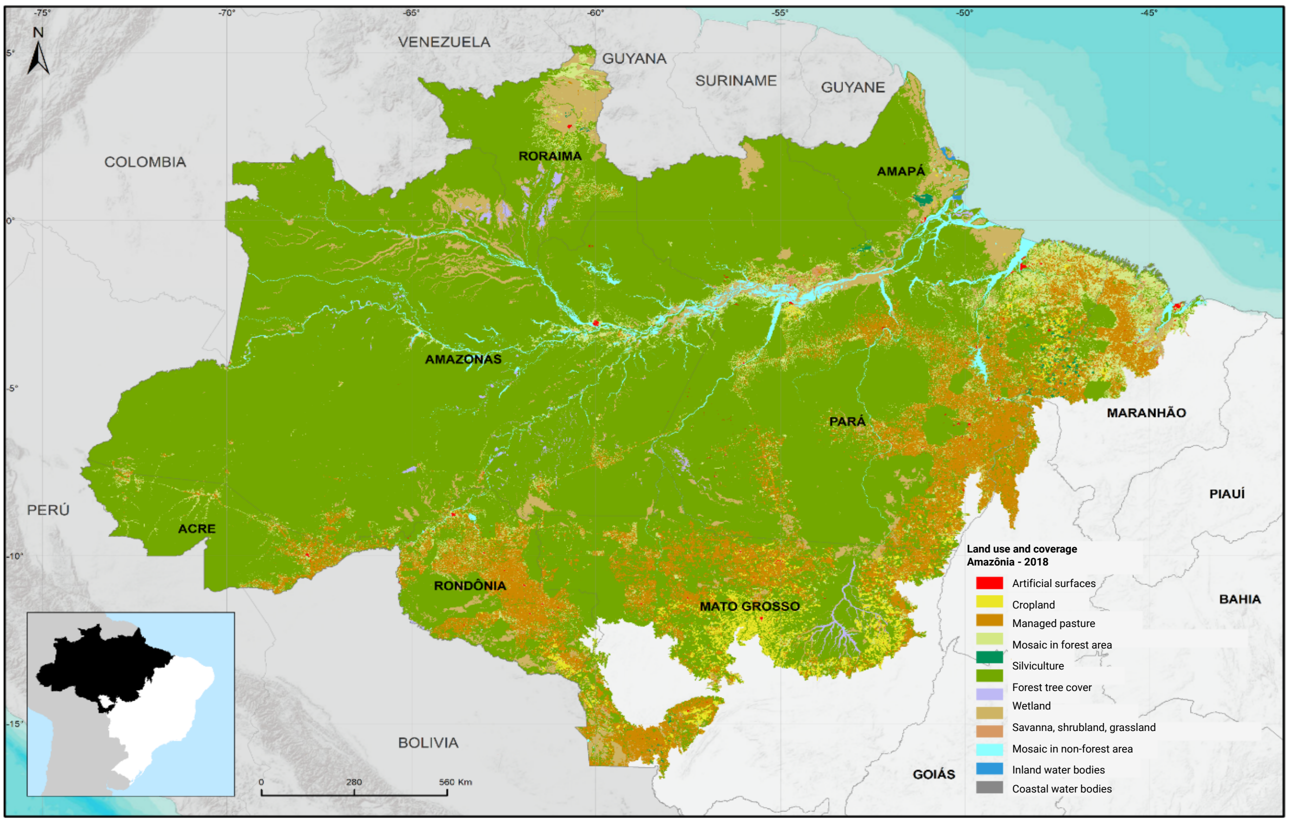


Source: IBGE (2020a)

In relation to the land-use conversions of the two biomes with higher losses of natural areas, it is observed that the Amazon experienced an increase of 71.4 per cent in managed pasture, and 288.6 per cent in cropland area, evidencing a transition dynamics typical of its occupancy and exploitation process; which includes 31.0 per cent of mosaic conversions, indicating a landscape fragmentation process. The current preservation status of the biome in spatial terms can be observed in Figure 5 (IBGE, 2020a).

As a result of these conversions, the biome is responsible for 74 per cent and 23.9 per cent of growth, respectively, of the managed pasture and cropland categories in relation to the total changes of these categories in Brazil between 2000 and 2018 (IBGE, 2020a).

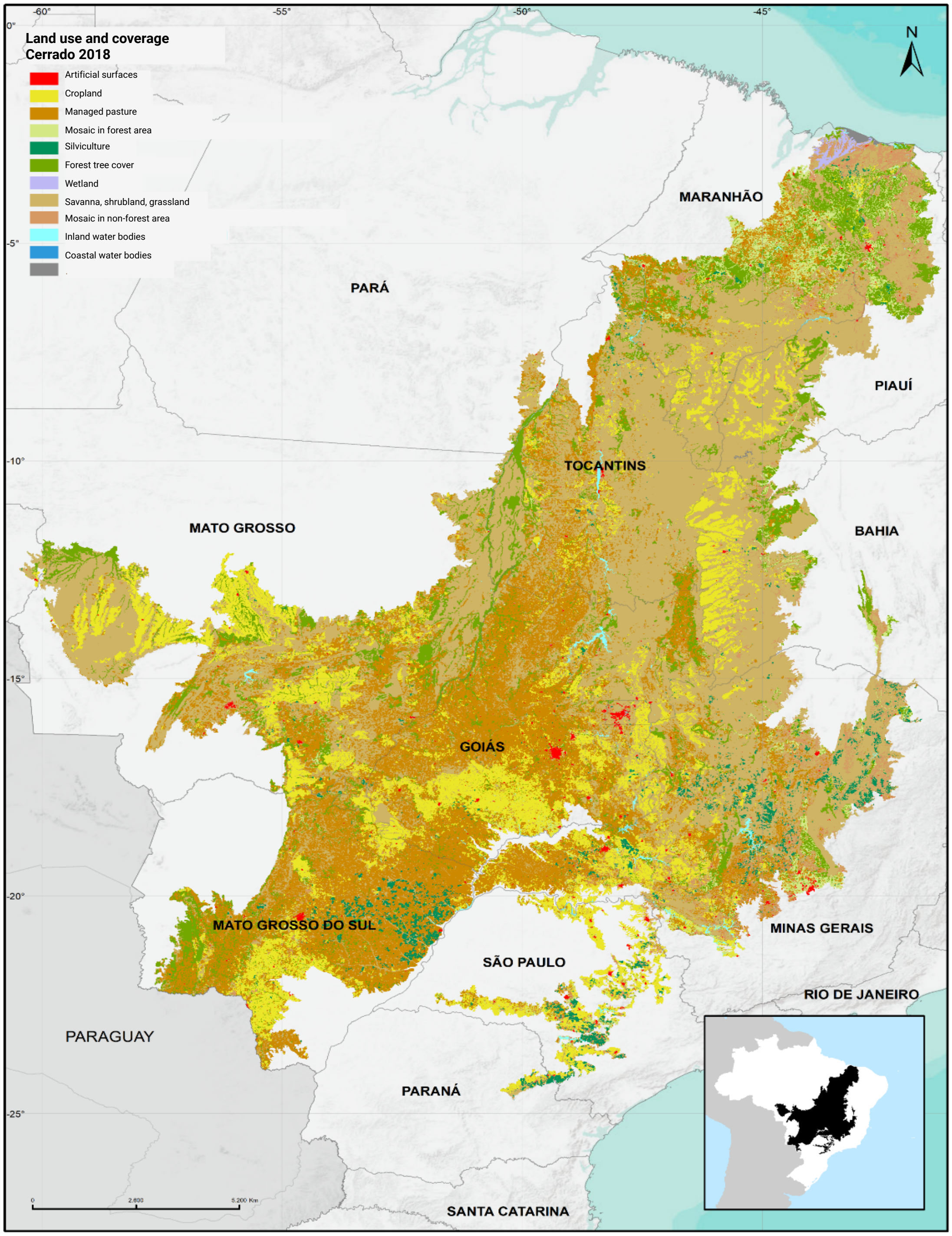
Figure 5: Land cover and land use in the Amazon Biome - 2018



Source: IBGE (2020a)

In the Cerrado biome, a continuous and accelerated expansion of agriculture was observed between 2000 and 2018, with an increase of 102,603 km² (+ 52.92 per cent) cropland area, and expansion of managed pasture of 55,451 km² (+ 13.22 per cent), with progressive reductions in the areas of grassland and forestry vegetation. After agriculture, pasture is the second largest category of land use in this biome, whose areas are represented on Figure 6 below (IBGE, 2020a).

Figure 6: Land cover and land use in the Cerrado Biome - 2018



Source: IBGE (2020a)

The Caatinga Biome also stands out for undergoing hegemonic conversion to categories of anthropic uses, whether restricted, such as managed pasture and croplands, or broad, such as mosaics of occupations in savannah, shrubland and grassland areas (IBGE, 2020a).

The Atlantic Forest biome is the only Brazilian terrestrial biome whose predominant land-use category is not of natural coverage. Forest vegetation, whose phyto-physiognomies were originally predominant in its ecosystems, currently represents only 12.6 per cent of its territory, while it represented 13.3 per cent in 2000. The highlights in the conversions of categories in this biome are the cropland and silviculture areas, which represented 32.9 per cent and 42.7 per cent, respectively, of the areas in the country in 2018, with the latter presenting the largest growth, at 33.9 per cent, followed by the cropland area at 19.6 per cent (IBGE, 2020a).

In 2018, the Pampa Biome was predominately savannah, shrubland and grassland (37.4 per cent), followed by the cropland category (36.3 per cent), as well as 19.3 per cent of the natural barren land areas of Brazil, which includes dunes and sandy areas. However, its territory underwent intense changes in recent decades, registering a reduction of 15,607 km² in its natural savannah, shrubland and grassland vegetation between 2000 and 2018. During this period, the largest areas converted to other land uses were: 58.0 per cent of savannah, shrubland and grassland into cropland; and 18.8 per cent into silviculture (IBGE, 2020a).

2.4 Ongoing Methodological Improvements

In order to deepen the technical discussions about a common classification for the different ecosystems types between countries, IBGE has held an experiment to test the Global Ecosystem Typology proposed by the International Union for Conservation of Nature (IUCN) at its level 3-categories of Ecosystem Functional Groups (EFGs). This experiment was carried out in two stages.

The first stage consisted of a conceptual comparison between the IBGE vegetation and land cover and use categories and the EFGs proposed by the IUCN, presented in table format (IBGE, 2020d). This comparison followed the instructions presented in the webinar "Testing of SEEA-EEA Ecosystem Type Classification", which took place on April 20 and 22, 2020, based on the text by Bogaart and Schenau (2020).

Next, the second stage of the experiment consisted of verifying the correspondence of the functional groups spatially, comparing the data from the vegetation (IBGE, 2019) and land cover and land-use mappings with the Ecosystem Functional Groups (IBGE, 2020e, in press). In order to do so, cartographic and statistical results are presented, seeking to express the spatial impact of this type of comparison in the Brazilian territory.

The cartographic experiment enabled the analysis of compatibility between vegetation categories and EFG classes, resulting in the elaboration of four large correspondence groups:

i) Full correspondence (one-to-one)
ii) Partial correspondence in the same biome (one-to-many)
iii) Partial correspondence between biomes (one-to-many)
iv) No correspondence

Table 4 presents the aggregated areas by these correspondence groups. It is observed that 51.4 per cent of the national territory has a full correspondence (one-to-one) between the IBGE categories and the EFG categories, 24.9 per cent have partial correspondence (one-to-many) where IBGE categories, within or between biomes, correspond to different EFG categories, and 23.8 per cent of the territory has no correspondence between the IBGE categories and those proposed by the IUCN (IBGE, 2020e).

Table 4: Compatibility statistics between IBGE mappings and IUCN EFGs

	AREA (KM2)	PERCENTAGE
Full correspondence (one-to-one)	4,493,936	51.4%
Partial correspondence in the same biome (one-to-many)	968,677	11.1%
Partial correspondence between biomes (one-to-many)	1,203,799	13.8%
No correspondence	2,081,901	23.8%
TOTAL	**8,748,313**	**100%**

Source: IBGE, (2020e)

The results indicate the presence of full correspondence (one-to-one) with 14 EFGs, distributed over six biomes, totalizing 4,493,936 km², or 51.37 per cent of the Brazilian territory (IBGE, 2020e). When one-to-many correspondences are also considered, the number of EFGs present in Brazil increases from 14 to 26. It is important to remember that, although some EFGs proposed by the IUCN classification do not actually exist in Brazil (such as Polar Tundra, for example), others occur, but are not captured at the available mapping scale, which makes a comparison impossible (as it is the case of several marine, subterranean ecosystems, etc.) (IBGE, 2020e).

Regarding the "one-to-many" correspondence areas, it is noted that some areas (968,677 km², 11.1 per cent of the territory) are grouped in the same biome, sharing general characteristics of this level. In this case it would be possible to adapt them, with some changes in the category descriptions, to a specific EFG (IBGE, 2020e). Included in the statistics of partial correspondence with an area of 11,232 km², the EFG "Tropical alpine meadows and shrublands" is noteworthy. It concerns local classifications of mountain refuge vegetation, which only partially (50 per cent) correspond to the description of the aforementioned EFG, while they do not correspond to any other EFG currently described in the IUCN typology. Brazilian mountain refuges, despite not being truly a cryogenic ecosystem, have altitude as a condition of the habitat with characteristics consistent with those listed for the vegetation of the EFG mentioned above (IBGE, 2020e).

Other land-use categories have a one-to-many correlation with characteristics dispersed by the IUCN EFGs, totaling 1,203,799 km² (13.8 per cent of the territory). In these cases, one possibility would be to improve the description of IUCN categories by way of incorporating local realities, with emphasis on 1) the areas corresponding to the savannas scattered throughout the Brazilian territory (in some cases, a spatial distinction considering the biome or region of occurrence of the phyto-physiognomy which are equivalent to the IUCN categories) and 2) the ecosystems of the Brazilian "Caatinga" which are more concentrated in the Northeast region of the country. The characteristics of the "Caatinga" vegetation, such as xeromorphic adaptations of shrubs and small trees that form a deciduous, thorny woody layer profusely spread over a woody-grass layer with cacti, are dispersed over different EFGs (IBGE, 2020e).

In areas classified in the Brazilian territory as "ecotones", it was not possible to establish an equivalent, as ecotones are a floristic mixture between types of vegetation, according to the definition described in the Technical Manual of Brazilian Vegetation (IBGE, 2012).

The precise delimitation of ecotones requires a floristic survey of each phyto-ecological region involved. The contact between vegetation types with similar physiognomic structures is impossible to be detected by simple photointerpretation, for example: Ombrophilous Forest /Seasonal Forest. It is also very difficult to separate or identify this contact, even when the types of vegetation involved have different physiognomic structures, for example: Ombrophilous Forest/ Savanna. That is because the elements that mix are isolated and dispersed individuals, forming generally very homogeneous or uniform sets (IBGE, 2020e). Another important point is the category of mosaics in the IBGE's land cover and land-use mapping, characterized by a high fragmentation of the landscape, for which an equivalence with the EFG proposed by the IUCN was not found. These unmatched categories account for 23.8 per cent of the Brazilian territory (2,081,901 km²) (IBGE, 2020e).

The spatial distribution and concentration of categories across the territory allows us to verify that it is still necessary to better elaborate the compatibilities with the Brazilian regions of the Cerrado and Caatinga (IBGE, 2020e).

This experiment expands the discussion of the feasibility of using the IUCN proposal for the classification of ecosystems in a given region or country, aiming at an international comparability of results in the context of the construction of ecosystem accounts and their derived activities. In the spatial analysis, it was noted that issues such as the fragmentation of landscapes, ecotones and some local phyto-physiognomies (with significant territorial extent) need to be improved in order to achieve a more comprehensive global proposal, which meets the specificities of the tropical world (IBGE, 2020e).

Finally, with the first experiment carried out, there are still future tests to be developed considering the published 2.0 version, namely, IUCN Global Ecosystem Typology 2.0 (Keith et al., 2020). Future tests will be able to assess whether the specifics of the Brazilian case are included in the IUCN GET 2.0 categories. It is noteworthy that any determination of an ecosystem profile may require technical debates with other institutional bodies, such as the Ministry of the Environment (MMA), directly involved in the implementation of public policies and in the use of the generated data.

Section 3:
Condition Account of Water Bodies

3.1. Introduction

Ecosystem condition measures the quality of an ecosystem measured in terms of its biotic and abiotic characteristics. This is assessed against the composition, structure and function of an ecosystem that sustains ecological integrity and supports its ability to provide services on an ongoing basis. Variables measuring the condition of the ecosystem can reflect different values and can be carried out at a range of temporal and spatial scales (UNCEEA, 2021).

The Ecosystem Condition Account provides data on the status and functioning of ecosystem assets by their typology, and how their status varies over the accounting period. Its measurement is intended to support environmental policy and decision-making that generally focuses on protecting, maintaining and restoring the condition of the ecosystem. The ecosystem condition typology (ECT) is a hierarchical organization of data on ecosystem condition characteristics aiming to establish a common language to support comparability between different ecosystem condition studies. Ecosystem condition accounts are commonly compiled by ET as each type has distinct characteristics. According to the United Nations (UNCEEA, 2021), a three-stage approach is used to compile the ecosystem condition accounts (IBGE, 2021a):

i) In stage 1, the main characteristics are selected and data on relevant variables are grouped together;

ii) In stage 2, a general reference condition is determined for the selected ETs, and for each variable a corresponding reference level is established, which helps to derive a condition indicator;

iii) In stage 3, condition indicators are normalized to support the aggregation and derivation of ecosystem condition indices.

The Experimental Condition Account for Water Bodies of Brazil was generated with information corresponding to stages 1 and 2.

3.2. Methodology and Database

3.2.1. Definition of Ecosystem Accounting Area and Spatial Units of Ecosystem Assets and Ecosystem Types

As for the development of extent accounts, it is necessary to define the spatial units of EAA, EA and ET. The goal of this study was to evaluate the condition of water bodies within the biomes, and not the condition of the biomes themselves. Therefore, the water bodies were considered as the EA.

Table 5 presents the definition of each attribute, namely, EAA, EA and ET, for the implementation of Experimental Condition Accounts in Brazil. The EEA is determined as the Brazilian territory, subdivided into the six Brazilian biomes, and the ET is defined as the rivers and lakes in each biome.

Table 5: Ecosystem Accounting Area, Ecosystem Assets and Ecosystem Types adopted in Extent Accounts

Ecosystem Accounting Area	Ecosystem Types	Ecosystem Assets
EAA	**ET**	**EA**
Amazon Biome	Amazon rivers and lakes	Individual Surface Water Bodies
Cerrado Biome	Cerrado rivers and lakes	
Caatinga Biome	Sertão rivers and lakes	
Atlantic Forest Biome	Atlantic rivers and lakes	
Pantanal Biome	Pantanal rivers and lakes	
Pampa Biome	Pampa rivers and lakes	

3.2.2. Variable selection and analysis method

The process of identifying information that can be reported in the Experimental Condition Account of Brazil was initially conducted based on Maes (2020) (IBGE, 2021a). Thus, based on this reference, surveys were carried out in order to identify which data is available at the Brazilian Institute of Geography and Statistics (IBGE) and at the National Water Agency (ANA). These data sources were assessed on the following three criteria (IBGE, 2021a):

i) Whether it would be possible to aggregate the data by biome;

ii) Whether the data are available for at least two different years;

iii) Whether it would be possible to organize the data in such a way as to distinguish between lotic water bodies (running waters, such as rivers and streams) and lentic waters (still waters, such as lakes, reservoirs and the like).

To organize the data on the characteristics of ecosystem condition, a hierarchy was proposed according to the SEEA Ecosystem Condition Typology (ECT), which proposes a aggregation framework for the ordering and coverage of characteristics as a model for selecting variables and indicators (IBGE, 2021a). The ECT also establishes a common language to support comparability between different studies of ecosystem conditions (UN, 2020c). Table 6 thus presents such a hierarchy, as well as the variables selected for each ECT category. Composed of three important groups, namely: the abiotic, biotic and landscape characteristics of the ecosystem, the Brazilian Surface Water Bodies Experimental Condition Account includes variables for three categories (IBGE, 2021a):

i) The quantitative and qualitative water balance of the micro-watersheds in each biome as a variable that represents the physical status of the surface water bodies;

ii) Chemical quality parameters in each biome as a variable that represents the chemical status of surface water bodies;

iii) The number of threatened species of fauna and flora in 2014 per biome as a variable that represents the status of composition of biotic characteristics, such as aquatic species in water bodies.

Table 6: Ecosystem condition typology, variables and analysis methods

ECT Groups	ECT Categories	Description of ECT categories	Variables	Analysis method*
Abiotic characteristics of the ecosystem	Physical state	1. Physical state characteristics (including soil structure and water availability)	Quantitative water balance (built from the combination of data from 2013, 2014 and 2015) and qualitative water balance (built with data from 2008)	Proportion of micro-watersheds, in each biome, classified by status of the quantitative water balance
	Chemical state	2. Chemical state characteristics (including soil nutrient levels, water quality and air pollutant concentrations)	Biochemical Oxygen Demand, Dissolved Oxygen, E. coli, Total Phosphorus and Turbidity in lotic and lentic aquatic bodies in 2010 and 2017	Proportion of micro-watersheds, in each biome, classified by status of the qualitative water balance
Biotic characteristics of the ecosystem	Compositional state	3. Characteristics of compositional status (including species-based indicators)	Number of aquatic, fauna and flora species threatened in 2014	Number of aquatic, fauna and flora species threatened in 2014 by biome
	Structural state	4. Structural status characteristics (including vegetation, biomass and food chains)	Not compiled	
	Functional state	5. Functional status characteristics (including ecosystem processes and disturbance regimes)	Not compiled	
Landscape features	Landscape features	6. Landscape and seascape characteristics (including landscape diversity, connectivity, fragmentation and semi-natural elements embedded in agricultural land)	Not compiled	

*Reference conditions for each variable are shown throughout the text.

Source: IBGE (2021a)

3.2.3. Ecosystem condition: abiotic characteristics of the chemical status

Regarding the condition of these ecosystems, the following abiotic parameters were selected, which help in the assessment of the quality of freshwater surface water resources, namely (IBGE, 2021a):

- Dissolved Oxygen (DO);
- Total Phosphorus (TP);
- Biochemical Oxygen Demand (BOD)
- Turbidity;
- Escherichia coli (E.coli).

The reference conditions of these parameters for Brazil, considering the national standards defined by the Resolution of the National Council for the Environment (CONAMA) N. 357/2005 for category 2 (water for supply and other uses) are found in Table 7 (IBGE, 2021a).

Table 7: Reference conditions for the chemical status of water quality

Variables	Measurement units	Category 2
Dissolved Oxygen	mg/L	> 5, except for the rivers (lotic water bodies) of the Pantanal affected by lye
Total Phosphorus	mg/L	< 0.030 for lentic environments (reservoirs), < 0.10 for lotic environments
Biochemical Oxygen Demand	mg/L	≤ 5
Turbidity	UNT	< 100
Escherichia Coli	NMP/100mL	≤ 800

Source: IBGE (2021a)

To survey these variables, the ANA public database called "Water Quality Indicators (2001 to 2017)[1]" was used and, based on the latitude and longitude, monitoring points for each biome were located (IBGE, 2021a). Then, for each indicator, the proportion of monitoring points classified as "good quality" in relation to the total number of monitoring points in each biome for the years 2010 and 2017 was calculated, and the reference condition for each indicator was identified. Water was considered to be of "good quality" when 80 per cent or more of the evaluated monitoring records met the established reference standards (IBGE, 2021a).

3.2.4. Ecosystem condition: Abiotic characteristics of the physical status

For the group of abiotic characteristics of the ecosystem, the following variables that help to identify the physical state of freshwater surface water resources were selected (IBGE, 2021a):

i) Quantitative Water Balance

ii) Qualitative Water Balance

The reference conditions for the quantitative water balance are determined by the classification ranges adopted for this index, which are the same used by the European Environment Agency and the United Nations. The consumptive water demand was based upon the demand from manufacturing and irrigation (updated until 2014), urban water supply and livestock (updated until 2013). Water availability was updated in 2015 for river basins and reservoirs (ANA, 2020). For the spatial distribution by biome, the information from 558,699 micro-watersheds was used (IBGE, 2021a).

In turn, the qualitative water balance is also carried out by river stretch and by micro-watershed, considering the assimilative capacity of household organic loads by water bodies. Because of this characteristic, within the scope of the condition account, this balance is considered a physical variable, as it is related to the capacity to dilute pollutants in water bodies. Values greater than one indicate that the supplied organic load is greater than the assimilable load, and values less than one indicate that the supplied organic load is less than the assimilable load. For the analysis of the qualitative water balance and spatial distribution by biome, information was used for 165,197 micro-watersheds (IBGE, 2021a).

The collection of these variables was based upon two ANA databases, one on the quantitative balance, built from the combination of data from 2013, 2014 and 2015, and the other on the qualitative balance,

1 Available at: https://metadados.ana.gov.br/geonetwork/srv/pt/metadata.show?id=318&currTab=distribution

built with data from 2008.[2] Both databases were published in 2016. The difference between the quantity of micro-watersheds of the quantitative balance data and the quality of micro-watersheds results from the adopted version of the reference Ottocoded Hydrographic Base (IBGE, 2021a). Table 8 presents the reference levels considered for the quantitative and qualitative water balance. Based on the available information, the data was analysed in order to obtain the proportion of micro-watersheds that classify into each of the five mentioned classes, both for the quantitative and qualitative water balance, in each biome (IBGE, 2021a).

Table 8: Reference conditions of the physical state of the quantitative and qualitative water balance

Quantitative water balance		Qualitative water balance	
Reference level	**Status**	**Reference level**	**Status**
< 5%	Excellent - little or no management activity required	0% to 0.5%	Excellent
5% to 10%	Comfortable - management may be needed to solve local supply problems	0.5% to 1.0%	Good
10% to 20%	Worrying - the management activity is essential and requires investments are made	1.0% to 5.0%	Reasonable
20% to 40%	Critical - intense management activity and large investments are required	5.0% to 20.0%	Bad
> 40%	Very critical	> 20%	Very Bad

Source: IBGE (2021a)

3.2.5. Ecosystem condition: Biotic compositional characteristics

For the group of biotic characteristics of the ecosystem, the following variables that help to identify the compositional status of aquatic species of surface water resources were selected (IBGE, 2021a):

i) Total evaluated species.
ii) Number of threatened species.
iii) Percentage of threatened species.

These variables were assessed for aquatic species of flora, fauna and vertebrates for the year 2014, based on the National Red Lists of Fauna (Chico Mendes Institute for Biodiversity Conservation - ICMBio) and Flora (Brazilian National Center for Flora Conservation - CNCFlora /JBRJ), published in 2014[3] that meet the same threat degree classification criteria[4] defined by the IUCN and have a methodology for surveying threatened species that has been consolidated in ICMBio and CNCFlora (IBGE, 2021a).

Based on data from the National Red Lists, a table was drawn up with the number of threatened species in aquatic environments by biome, according to the methodology described in the Threatened Species Account, published by IBGE under the NCAVES Project and presented in Section 5 of this present report (IBGE, 2021a).

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[2] Available at: https://metadados.ana.gov.br/geonetwork/srv/pt/metadata.show?id=313&currTab=distribution and https://metadados.ana.gov.br/geonetwork/srv/pt/metadata.show?id=314&currTab=distribution

[3] On December 18, 2014, the Red Lists were made official by the ordinances that published the Lists of Threatened Species of the Brazilian Fauna and Flora published in the Official Gazette of the Union (MMA Ordinances N. 443/2014, 444/2014 and 445/2014).

[4] (i) Least Concern (LC); (ii) Near Threatened (NT); (iii) Vulnerable (VU); (iv) Endangered (EN); (v) Critically Endangered (CR); (vi) Extinct in nature (EW); (vii) Extinct; and (viii) Insufficient data.

3.3. Results

3.3.1. Chemical status of lotic and lentic water bodies by biome in 2010 and 2017

The chemical status analysis generated results for the five parameters in each biome. Similar to the methodology adopted by ANA to estimate the SDG indicator 6.3.2 "Proportion of Water Bodies with Good Water Quality" – to monitor the Global Goal 6.3 "Assess the Water Quality Conditions of a Country" of the SDG 6 "Clean Water and Sanitation" – in addition to the growth or fall in the proportion by variable, the results also reflect the change in the number of monitoring points between the years studied, as shown in Table 9 (IBGE, 2021a).

Table 9: Number of monitoring points by biome, type of water body and abiotic variable (2010 and 2017)

Variables	Year	Amazon		Caatinga		Cerrado		Atlantic Forest		Pampa		Pantanal	
		lotic	lentic	lotic	lentic	lotic	lentic	lotic	lentic	lotic	lentic	lotic	lentic
DO	2010	19	0	128	78	479	12	1,105	100	30	1	26	0
	2017	82	0	204	214	447	30	1,238	124	3	0	34	0
TP	2010	19	0	125	21	413	10	997	88	34	1	21	0
	2017	23	0	189	190	455	39	1,178	110	4	0	19	0
BOD	2010	19	0	127	78	475	12	1,105	103	38	14	21	0
	2017	23	0	201	202	473	42	1,249	124	4	0	34	0
Turbidity	2010	19	0	127	51	510	13	1,025	96	19	0	26	0
	2017	87	0	204	211	474	42	1,238	120	4	0	34	0
E.coli	2010	19	0	0	0	54	0	86	0	18	0	8	0
	2017	23	0	75	146	388	42	834	70	4	0	9	0

Source: IBGE (2021a)

In the Amazon biome, the results show that there was a small improvement in the number of monitoring points that classify water in lotic water bodies as falling in the category of good quality, for the levels of Dissolved Oxygen (DO) (+6%) and E. Coli bacteria (+8%). However, there was a deterioration in the number of monitoring points with regard to total phosphorus and turbidity in 2010 and 2017 (IBGE, 2021a). It is important to mention that, with regard to monitoring points located in lentic water bodies, there were no observations for the Amazon biome in 2010 and 2017, as monitoring points in lentic environments are concentrated in the Caatinga and Atlantic Forest biomes, which are home to the largest number of reservoirs with multiple uses (IBGE, 2021a).

In the Caatinga, the main results for lotic water bodies showed a decrease in the number of monitoring points that presented good levels of Biological Oxygen Demand (BOD) (-15 pp) and Total Phosphorus (TP) (-12 pp), a significant improvement in those that presented good levels of E.coli (85 pp) and DO (26 pp). In lentic water bodies, there was a significant drop in relation to BOD (-52 pp) and a significant improvement in relation to E.coli (97 pp) (IBGE, 2021a).

In the Cerrado biome, it was noted that, in lotic water bodies, there was a decrease in the number of monitoring points that presented levels considered good for TP (-14 pp) and E.coli (-13 pp). In lentic water bodies, there were great improvements with regard to E.coli (92 pp) and BOD (15 pp) (IBGE, 2021a). In the Atlantic Forest biome, among the main results, it was noted that there was an increase in the number of monitoring points located in lotic water bodies whose E.coli levels are considered good quality (18 pp). In lentic water bodies, there was great improvement with regard to E.coli (71 pp) and TP (14 pp) (IBGE, 2021a). In the Pampa biome there was an improvement in indicators related to TP (28 pp) and Turbidity (10 pp) in lotic water bodies. In lentic water bodies it was not possible to analyze the results because there was no observation for the year 2017 (IBGE, 2021a).

In the Pantanal there was a significant drop in the proportion of monitoring points located in lotic water bodies that presented levels considered good for TP (-71 pp) and a significant improvement in relation to E.coli (37 pp) and DO (13 pp). Regarding TP, "close to urban areas it mainly indicates pollution caused by household and industrial effluents, while in the countryside it is linked to sediments and nutrients from soil erosion processes. Its concentration increases in water bodies after the rains, due to sediment loading, and it is one of the main nutrients responsible for the eutrophication of lakes and reservoirs [...]" (IBGE, 2021a).

In general, there was a reduction in monitoring points with good levels of TP in lotic water bodies and an increase of monitoring points with good levels of E.coli, both in lotic and lentic water bodies. In turn, these results may be associated with two issues, namely (IBGE, 2021a):

i) Water pollution by excess phosphorus may be associated with increased erosion resulting from the intensification of land use.

ii) The improvement in the proportion of monitoring points that meet the water quality parameters with regard to E.coli may be associated with greater coverage of sanitary sewage by the collection network and sewage treatment.

3.3.2. Physical status: Water balance by Brazilian Biome

The analysis of the results in this section refers to the proportion of micro-watersheds that fall within the reference intervals, in relation to the quantitative and qualitative water balance, in each biome (IBGE, 2021a).

Regarding the quantitative water balance, Table 10 shows that most micro-watersheds were in excellent condition, with the exception of the micro-watersheds in the Caatinga and Pampa biomes, where most were in a very critical condition, due to low water availability and high water demand. The result for the Pampa confirms the information gathered in other studies that point to the important role of the direct abstraction from surface and underground water for the irrigation of crops in the biome.

In other biomes, however, most micro-watersheds have an excellent quantitative water balance, which points to the importance of considering other characteristics of the studied regions as well. In the Atlantic Forest, for example, 11% of the micro-watersheds presented a very critical quantitative water balance. Possibly, these are micro-watersheds with the highest population density, since the greatest presence of the highest urban concentrations occurs in this biome (IBGE, 2021a). The Cerrado biome, in turn, has 16% of its micro-watersheds in a state of concern, being in critical or in very critical condition in terms of water quantity (IBGE, 2021a).

Table 10: Condition of biomes in terms of quantitative water balance (proportion of micro-watersheds, 2013-2015)

Classification	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Excellent	95%	21%	75%	82%	30%	88%
Comfortable	2%	10%	9%	7%	11%	4%
Worrying	2%	14%	7%	3%	12%	3%
Critical	1%	12%	5%	2%	13%	4%
Very critical	1%	44%	4%	6%	34%	1%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: IBGE (2021a)

Regarding the qualitative water balance, Table 11 shows that in all biomes, most micro-watersheds presented optimal conditions. However, it is important to highlight that 28 per cent of the micro-watersheds in the Atlantic Forest had a reasonable, bad or very bad qualitative water balance as it is a biome with a high degree of urbanization (IBGE, 2021a).

Table 11: Condition of biomes in terms of qualitative water balance (proportion of micro-watersheds (2008)

Classification	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Optimal	99%	75%	89%	65%	81%	95%
Good	0%	2%	3%	8%	7%	0%
Reasonable	1%	6%	5%	16%	7%	1%
Bad	0%	7%	2%	7%	3%	0%
Very Bad	0%	9%	1%	5%	1%	3%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: IBGE (2021a)

3.3.3. Compositional status: Threatened Aquatic Species

Regarding the threatened aquatic species compositional indicator, Table 12 shows that the largest number of assessments took place of fauna species, with 8,893 species assessed. Of this total, 560 species are threatened with extinction, of which 79 per cent are vertebrates (IBGE, 2021a). Also 1,840 species of flora were evaluated, of which 254 are threatened with extinction. Among the species evaluated, when considering the number of aquatic threatened species in Brazil, it appears that most species of fauna, mostly vertebrates, and flora are threatened in the Atlantic Forest biome, followed by the Cerrado and Amazon (IBGE, 2021a). The largest portion of threatened vertebrate species occurred in the Atlantic Forest biome, followed by the Cerrado, Pampa and Caatinga.

Table 12 - Threatened aquatic species in Brazil by biome in 2014

	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal	Total
Number of threatened flora species	25	17	73	115	17	7	254
Total evaluated species of flora	297	209	508	651	92	83	1,840
Number of threatened fauna species	79	36	143	244	48	10	560
Total evaluated species of fauna	2,925	504	1,943	2,268	569	684	8,893
Number of threatened vertebrate species	77	33	133	195	36	9	483
Total evaluated vertebrate species	**2,376**	**447**	**1,455**	**1,726**	**464**	**517**	**6,985**
Threatened vertebrate species (%)	**3.24%**	**7.38%**	**9.14%**	**11.30%**	**7.76%**	**1.74%**	

Source: IBGE (2021a)

Section 4:
Ecosystem Services

4.1. Introduction

The measurement of ecosystem services (ES) aims to explain the diversity of contributions that ecosystems provide to individuals and economic activities. These contributions extend far beyond marketed goods and services, such as timber, ore and food, as they also ensure the delivery of services such as air filtration, water purification, climate regulation, erosion control, and services related to culture and recreation. Usually, these types of services are provided to businesses and households outside of market institutions, which hides them from economic statistics such as the measurement of GDP.

In the ecosystem accounting framework, ES work as the connecting concept between ecosystem assets, measured by the extent and condition accounts, and the production and consumption activity of companies, households and governments. Therefore, to establish their relationship with the extent and condition accounts, it is of paramount importance that the measurement of the flows of ES is carried out based on the same spatial and territorial profiles adopted to measure the extent and condition of ecosystems, thus creating the connection between ecosystem assets, benefits provided by such assets and their direct beneficiaries.

The explicit recording of the contributions of ecosystems, in the form of flows of ecosystem services, enables integration between the benefits of ecosystems, including those which are internalized and those that are not internalized by the market. From the assessment of variations that arise in the conversion of extent areas, for example, and due to changes in land use, changes in the condition of ecosystems and variations in service flows need to be measured. This link makes it possible to understand the variations in ecosystem contributions that can be affected or become scarce.

The key concepts related to ecosystem services concern (i) the Supply Table of ecosystem services; and (ii) the Use Table of ecosystem services that depict the beneficiary agents, that is, the goods and services used and enjoyed by the economy and society. This section presents the results of the experimental study of the Water Supply Service and the Non-Timber Forest Products Supply Service, which have been disaggregated by Brazilian biome, thus making them compatible with the spatial distribution of the ecosystem assets, analysed in the Extent and Condition Accounts. It also presents the respective valuation analyses.

4.2. Water supply service in Brazilian Biomes

The blue water supply service is represented by the flow of direct abstraction of surface and ground water. This variable consists of water resource use and constitutes a pressure factor on water bodies since it diminishes the flow of rivers and interferes with their quantitative and qualitative water balance. Therefore, the analysis of the provisioning service is closely related to the analysis of the condition of certain ecosystem types, such as the surface water bodies of Brazilian biomes, which can be affected by different pressure factors, causing variations in the variables measured. Consistent with the spatial analysis adopted in the extent and condition accounts, an analysis of the blue water provisioning service flow per Brazilian biome was elaborated.

4.2.1. Methodology and Database

The use of water is considered consumptive when it is withdrawn and consumed, partially or totally, in the process for which it is intended. Consumption can occur by evaporation, transpiration, incorporation into products, or consumption by living beings, among others. To assess the flow of direct abstraction, the "Manual on the consumptive uses of water in Brazil" (IBGE, 2021a) produced by the National Water Agency was used. This database provides information on water abstraction, consumption and return, measured in cubic meter per second (m^3/s) for the following sectors (IBGE, 2021a): i) Irrigated agriculture; ii) Animal supply; iii) Mining; iv) Manufacturing industry; v) Thermoelectricity; vi) Urban human supply; and vii) Rural human supply.

The organization of information took place, firstly, by identifying the biome in which each municipal seat[5] is located. This step was carried out through the spatial crossing of the vector files of Brazilian cities, obtained from the Continuous Cartographic Base of Brazil, with the Map of Biomes and Coastal-Marine System of Brazil (IBGE, 2019b). Thus, municipal data on water use was attributed to the biomes. Following this step, the sum of the water abstraction flows by each sector among the cities that make up each biome was calculated, considering the location of the respective cities. The data was organized in order to obtain the direct abstraction of water, in m^3/s, by sector and biomes in the years 2010 and 2017.

4.2.2. Water supply flow by economic activity

Tables 13 and 14 present the results of direct water abstraction flows in Brazil, by biome. In 2010 the flow was 1,843m^3/s, while in 2017 it was 2,043m^3/s, corresponding, therefore, to a growth of 13 per cent during the period analysed and an average annual growth of 1.9 per cent between 2010 and 2017. It is observed that the sectors that benefited most from the water supply service flows are irrigated agriculture (49 per cent and 52 per cent, in 2010 and 2017, respectively, of the total direct abstraction), followed by the urban water supply sector (24 per cent in both years), and the manufacturing industry (11 per cent and 9 per cent, in 2010 and 2017, respectively) (IBGE, 2021a).

Table 13: Blue water abstraction in 2010 – m³/s

	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal	Brazil
Irrigated agriculture	17	180	210	213	284	0	**904**
Animal supply	36	15	52	47	7	2	**160**
Mining	8	0	3	14	1	0	**25**
Transformation Industry	6	7	32	147	3	0	**195**
Thermoelectricity	21	0	2	47	5	0	**75**
Urban human supply	45	34	65	288	15	1	**448**
Rural human supply	7	10	5	14	1	0	**36**
Addition	**140**	**247**	**368**	**769**	**316**	**4**	**1,843**

Source: IBGE (2021a)

5 "[...] location with the same name as the Municipality to which it belongs (municipal seat) and where the respective City Hall is located [...]" (IBGE, 2019, p. 22).

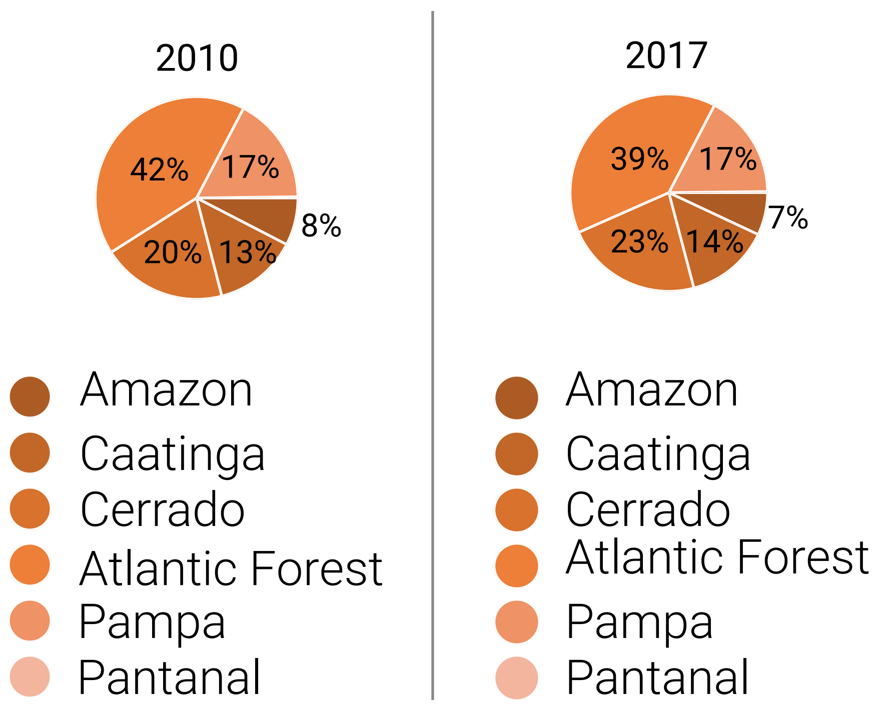
Table 14: Blue water abstraction in 2017 – m³/s

	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal	Brazil
Irrigated agriculture	20	219	284	235	325	0	**1,084**
Animal supply	40	15	55	48	7	2	**167**
Mining	10	0	3	18	1	0	**33**
Transformation Industry	6	8	38	134	4	0	**189**
Thermoelectricity	11	1	9	55	4	0	**79**
Urban human supply	52	38	73	316	16	1	**496**
Rural human supply	7	10	5	13	1	0	**34**
Addition	145	290	468	818	357	4	**2,083**

Source: IBGE (2021a)

Figure 7 below shows the share of water abstraction in each biome in the total flow abstracted in the country in 2010 and 2017. The order of importance of the biomes in terms of water abstraction was maintained during the period. That is, the abstraction in the Atlantic Forest biome was the main responsible factor for the direct abstraction of water in Brazil, followed by the Cerrado, Pampa, Caatinga and Amazon. However, the abstraction rate in each biome changed slightly. As shown in Figure 7, between 2010 and 2017, there was an increase in the relative share of abstraction in the Cerrado, from 20 per cent to 23 per cent, and in the Caatinga, from 13 per cent to 14 per cent, and a reduction in the relative share of the Atlantic Forest, from 42 per cent to 39 per cent, and Amazon, from 8 per cent to 7 per cent (IBGE, 2021a).

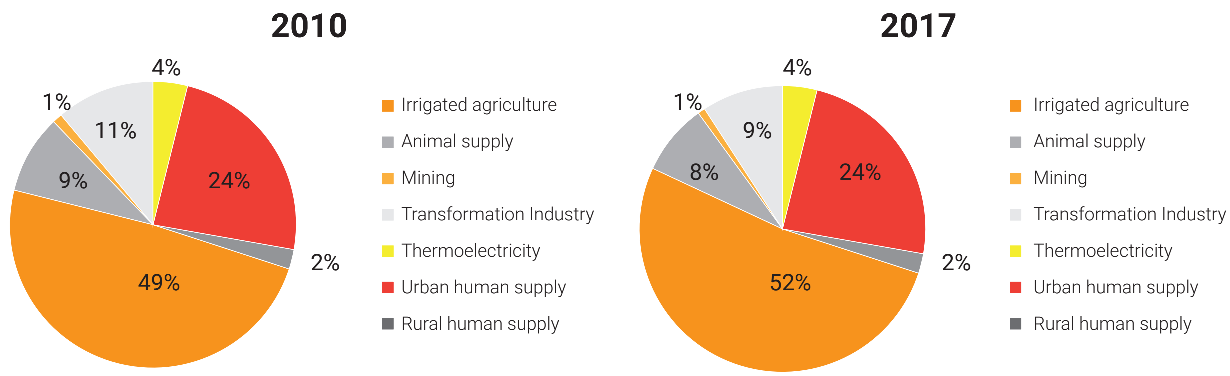
Figure 7: Proportion of direct water abstraction in biomes in relation to total water abstraction in Brazil



Source: IBGE (2021a)

Similarly, it can be seen that the order of importance of the sectors in terms of water abstraction in the country was maintained during the period. Figure 8 shows the distribution of water abstraction among economic sectors. Irrigated agriculture was the main sector responsible for the direct abstraction of water, followed by urban water supply, manufacturing industry, livestock, thermoelectricity, rural water supply and mining. The relative share of each sector has changed slightly. As shown in Figure 8 between 2010 and 2017, there was an increase in the relative share of irrigated agriculture (3 pp) and mining, and a reduction in the share of the manufacturing industry (2 pp) and livestock (1 pp) (IBGE, 2021a).

Figure 8: Relative share of direct water abstraction by sectors in Brazil (2010 and 2017)



Source: IBGE (2021a)

Table 15 below shows the share of direct water abstraction by sectors in the biomes. It is observed that, in the Pampa, Caatinga and Cerrado biomes, the direct abstraction of water is concentrated in the irrigated agriculture sector. In the Pampa, Brazil's main rice producing region, 91 per cent of the water abstracted was for irrigation purposes in 2017 (IBGE, 2021a). It is noteworthy that, in the Caatinga biome, known for episodes of severe water shortages and supply restrictions, 73 per cent of water abstraction was used for irrigation in 2017. It is worth remembering that this region has large deficits for rainfed agriculture, due to its typical climatic characteristics (IBGE, 2021a).

The Atlantic Forest and Amazon biomes showed the highest proportion of direct water abstraction for urban water supply, with 39 per cent and 36 per cent, respectively, followed by irrigated agriculture, with 29 per cent and 14 per cent, respectively. The Pantanal biome's water demand stems mostly from the livestock sector, amounting to 60% in 2017 (IBGE, 2021a).

Table 15: Relative share of direct water abstraction by sectors in Brazilian biomes (2017)

	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Irrigated agriculture	14%	75%	61%	29%	91%	7%
Animal supply	28%	5%	12%	6%	2%	60%
Mining	7%	0%	1%	2%	0%	13%
Transformation Industry	4%	3%	8%	16%	1%	1%
Thermoelectricity	7%	0%	2%	7%	1%	0%
Urban human supply	36%	13%	16%	39%	4%	18%
Rural human supply	5%	3%	1%	2%	0%	1%
Addition	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: IBGE (2021a)

Table 16 shows the share of direct water abstraction by sectors in the biomes in 2017. Regarding the main use of water in the country - namely, irrigated agriculture - that year, it was observed that it was concentrated in the Pampa biome (30 per cent), followed by the Cerrado (26 per cent), Atlantic Forest (22 per cent) and Caatinga (20 per cent) (IBGE, 2021a).

Regarding the second and third main use of water in the country, that is, the urban water supply and the manufacturing industry, about 64 per cent and 71 per cent, respectively, of the abstraction of water destined for these two purposes occurred in the Atlantic Forest biome in 2017. These results reflect the concentration of urban areas in the Atlantic Forest biome, in which more than half of the national population is concentrated (IBGE, 2021a).

In 2017, the largest share of water abstracted for livestock was in the Cerrado biome, with 33% of the water abstracted for this purpose in the country due to agricultural activity in the region, followed by the Atlantic Forest with 29%, and the Amazon with 24% (IBGE, 2021a). The Amazon was the second biome in terms of water abstraction for mining and hydro-electric energy, where activity stands out in Carajás[6] and in the alumina poles[7], followed by the Atlantic Forest (IBGE, 2021a).

Table 16: Relative share of biomes in direct water abstraction in each economic activity – 2017

	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal	Addition
Irrigated agriculture	2%	20%	26%	22%	30%	0%	**100%**
Animal supply	24%	9%	33%	29%	4%	1%	**100%**
Mining	29%	1%	9%	56%	4%	1%	**100%**
Transformation Industry	3%	4%	20%	71%	2%	0%	**100%**
Thermoelectricity	14%	1%	12%	69%	5%	0%	**100%**
Urban human supply	11%	8%	15%	64%	3%	0%	**100%**
Rural human supply	20%	28%	14%	37%	2%	0%	**100%**

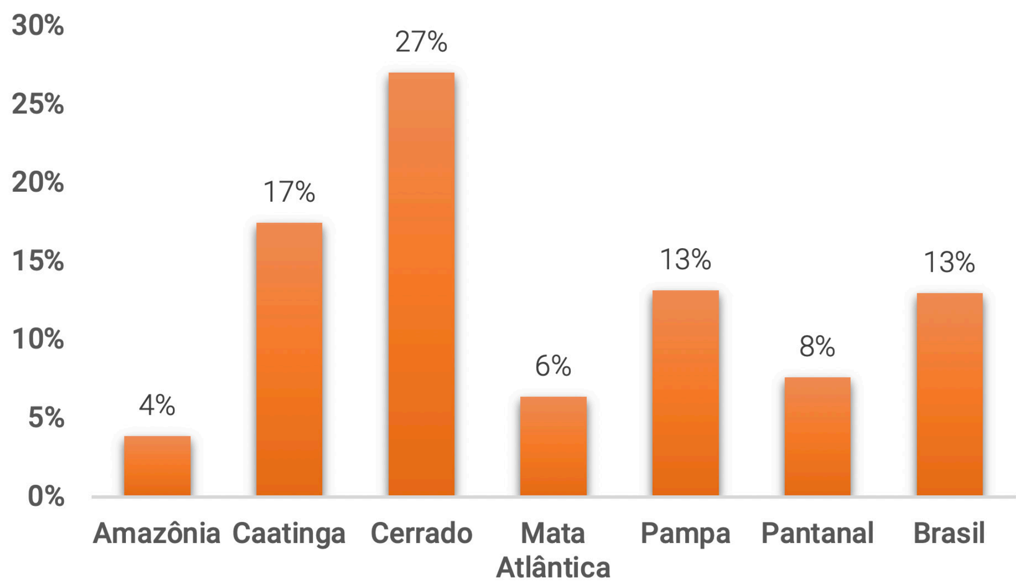
Source: IBGE (2021a)

In the analysed period, the Cerrado biome had the highest growth rate of water abstraction (27 per cent), as shown in Figure 9, mainly for irrigation purposes. As a highlight, it is observed that water abstraction in the Cerrado for the use of thermoelectric power plants grew by 364 per cent between 2010 and 2017, although the level of water abstraction is quite low compared to other sectors in the biome (IBGE, 2021a). The Caatinga biome is the second highest in terms of growth in water abstraction, after the Cerrado, with 17 per cent, largely due to the increase in direct abstraction from irrigated agriculture, which was 22 per cent between 2010 and 2017 (IBGE, 2021a). In the main biome where the largest volumes of abstraction for urban water supply occur, the Atlantic Forest, growth was only 6 per cent (IBGE, 2021a).

6 Largest open pit iron ore mine in the world - http://www.vale.com/brasil/pt/Paginas/default.aspx

7 Raw material for aluminum production.

Figure 9: Development of direct water abstraction between 2010 and 2017



Source: IBGE (2021a)

4.3. Experimental valuation of the water provisioning service for the sector "Water collection, treatment and supply"

Aiming to support the production of estimates on the valuation of the ecosystem service of blue water provisioning in Brazil, first an extensive literature review was carried out. In this process, only a few empirical studies on the valuation of water in Brazil were found (Seidl and Moraes, 2000; Casey, Kahn and Rivas, 2006; Rosado et al., 2006; Briscoe et al., see IBGE, 2021c).

Given the pioneering role that Brazil has been playing in the construction and dissemination of Environmental Economic Accounts for Water (EEAW), as well as the potential contribution of studies on the valuation of natural resources in the discussion about charging for the direct abstraction of blue water, this section presents the results of the experimental valuation of the water provision ecosystem service used by the activity "Water Abstraction, Treatment and Distribution" (division of the National Classification of Economic Activities - CNAE 36) (IBGE, 2021c)

4.3.1. Methodology and Database

Determining the economic value of an environmental resource is to estimate its monetary value in relation to other goods and services available in the economy. The use of an environmental asset, such as water for example, can translate into use values and non-use values (IBGE, 2021c). To estimate the water provisioning service used by the economic activity "Water collection, treatment and supply" (CNAE 36 division), the "resource rent" method was adopted, according to empirical studies found in the literature on the valuation of water. Among these studies, the following stand out: Edens and Graveland (2014) for the Netherlands, National Institute of Statistics and Geography (INEGI, 2014) for Mexico, Comisari, Feng and Freeman, (2011) for Australia and Lange and Hassan (2006) for Namibia (see IBGE, 2021c).

According to the SEEA-CF, the market prices of environmental assets can be estimated through the net present value of future resource rents. Resource rent is the net revenue from extraction, defined as total sales revenue less all costs incurred in the extraction process, including the user's cost of produced capital. This means that the resource rent represents the return of the natural resource (IBGE, 2021c). The resource rent can be estimated through the operating surplus of the activities involved in the extraction of the natural resources in question, as presented in SEEA-CF (IBGE, 2021c). The resource rent can be considered the residual that measures the contribution of the environmental asset to production, consistent with the concepts of the national accounts.

Regarding the methodology, it is important to highlight that the most detailed sectoral breakdown of the national accounts of Brazil (68 economic activities and 128 products) does not separately identify CNAE36 division. It is included in the sector called "Water, sewage and waste management", corresponding to the CNAE 36 divisions, 37, 38 and 39[8] (IBGE, 2021c). One of the contributions of the EEAW in Brazil is the estimation of Gross Production Value (GPV) and Intermediate Consumption (IC) for a more detailed sector called "Water and Sewage", corresponding to the CNAE 36 and 37 divisions, for the years 2013 to 2017, at the national level. Therefore, this estimate was used to obtain information on GPV, IC and Gross Value Added (GVA) - as well as their components, such as "salaries", "other taxes on production" and "other subsidies to production" (IBGE, 2021c).

To meet the objective of the current study and given data availability, the GPV and the IC specifically for the CNAE 36 division between 2013 and 2017 were estimated. The applied methodology is based on data from the national accounts, from the EEAW Brazil, the Ministry of Cities, as well as from other data sources, as listed below (IBGE, 2021c):

- GPV of CNAE divisions 36 and 37 divisions from EEAW Brazil (IBGE, ANA, 2020);
- Estimate of the GPV proportion for the water product in relation to the total output of the water product and the sewage service;
- Estimate of the value added of CNAE division 36 for the years 2013 to 2017, based on the difference between the GPV and the IC of that activity in those years;
- Cost of companies that offer only the "water" service, or the "sewage" service, from the National Sanitation Information System - SNIS (Ministry of Cities, 2017);
- Estimate of Gross Operating Surplus from the National Sanitation Information System – SNIS (Ministry of Cities, 2017);
- Data on "salaries and "net taxes on production" released by the Brazilian national accounts (IBGE) for the activity "Water, sewage and waste management" (CNAE Divisions 36, 37, 38 and 39);
- Estimate of the variable "net taxes on production" of the CNAE 36 division;
- The variable "gross operating surplus" is estimated as the difference between "value added", "salaries" and "net taxes on production";
- Estimate of the capital stock of the water supply activity, based on Timmer et al. (2015).

8 CNAE 36 (International Standard Industrial Classification of All Economic Activities (ISIC) 36): abstraction, treatment and distribution of water, CNAE 37 (ISIC 37): sewage and related activities, CNAE 38 (ISIC 38): abstraction, treatment and disposal of waste; materials recovery and CNAE 39 (ISIC 39): decontamination and other waste management services.

4.3.1. Results

Table 17 presents the monetary data on the water supply activity (CNAE 36 division) for the period between 2013 and 2017. In this study, it was found that the value of the blue water provisioning ecosystem service used by the water supply activity in Brazil was R$6.3 billion, on average between 2013 and 2017, ranging from R$4.0 billion in 2015 to R$9.3 billion in 2017 (IBGE, 2021c).

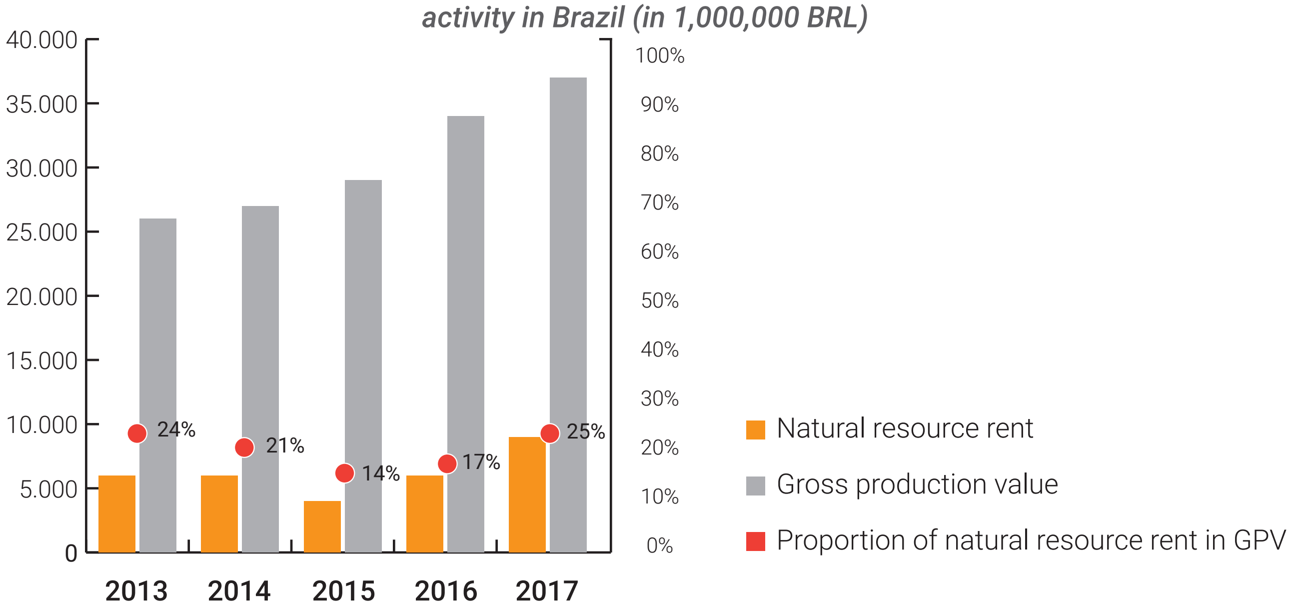
Table 17: Valuation of the blue water provisioning ecosystem service (in 1,000,000 BRL) - 2013 to 2017

Items	2013	2014	2015	2016	2017
Gross production value	26,472	28,138	28,985	33,953	37,639
Production of the distribution water product	26,180	27,800	28,619	33,540	37,204
Intermediate Consumption	8,784	9,589	11,170	12,418	13,692
Value added	17,688	18,549	17,815	21,535	23,947
Salaries	3,545	4,138	3,972	4,480	6,083
Net taxes on production	224	242	267	306	380
Gross operating surplus	13,920	14,169	13,576	16,748	17,485
Operating surplus related to water	13,766	13,998	13,404	16,544	17,283
Capital stock	41,523	44,136	45,465	53,257	59,039
Return to capital	5,278	5,742	7,111	8,058	5,012
Fixed capital consumption	2,076	2,207	2,273	2,663	2,952
Fixed capital user cost	7,354	7,949	9,384	10,721	7,964
Resource rent	6,412	6,049	4,020	5,823	9,319

Source: IBGE (2021c)

Comparing these results to the production of the water supply activity, it appears that the resource rent of blue water is equivalent to about 20 per cent of this production value, on average, between 2013 and 2017 (IBGE, 2021c), as shown in Figure 10.

Figure 10: Proportion of resources rent in the production of the water supply activity in Brazil (in 1,000,000 BRL)

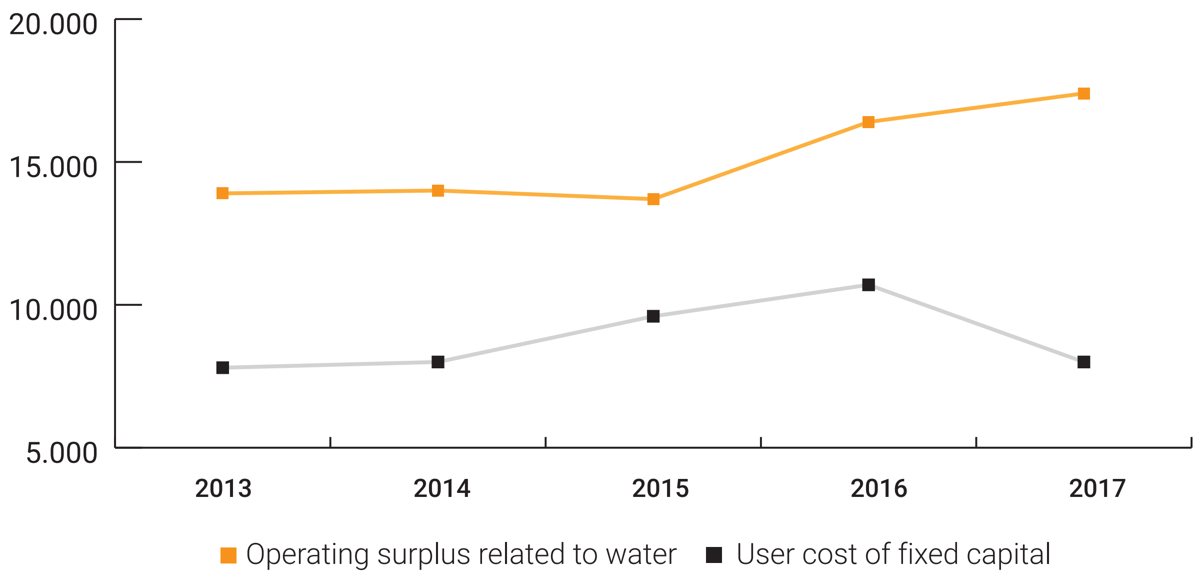


Source: IBGE (2021c)

In turn, as the resource rent is estimated based on the difference between the water-related operating surplus and the user cost of fixed capital, it is then possible to assess the main factors which explain these variations (IBGE, 2021c).

As illustrated in Figure 11, there is a tendency towards an approximation between the surplus and cost curves, mainly due to the increase in the user cost of fixed capital. Between 2016 and 2017 this trend reversed, mainly due to the reduction in this cost, compared to the reduction in the rate of return to fixed capital (IBGE, 2021c). Additionally, it is important to point out the drop in the surplus found in 2015. This result was influenced by the deceleration in the activity's production that year, due to the water crisis of 2014 and 2015. "[...]. The water crisis in 2014 and 2015 in the Southeast region directly interfered in the sanitation and electricity sectors. There was a direct impact on the financial health of large Brazilian companies in the sanitation sector. [...]" (IBGE, ANA, SRHQ, 2018; p.9).

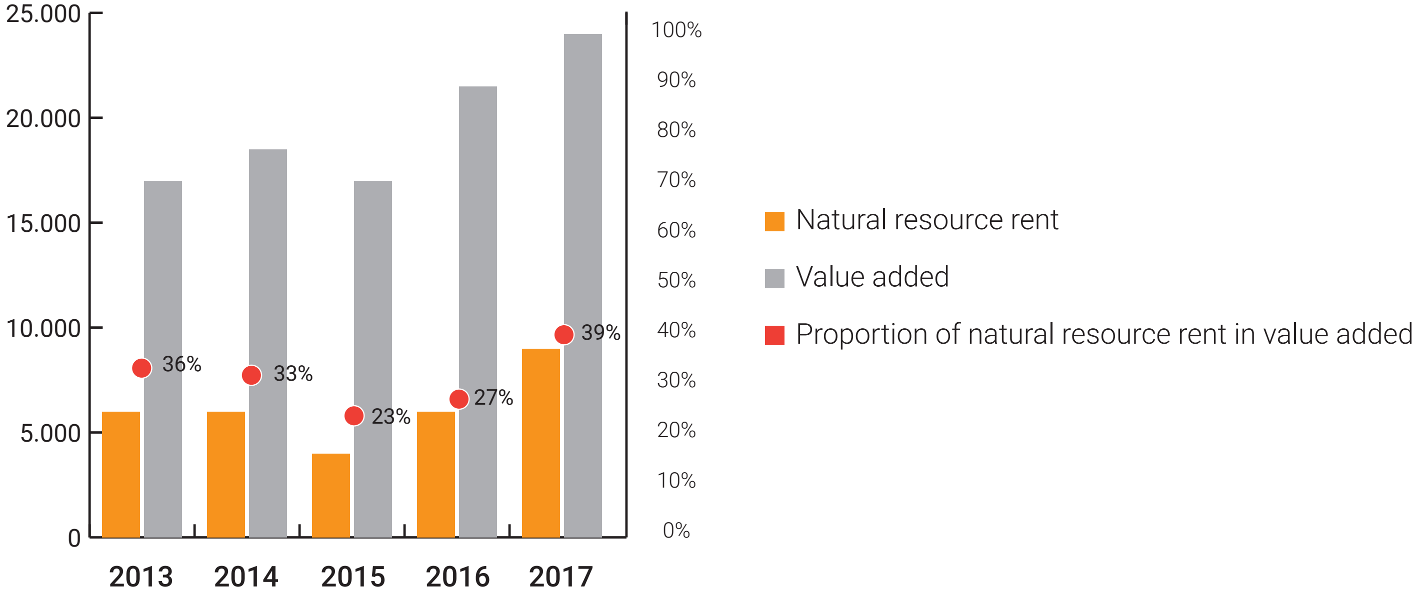
Figure 11: Factors in resource rent estimation in the water supply activity (in 1,000,000 BRL)



Source: IBGE, (2021c)

One of the most relevant results of the study pertains to the proportion of resource rent in the "value added" of the activity. "Value added" refers to the value that the activity adds to the goods and services consumed in its production process, representing the contribution to the GDP. When estimating the value of the ecosystem service of water provisioning used by a given economic activity, the potential "remuneration" of the natural capital production factor is calculated, given the characteristics of the economic activity studied (IBGE, 2021c). That is, given the production structure and cost of the water supply activity, the results of this study show that the income due to the blue water environmental resource is equivalent to approximately 31 per cent of the estimated value added of the sector, on average, between 2013 and 2017 (IBGE, 2021c).

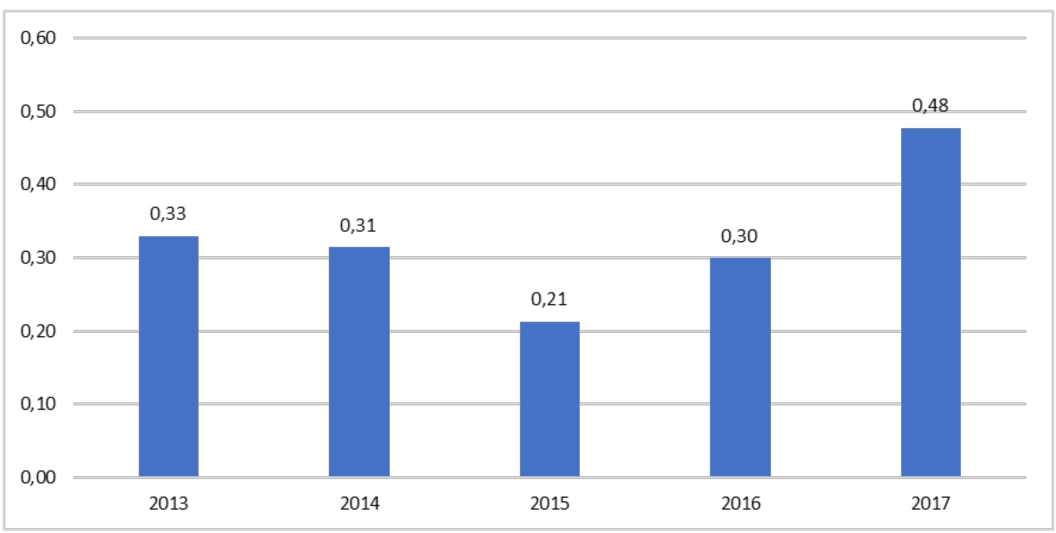
Figure 12: Proportion of resources rent in the added value of the water supply activity (in 1,000,000 BRL)



Source: IBGE, 2021c

Additionally, we highlight the result derived from the combination of estimates made in this study with the physical data on the direct abstraction of water resources by the water supply activity, derived from the second publication.

Figure 13: Unit price for the water supply provisioning service (BRL/hm³/year) of the EEAW in Brazil



Source: IBGE, 2021c

This result shows that each hm³/year of water abstracted by the CNAE 36 division in Brazil has the potential to be remunerated at R$0.33 by this sector (average, between 2013 and 2017), varying over the period analyzed (IBGE, 2021c). Given the numerous hypotheses that were necessary in the absence of more detailed information, it is important to emphasise that the values and results obtained here must be considered experimental. However, this study demonstrates that the valuation of water resources using accounting principles is possible, and more research in this area is desirable to improve the studies (IBGE, 2021c).

4.4. Non-Timber Forest Products, Wild and Cultivated

The flora species of Brazilian biodiversity, distributed across the six biomes of the country, provide a wide variety of environmental and socioeconomic benefits. Among the services generated by flora biodiversity is the provisioning of non-timber forest products (NTFP) collected from the forest, which generates income for various agents, such as families of traditional and indigenous populations, and economic activities, such as specific sectors of processing and trade, associated with the extraction or cultivation of NTFP (IBGE, 2021b).

The income generated by these agents occurs at different stages of the production and trade chain of products. The NTFP provisioning service, which is directly related to the knowledge of traditional and indigenous populations, guarantees both the sustainable exploitation of the standing forest, as well as the wide range of more than fifty products sold in the domestic and international markets (IBGE, 2021b).

Due to their high demand, certain NTFPs collected from the native forest have started to be cultivated in permanent plantation systems, such as rubber, açaí, hearts of pam, among others. However, the production of NTFP through agricultural cultivation, although generating income through systems of greater economic productivity, also requires productive inputs and agricultural areas that depend on favourable ecological factors. In this regard, from the perspective of the provision of ecosystem services, it is extremely important to distinguish NTFP that are collected from the native forest from those that are cultivated (IBGE, 2021b).

The production of NTFP is included in the SNA, registered under Forestry Production - Native Forests (CNAE 2.0 – Class 02.20-9). However, since production is directly dependent on the conservation of each ecosystem, the recovery or degradation of the forest may directly affect the sector (IBGE, 2021b). This analysis is restricted to the perspective of the production NTFP, without taking into account the different economic agents that depend on these ecosystems, that is, the use of NTFPs, whether for processing and transformation, or for trade and final consumption.

This experimental work has applied the SEEA-EA methodology in order to measure, in physical and monetary units, the benefits of NTFP provisioning in biomes. Such experimental statistics contribute to advances in identifying the interrelationship between ecosystems and the benefits of NTFP production (IBGE, 2021b).

4.4.1. Methodology and data sources

The analysis included a list of 12 selected products grouped into six types of purpose of use, specifying the scientific name of each species, and distinguishing where relevant between extracted and cultivated products, namely: wild and cultivated açaí; wild and cultivated yerba-mate; wild and cultivated palm hearts; Brazil nuts; pequi fruit, souari nut; babassu; clotted latex; jaborandi; carnauba powder and wax; piassava. It is important to emphasise that the listed products were selected based on their economic importance (IBGE, 2021b).

In order to analyse the evolution over the period of a decade, the NTFP tables and spatial analysis were carried out for the period between 2006 to 2016, enabling future analyses based on cross-referencing with information from the decennial variables collected in the agricultural censuses. The variables selected from the Vegetal Extraction and Forestry Survey (PEVS, according to its Portuguese acronym) and the Municipal Agricultural Production Survey (PAM according to its Portuguese acronym) used in the analysis are (IBGE, 2021b):

i) Amount extracted (variable investigated and disclosed by PEVS and PAM) - this refers to the total quantity of each product obtained in the municipality during the survey reference year;

ii) Production Value (variable disclosed by PEVS and PAM) – this is the amount extracted multiplied by the average unit price;

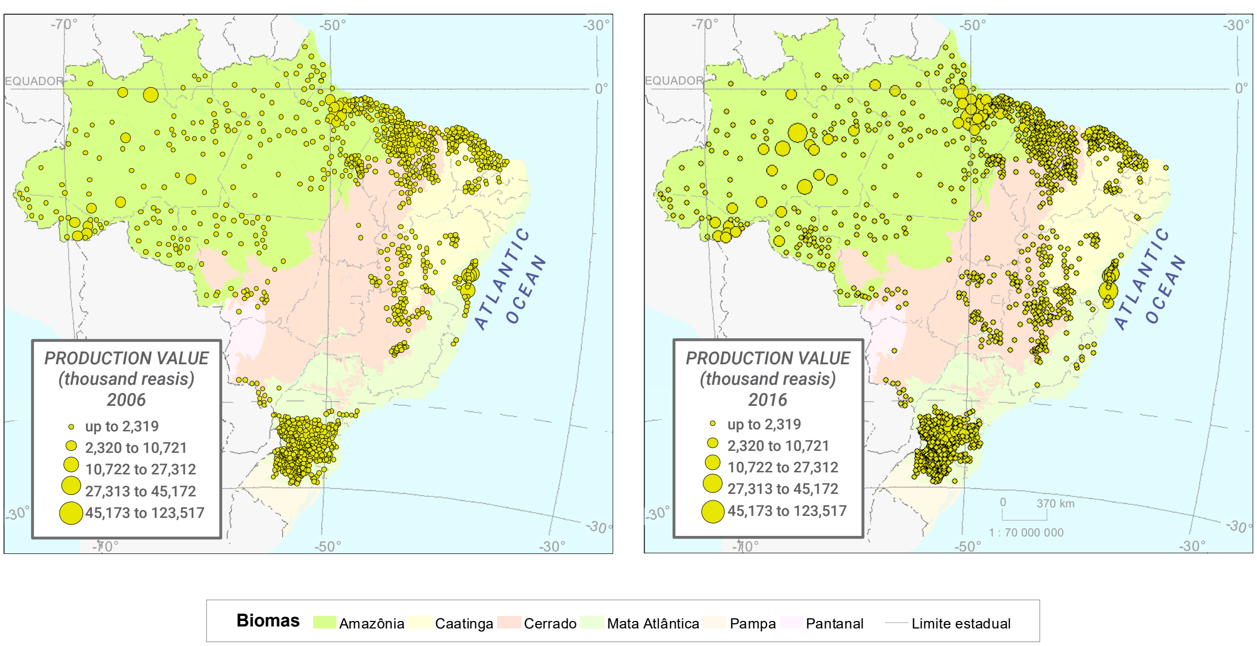
iii) Average unit price (investigated variable, not disclosed by PEVS and PAM, therefore, calculated from PEVS and PAM) - this is the weighted average, by product, of the prices received by producers in the municipality, over the reference year of the survey. For municipalities with production value equal to or less than R$1000 (due to the rounding of values), it was not possible to calculate the average unit price.

To assess the evolution of the quantity and value of each product, from 2006 to 2016, the quantity index (QI) and the price index (PI) for each year were calculated, for base year 2006 as well as the development of this index over the studied period.

The NTFP Provisioning Table presents the production, in quantity and value, of each product, differentiating whether they are extracted or cultivated by each Brazilian biome, namely: Amazon, Caatinga, Cerrado, Atlantic Forest, Pampa, and Pantanal. The allocation of information by municipalities to quantify the physical and monetary flows by biome was carried out by overlaying the municipal delimitation map with the Map of Biomes and Coastal-Marine System of Brazil (IBGE, 2021a). In cases where the municipality had more than one biome in its territory, two criteria were applied to define the biome: i) the first criterion considered the definition of products produced preferentially in each biome; ii) in cases where the municipality does not have a preferential biome, production was attributed to the biome with the largest area in that municipality (IBGE, 2021b).

It is noteworthy that the disaggregation by biomes is in line with the approach taken in the first edition of the ecosystem extent accounts in Brazil (IBGE, 2020a).

Figure 14: Production value of selected wild products (BRL thousand) – 2006 and 2016



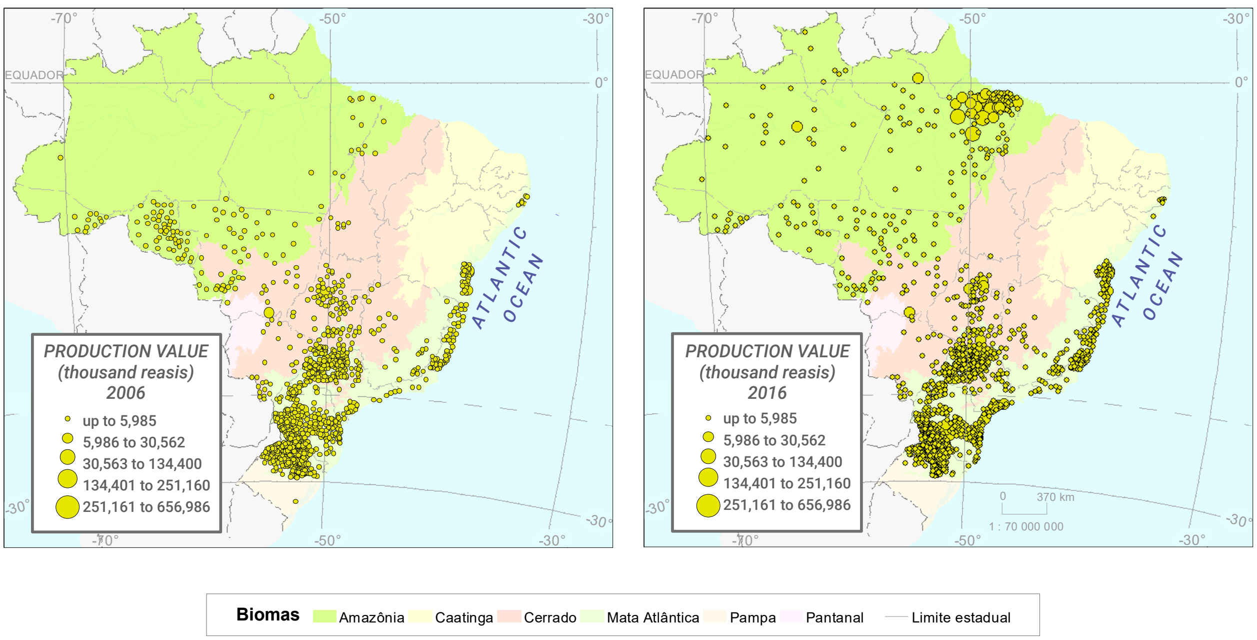
Source: IBGE (2021b)

4.4.2. Results of physical and monetary flows of NTFP provisioning

Figures 14 and 15 show the spatial distribution, by biome, of the total monetary provisioning flows of the twelve selected NTFPs (respectively of wild and cultivated products) for the years 2006 and 2016.

The Physical Supply Tables for 2006 and 2016 indicate the importance of each biome in the production of 12 NTFPs extracted from their ecosystems and four NTFPs cultivated in permanent culture. As shown in Table 18, the majority of NTFPs, specifically açaí, palm hearts, Brazil nut, pequi, babassu, carnauba and jaborandi, are extracted in the Amazon, Cerrado and Caatinga. On the other hand, cultivated NTFPs are concentrated in the Atlantic Forest, except for açaí, rubber and cultivated palm palm which are also found in the Amazon.

Figure 15: Production value of selected cultivated products (BRL thousand) – 2006 and 2016



Source: IBGE (2021b)

Table 18: Physical Supply Table of NTFP (in tons) - 2016

Product	EXTRACTED FROM THE ECOSYSTEM						
	Total per Product	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Food							
Açaí	215,439	215,419	-	20	-	-	-
Yerba mate	352,944	-	-	93	347,780	5,071	-
Palm Hearts	4,278	4,166	-	28	84	-	-
Brazil nuts	34,870	34,870	-	-	-	-	-
Pequi fruit	17,866	4	1,382	16,436	44	-	-
Oilseeds							
Souari nuts	1,466	491	381	567	-	-	27
Babassu almond	61,612	16,481	449	44,682	-	-	-
Rubber							
Clotted latex	1,205	1,205	-	-	-	-	-
Waxes							
Carnauba wax	1,708	-	1,708	-	-	-	-
Carnauba powder	1,129	5	1,123	1	-	-	-
Medicinal							
Jaborandi	229	188	-	41	-	-	-
Fibers							
Piassava	45,661	2,656	17	4	42,984	-	-
Product	**PERMANENT CULTURE**						
	Total per Product	**Amazon**	**Caatinga**	**Cerrado**	**Atlantic Forest**	**Pampa**	**Pantanal**
Food							
Açaí	1,084,667	1,084,039	8	-	620	-	-
Yerba mate	630,206	-	-	1,726	567,005	61,475	-
Palm Hearts	117,460	5,083	-	16,549	95,828	-	-
Brazil nuts	-	-	-	-	-	-	-
Pequi fruit	-	-	-	-	-	-	-
Oilseeds							
Souari nuts	-	-	-	-	-	-	-
Babassu almond	-	-	-	-	-	-	-
Rubber							
Clotted latex	315,880	16,524	-	47,682	250,914	-	760
Waxes							
Carnauba wax	-	-	-	-	-	-	-
Carnauba powder	-	-	-	-	-	-	-
Medicinal							
Jaborandi	-	-	-	-	-	-	-
Fibers							
Piassava	-	-	-	-	-	-	-

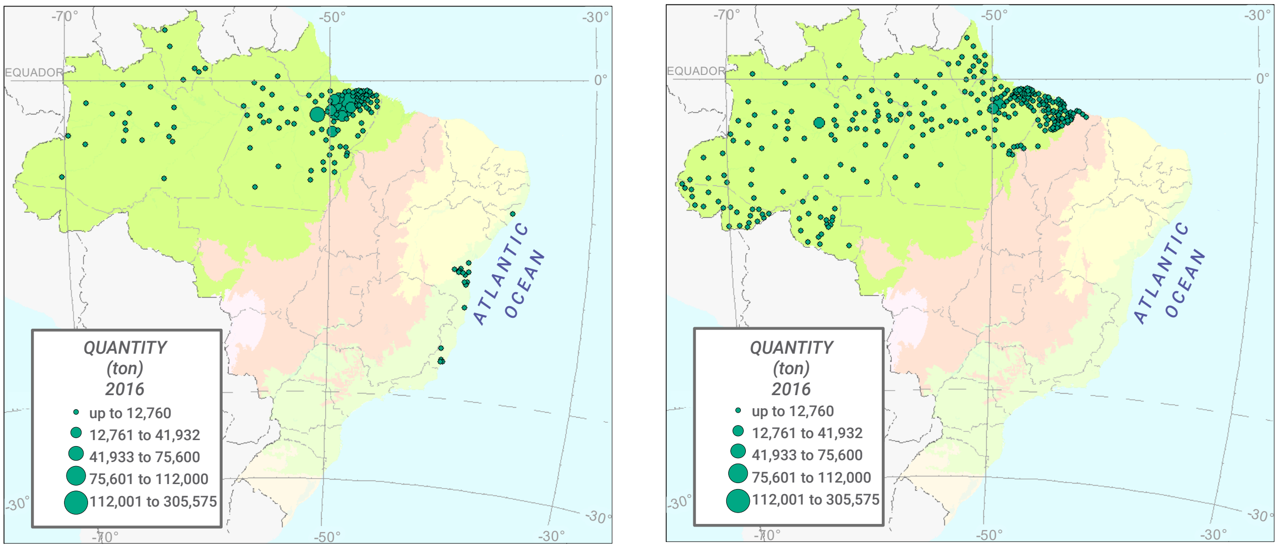
Source: IBGE (2021b)

As an example, Figure 16 shows the spatial distribution across municipalities of the amount of extracted and cultivated açaí, enabling to identify the location of both wild and cultivated açaí production, which is concentrated in the Amazon, but also occasionally present in the Atlantic Forest biome and with a small production in the Caatinga.

Figure 16: Production of wild and cultivated açaí (ton) - 2016

Wild Açaí production

Cultivated Açaí production



Source: IBGE (2021b)

Table 19 presents the percentage changes in the amount of produced NTFPs collected and cultivated between 2006 and 2016. There is a drop in several products in all biomes, except for the Pantanal. The biome that has the largest number of products with a fall is the Cerrado, followed by the Amazon, Caatinga, Atlantic Forest and Pampa.

Table 19: Changes in production of NTFP by biome (%) – 2006 to 2016

Product	EXTRACTED FROM THE ECOSYSTEM						
	Total per Product	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Food							
Açaí	113%	113%	-	33%	-	-	-
Yerba mate	51%	-	-	-61%	56%	-52%	-
Palm Hearts	-34%	-33%	-	-61%	-66%	-	-
Brazil nuts	22%	22%	-	-	-	-	-
Pequi fruit	-	-	-	-	-	-	-
Oilseeds							
Souari nuts	-73%	21%	-87%	-72%	-100%	-	145%
Babassu almond	-47%	-58%	-39%	-42%	-	-	-
Rubber							
Clotted latex	-69%	-69%	-	-	-100%	-	-
Waxes							
Carnauba wax	-46%	-100%	-45%	-100%	-	-	-
Carnauba powder	-51%	-29%	-51%	-67%	-	-	-

Product	Total per Product	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Medicinal							
Jaborandi	1%	9%	-	-25%	-	-	-
Fibers							
Piassava	-44%	-71%	-	-33%	-40%	-	-
Product	**PERMANENT CULTURE**						
	Total per Product	**Amazon**	**Caatinga**	**Cerrado**	**Atlantic Forest**	**Pampa**	**Pantanal**
Food							
Açaí	-	-	-	-	-	-	-
Yerba mate	45%	-	-	-56%	56%	-7%	-
Palm Hearts	60%	20%	-	-32%	114%	-	-
Brazil nuts	-	-	-	-	-	-	-
Pequi fruit	-	-	-	-	-	-	-
Oilseeds							
Souari nuts	-	-	-	-	-	-	-
Babassu almond	-	-	-	-	-	-	-
Rubber							
Clotted latex	79%	27%	-	79%	84%	-	447%
Waxes							
Carnauba wax	-	-	-	-	-	-	-
Carnauba powder	-	-	-	-	-	-	-
Medicinal							
Jaborandi	-	-	-	-	-	-	-
Fibers							
Piassava	-	-	-	-	-	-	-

Source: IBGE (2021b)

A drop in the production of several products can be seen in most biomes (Table 19). In the Amazon, and among the most relevant products that can generate monetary value, there is a marked decrease in the volume of wild palm hearts (-33 per cent), babassu almond (-58 per cent) and clotted latex (-69 per cent). In the Caatinga, there is a drop in the volume of extraction of important products, such as carnauba wax (-45 per cent) and carnauba powder (-51 per cent). In the Cerrado, there is a decrease in the volume of wild babassu almonds (-42 per cent). In the Atlantic Forest there is a decrease in the volume of wild palm hearts (-66 per cent). In the Pampa, there is a drop in the volume of wild yerba-mate (-52 per cent). Out of the products that show a positive development, wild açaí in the Amazon (+113 per cent) and wild yerba-mate in the Atlantic Forest (+56 per cent) stand out.

Regarding the 4 NTFPs in permanent culture, Table 19 above shows that despite the considerable increase in the physical production of some cultivated products, there were also decreases detected in a number of them. In the Cerrado there was a drop in the volume of cultivated yerba-mate (-56 per cent). In the Atlantic Forest there was an increase in the volume of cultivated palm hearts (+114 per cent) and cultivated clotted latex (+84 per cent), while açaí cultivation started in 2014 with a production of 620 tons in 2016. As an example, Figures 17 and 18 below show the changes in the quantity index of the production of souari nut and babassu. It can be seen there was an interruption in production within several municipalities between 2006 and 2016.

Figure 17: Change in the production of wild souari nut 2006-2016

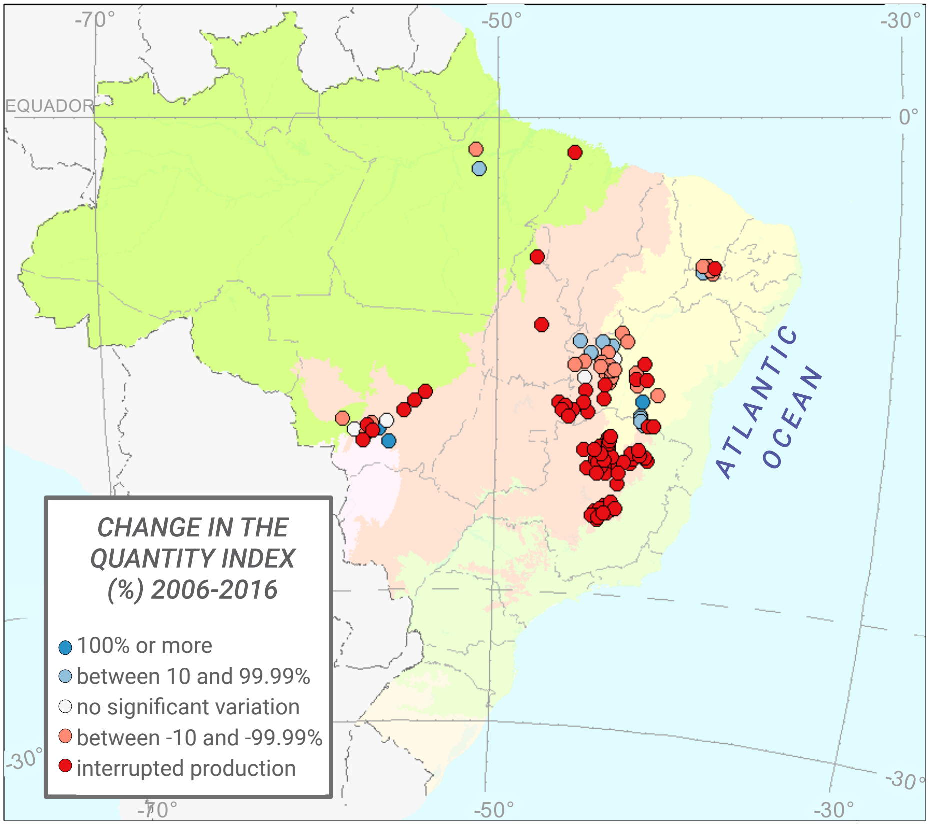
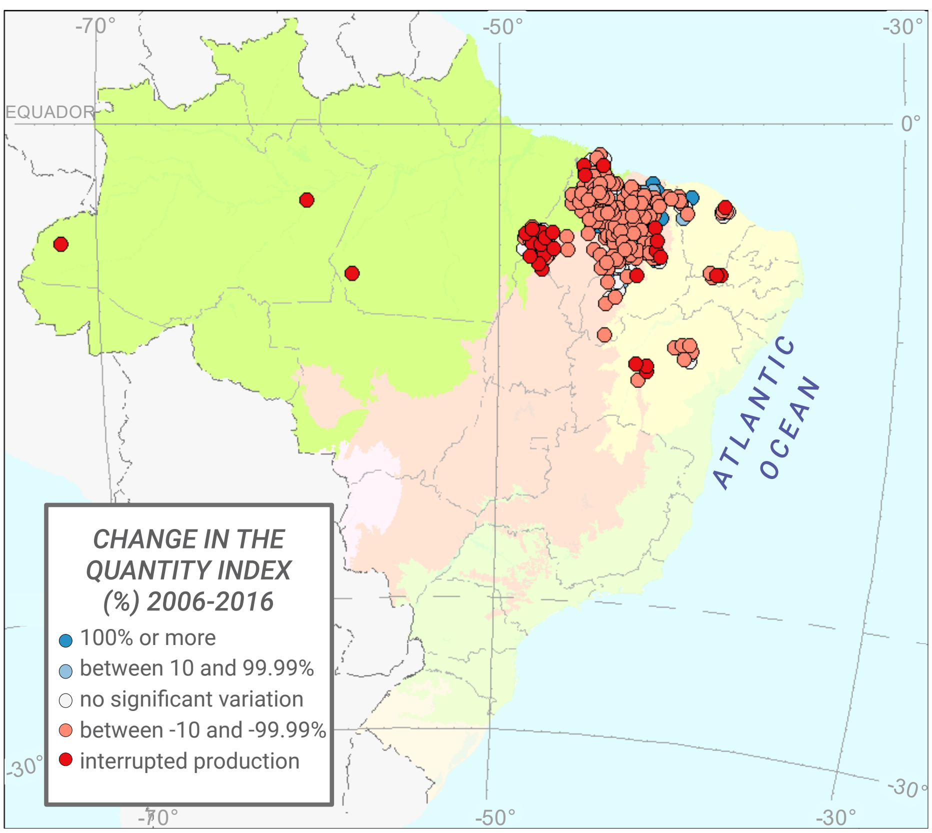


Figure 18: Change in the production of wild babassu 2006-2016



Source: IBGE (2021b)

In monetary terms, Table 20 below shows the market sales of extracted and cultivated NTFPs. In the Table, it can be seen that, in 2016, the production of wild NTFPs amounted to R$1,296 million, and the biome with the highest production value of NTFPs collected was the Amazon, followed by the Atlantic Forest. The production value of cultivated NTFPs was R$3,466 million, with the same predominant biomes.

The extracted NTFPs that generate the highest production value in 2016 is açaí, followed by yerba-mate and Brazil nuts. While the cultivated NTFPs that generate the highest production value are açaí and clotted latex.

Table 20: Monetary Supply Table of NTFP (BRL - thousand) - 2016

Product	EXTRACTED FROM THE ECOSYSTEM						
	Total per Product	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Food							
Açaí	514,222	514,177	-	45	-	-	-
Yerba mate	404,287	-	-	55	398,420	5,812	-
Palm Hearts	16,126	15,536	-	144	446	-	-
Brazil nuts	110,310	110,310	-	-	-	-	-
Pequi fruit	15,406	11	2,361	12,995	39	-	-
Oilseeds							
Souari nuts	4,031	2,150	1,053	796	-	-	32
Babassu almond	95,793	20,570	591	74,632	-	-	-
Rubber							
Clotted latex	4,145	4,145	-	-	-	-	-
Waxes							
Carnauba wax	24,532	-	24,532	-	-	-	-
Carnauba powder	2,411	23	2,382	6	-	-	-
Medicinal							
Jaborandi	922	742	-	180	-	-	-
Fibers							
Piassava	103,869	4,624	156	14	99,075	-	-
TOTAL	**1,296,054**	**672,288**	**31,075**	**88,867**	**497,980**	**5,812**	**32**

Product	Total per Product	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Food							
Açaí	1,989,996	1,988,653	22	-	1,321	-	-
Yerba mate	554,927	-	-	896	519,058	34,973	-
Palm Hearts	248,058	13,791	-	24,748	209,519	-	-
Brazil nuts	-	-	-	-	-	-	-
Pequi fruit	-	-	-	-	-	-	-
Oilseeds							
Souari nuts	-	-	-	-	-	-	-
Babassu almond	-	-	-	-	-	-	-

Rubber							
Clotted latex	673,100	38,285	-	106,494	526,721	-	1,600
Waxes							
Carnauba wax	-	-	-	-	-	-	-
Carnauba powder	-	-	-	-	-	-	-
Medicinal							
Jaborandi	-	-	-	-	-	-	-
Fibers							
Piassava	-	-	-	-	-	-	-
TOTAL	**3,466,081**	**2,040,729**	**22**	**132,138**	**1,256,619**	**34,973**	**1,600**

Source: IBGE (2021b)

Note: Extracted from the ecosystem according to category CNAE02.2-2.0; permanent culture according to category CNAE01.3-2.0

Unlike the variation in quantity, the development in the price index (PI) between 2006 and 2016 demonstrates that the increase in production value generated exhibited by various products is due to the increase in prices, surpassing the drop in volume. Table 21 presents said variations for each product by biome.

Table 21: Change in monetary production value of NTFPs by biome (%) – 2006 to 2016

Product	EXTRACTED FROM THE ECOSYSTEM						
	Total per Product	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Food							
Açaí	398%	398%	-	246%	-	-	-
Yerba mate	365%	-	-	62%	385%	25%	-
Palm Hearts	62%	83%	-	-13%	-65%	-	-
Brazil nuts	152%	152%	-	-	-	-	-
Pequi fruit	-	-	-	-	-	-	-
Oilseeds							
Souari nuts	-18%	221%	-54%	-58%	-100%	-	33%
Babassu almond	-6%	-30%	-15%	3%	-	-	-
Rubber							
Clotted latex	-48%	-48%	-	-	-100%	-	-
Waxes							
Carnauba wax	84%	-100%	84%	-100%	-	-	-
Carnauba powder	68%	77%	69%	-14%	-	-	-
Medicinal							
Jaborandi	64%	115%	-100%	-17%	-	-	-
Fibers							
Piassava	17%	-69%	-	133%	34%	-	-
TOTAL	**180%**	**222%**	**75%**	**19%**	**217%**	**25%**	**33%**

Product	Total per Product	Amazon	Caatinga	Cerrado	Atlantic Forest	Pampa	Pantanal
Food							
Açaí	-	-	-	-	-	-	-
Yerba mate	320%	-	-	111%	406%	20%	-
Palm Hearts	136%	136%	-	-21%	207%	-	-
Brazil nuts	-	-	-	-	-	-	-
Pequi fruit	-	-	-	-	-	-	-
Oilseeds							
Souari nuts	-	-	-	-	-	-	-
Babassu almond	-	-	-	-	-	-	-
Rubber							
Clotted latex	129%	82%	-	105%	139%	-	508%
Waxes							
Carnauba wax	-	-	-	-	-	-	-
Carnauba powder	-	-	-	-	-	-	-
Medicinal							
Jaborandi	-	-	-	-	-	-	-
Fibers							
Piassava	-	-	-	-	-	-	-
TOTAL	**553%**	**93%**	**-**	**58%**	**221%**	**20%**	**508%**

Source: IBGE (2021b)

Note: Extracted from the ecosystem according to category CNAE02.2-2.0; permanent culture according to category CNAE01.3-2.0

Regarding the 12 NTFPs extracted from the ecosystem, Table 21 shows that several products had an increase in production value. In the Amazon, among the products with greater economic relevance, there is an increase in the value of wild açaí (+398 per cent), wild Brazil nut (+152 per cent), but a drop in the value of wild babassu almond (- 30 per cent). In the Caatinga, out of the products with greater economic relevance, there was an increase in the value of wild carnauba wax (+84 per cent), wild carnauba powder (+69 per cent), and a drop in wild pequi almonds (-54 per cent). In the Cerrado, there was a small increase in the production value of wild babassu almonds (+3 per cent), and a decrease in the value of wild pequi almonds (-58 per cent). In the Atlantic Forest there was an increase in the value of wild yerba-mate (+385 per cent). In the Pampa there was an increase in the production value of wild yerba-mate (+25 per cent). In the Pantanal there was an increase in the value of wild pequi almonds (+33 per cent).

Regarding the 4 cultivated NTFPs, table 21 shows an increase in the value of several products. In the Amazon there was an increase in the value of cultivated palm hearts (+136 per cent). In the Cerrado, there was an increase in the value of cultivated yerba-mate (+111 per cent) and cultivated clotted latex (+105 per cent). In the Atlantic Forest there was an increase in the value of cultivated yerba-mate (+406 per cent) and cultivated palm hearts (+207 per cent). In the Pampa there was an increase in the value of cultivated yerba-mate (+20 per cent). In the Pantanal there was an increase in the value of cultivated clotted latex (+508 per cent).

The Amazon, Cerrado and Caatinga biomes are those with the greatest reductions in volume of most wild products. The products with the biggest drops are pequi almonds, followed by clotted latex, carnauba powder and wax, piassava and palm hearts. Although there is a reduction in the volume produced from most wild NTFPs, others stand out with a positive development, namely, açaí and Brazil nuts, especially in the Amazon biome.

Distinct from production of extracted crops, there is an increase in production of cultivated crops, especially for those products experiencing increased demand and economic appreciation. Thus, there was an expansion in the volume of yerba-mate and palm hearts cultivated in the Atlantic Forest biome, and rubber in the Atlantic Forest, Pantanal and Cerrado. However, in the Cerrado, there is a reduction in palm hearts and yerba-mate crops.

4.5. Experimental Valuation of the Ecosystem Provisioning Service of Non-Timber Forest Products

The valuation of the NTFP provisioning service aims to separately estimate the contribution from the ecosystem to the production value of NTFR, recognizing that the use of an ecosystem services may require inputs of energy, labor and/or machinery. A key distinction is usually made between wild and cultivated NTFPs as their production processes are very different, as reflected in the Common International Classification of Ecosystem Services - CICE V5.1, which distinguishes between "Terrestrial plants cultivated for nutrition, materials and energy" and "Wild plants (terrestrial and aquatic) for nutrition, materials and energy" (IBGE, 2021b).

The SEEA – CF also considers the importance of distinguishing "cultivated biological resources" from "other biological resources". Differentiating natural biological resources in relation to cultivated biological resources is necessary because the growth and natural regeneration of the former are not under the direct control, responsibility and management of an institutional unit, which makes it difficult to perform their accounting process (UN, 2012).

According to Schulp et al. (2014), the provisioning of products collected from the forest has a direct relationship with the properties and functions of ecosystems, such as the richness and abundance of species, and the productivity of ecosystems, which, in turn, depend on the management of land cover and use, among other aspects related to natural and socioeconomic factors. Ecosystem productivity generates flows of ecosystem services that are extracted and commercialized, generating well-being for society (IBGE, 2021b).

4.5.1. Methodology and data sources

In the SEEA, returns are defined using the concept of economic income, which is defined as the surplus for the extractor or user of an asset calculated after all normal costs and returns have been considered. The surplus, which is called the "resource rent" in the context of environmental assets, can be considered as the return attributable to the asset itself (UN, 2019). According to the residual value method, the resource rent is estimated by deducting user costs of produced assets from the gross operating surplus after adjustments for specific subsidies and taxes (UN, 2019).

In order to value the NTFP provisioning service supplied by ecosystems, four main databases were used (IBGE, 2021b):

i) Agricultural Census (IBGE)
ii) Vegetal Extraction and Forestry Production Survey - PEVS (IBGE)
iii) Municipal Agricultural Production Survey - PAM (IBGE)
iv) National Accounts data for calculating the indexes and the evolution of expenditures

Considering that the 2006 Agricultural Census is a structural survey that only covers the year 2006 and the fact that the PEVS and PAM consist of annual conjunctural surveys, for the valuation of the provisioning service, data from the 2006 Agricultural Census is used to obtain the value of production and costs of each product, for the base year 2006. PEVS and PAM are then applied in order to derive the evolution of quantity and price in the period from 2006 to 2016 (IBGE, 2021b). For the evolution of the production value and expenditure variables (e.g. intermediate consumption, remuneration, transportation, among others) obtained in the base year of 2006 through the Agricultural Census, the quantity and price indexes were calculated from PAM and PEVS and national accounts variables that are related to components of intermediate consumption and remuneration associated with the "Agriculture, Forestry, and forestry exploitation" activity.

In order to carry out the valuation of NTFP provisioning services, the production value at basic prices was assessed, as well as the costs associated with the collection and cultivation of each NTFP. For this purpose, the proportion of "other taxes and subsidies" of each production activity was obtained by extrapolating national accounts data, and this component was deducted from the production value, thereby obtaining an estimate of the value at basic prices.

Among the assumptions that have been adopted in applying this methodology, it is worth noting that (IBGE, 2021b):

i) For wild NTFPs collected from the ecosystem, it is assumed that the process does not require any type of payment to the government (royalties), nor intermediate consumption in the production process. Costs are restricted to remuneration and transportation.

ii) For cultivated NTFPs cultivated in permanent culture, it is assumed that the cultivation requires certain inputs, such as seeds and seedlings, fertilizers, soil improvers, pesticides, in addition to remuneration and transportation costs.

iii) For both wild and cultivated NTFPs, the "Depreciation of the fixed capital stock" and the "Return on capital" are considered null since the process of collecting products does not require fixed capital and the fixed capital used in cultivation processes is difficult to measure individually and by product. Therefore, in case fixed capital data for cultivated products can be obtained for future valuation studies, the estimate of the provisioning service value may be adjusted, which would result in a lower provisioning service value.

4.5.2. Wild NTFP results

Table 22 presents the value of the provisioning service of a selection of wild NTFPs, by product and by year, and their evolution is depicted in Figure 19 below. Between 2006 and 2016, the products that had the largest increases in the provisioning value were wild açaí, with an increase of 436 per cent, Brazil nuts, with an increase of 345 per cent, followed by yerba-mate and jaborandi, both with an increase of 229 per cent, and carnauba wax with an increase of 152 per cent. Some products experienced a drop in the provision service value, namely, wild rubber, with a drop of 65 per cent, pequi with a drop of 47 per cent, babassu almond with a drop of 19% and palm hearts with a drop of 6 per cent (IBGE, 2021b).

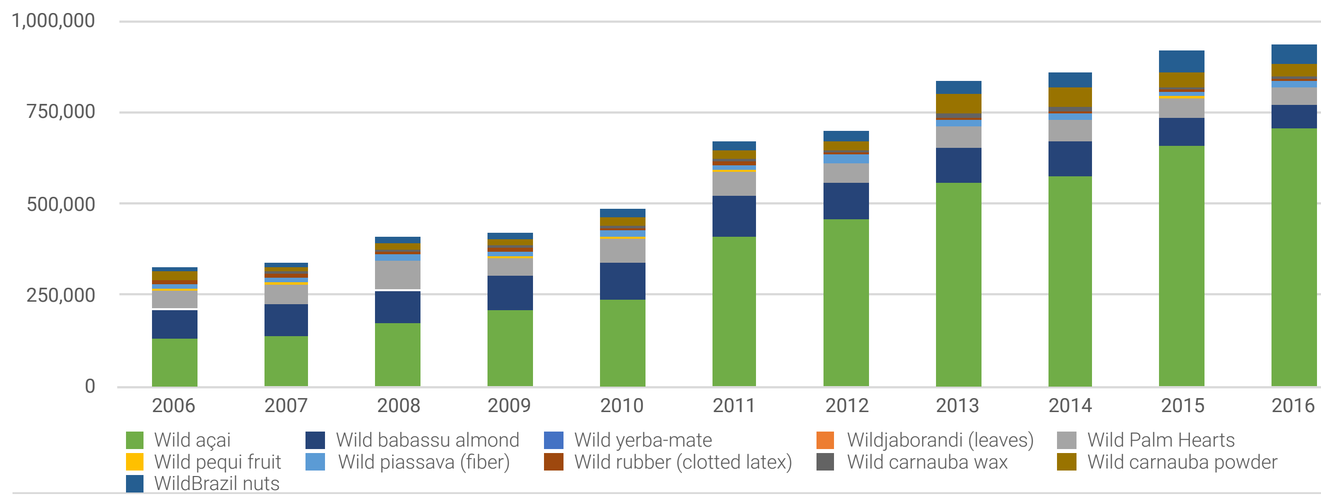
Table 22: Value of NTFP provisioning service for wild resources (thousand R$) – 2006 to 2016

YEAR	Extracted yerba-mate	Extracted jaborandi (leaves)	Extracted Palm Hearts	Extracted pequi fruit	Extracted piassava (fiber)	Extracted açai	Extracted babassu almond	Extracted rubber (clotted latex)	Extracted carnauba wax	Extracted carnauba powder	Extracted Brazil nuts
2006	333	279	50,209	4,933	10,275	131,197	79,990	11,362	2,975	21,531	12,379
2007	314	298	53,480	5,363	13,203	135,867	89,544	10,697	3,323	14,532	11,484
2008	297	592	78,157	3,162	13,709	172,997	90,714	10,839	4,304	19,909	12,573
2009	271	282	43,859	5,173	15,106	209,748	94,852	10,034	3,656	20,652	17,403
2010	275	397	63,733	6,172	16,860	235,391	102,516	10,812	3,895	21,691	22,780
2011	341	529	60,279	7,380	13,463	412,492	111,538	10,530	4,201	24,078	25,566
2012	411	629	54,215	602	21,816	457,026	98,338	7,652	4,808	26,995	29,107
2013	531	1,119	55,452	1,632	17,138	559,982	92,182	8,010	8,381	53,232	36,819
2014	676	1,088	58,230	1,548	19,046	576,022	92,350	5,832	8,804	53,475	43,920
2015	877	986	50,899	3,639	13,288	657,803	77,919	5,362	9,350	42,163	58,496
2016	1,094	917	47,264	2,600	17,230	703,128	65,191	3,935	7,487	34,797	55,043
Variation 2006-2016 (%)	**229%**	**229%**	**-6%**	**-47%**	**68%**	**436%**	**-19%**	**-65%**	**152%**	**62%**	**345%**

Source: IBGE (2021b)

Figure 19 shows the evolution of the provisioning service value of each wild-type NTFPs between 2006 and 2016, enabling the identification of products with the larger participation in the provisioning service and their evolution. Cumulatively in this period, it can be observed that the products with the greatest share in the total provisioning service of wild NTFPs are: açaí (62 per cent), followed by babassu almond (14 per cent) and palm hearts (9 per cent) (IBGE, 2021b).

Figure 19: Value of wild NTFP provisioning service (per thousand R$) – 2006 to 2016



Source: IBGE (2021b)

Over time, açaí and Brazil nuts have increasingly expanded their share in the generation of NTFP provisioning service. In 2006, açaí represented only approximately 40 per cent of the total value of the provisioning service, generating BRL 131.2 million and in 2016 wild fruit started to generate BRL 703.1 million, representing about 75 per cent of the total provisioning service value generated. In 2006, Brazil nuts generated approximately 4 per cent of the value of the total service, BRL 12.4 million. By 2016, it had grown to generate BRL 55 million, equaling about 6 per cent of the total value of the provisioning service (IBGE, 2021b).

On the other hand, babassu almond, carnauba powder and palm hearts have seen reduced shares in the total provisioning service of collected NTFP. In 2006, babassu almond represented approximately 25 per cent generating BRL 80 million, but in 2016 it only represented around 7 per cent, equaling BRL 65.2 million, of the total value of the provisioning service. Palm hearts represented approximately 15 per cent in 2006, with the generation of R$50.2 million, but representing only about 5 per cent, or BRL47.3 million, of the total value of the provisioning service generated in 2016. The reduction in the share of these products, over the analysed decade, is related to the decrease in their production; approximately -47 per cent, -51 per cent and -34 per cent, respectively (IBGE, 2021b).

4.5.3 Cultivated NTFP results

Table 23 shows the value of the provisioning service of a selection of NTFPs grown in permanent culture by product and by year. Between 2006 and 2016, the products that had the greatest growth in the provisioning value were cultivated açaí, with an increase of 2,559%, followed by cultivated yerba-mate with a growth of 462%, and cultivated palm hearts with an increase of 101%. Cultivated rubber showed a drop in the provision service value of 89% (IBGE, 2021b)

In 2006, the provision service of cultivated açaí amounted to R$77.8 million. In 2016, cultivated açaí generated around R$2 billion. In turn, cultivated yerba-mate generated R$ 51.2 million in 2006, and R$ 287.9 million in 2016. The evolution of cultivated rubber and palm heart first shows an increasing trend, and then a decrease. Cultivated palm hearts rose from a value of R$37.8 million in 2006 to R$76 million in 2016, reaching the highest value in 2014 with R$197.5 million. Cultivated rubber in 2006, generated R$ 52.8 million, and in 2016, R$ 5.6 million, reaching its highest value in 2011, with R$ 368.9 million (IBGE, 2021b).

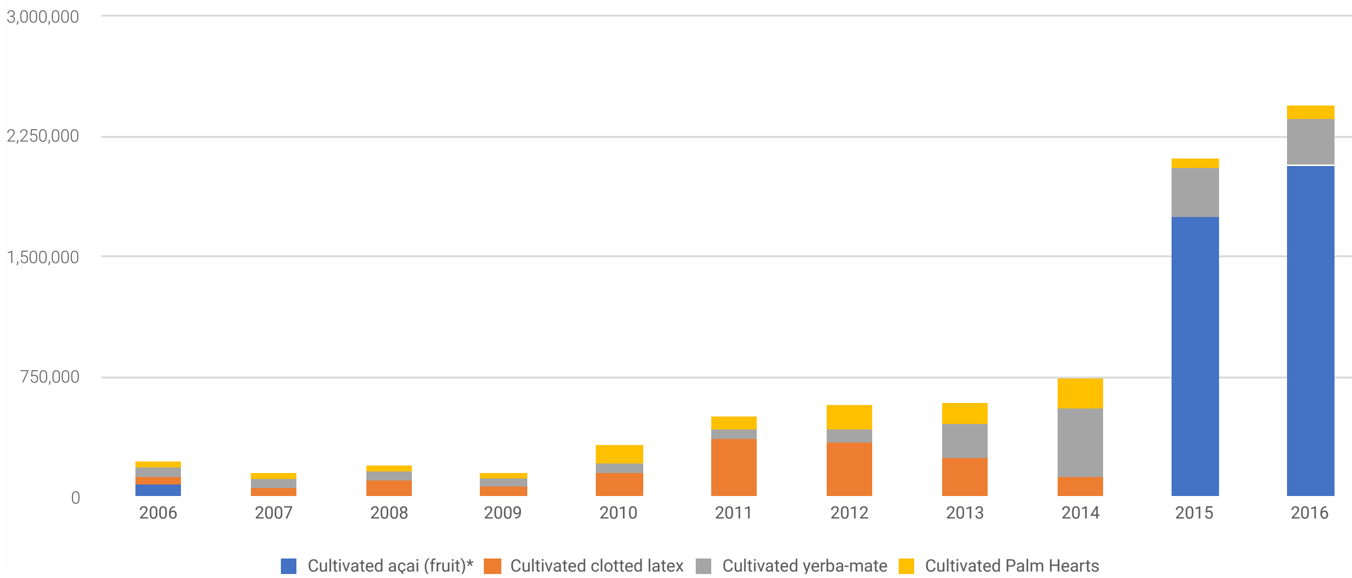
Table 23: Value of cultivated NTFP provisioning service (per thousand R$) – 2006 to 2016

YEAR	Cultivated açai (fruit)*	Cultivated clotted latex	Cultivated yerba-mate	Cultivated Palm Hearts
2006	77,826	52,826	51,225	37,779
2007	0	56,075	57,249	35,278
2008	0	109,254	48,631	47,003
2009	0	65,673	51,242	33,876
2010	0	156,178	55,101	116,941
2011	0	368,864	55,821	75,705
2012	0	337,002	86,043	150,276
2013	0	245,201	213,123	127,720
2014	0	125,095	423,785	197,484
2015	1,741,997	-18,951	313,838	57,440
2016	2,069,576	5,577	287,941	76,058
Variation 2006-2016 (%)	**2559%**	**-89%**	**462%**	**101%**

Source: IBGE (2021b)

Figure 20 shows the development of the provisioning service value of each NTFP grown between 2006 and 2016. Cultivated açaí has values only for the years 2006, 2015 and 2016, due to the absence of a survey of cultivated açaí production by the PAM survey prior to 2015. For the last years analysed, 2015 and 2016, it is noted that the products with the greatest share in the total provisioning service value of cultivated NTFPs are açaí, followed by cultivated yerba-mate and palm hearts.

Figure 20: Value of cultivated NTFP provisioning service (per thousand R$) – 2006 to 2016



Source: IBGE (2021b)

Section 5:
Thematic Accounting – Accounts of Threatened Species in Brazil

5.1. Introduction

The Threatened Species Accounts (IBGE, 2020b) are inserted in the context of the SEEA-EA development and aim to build national and subnational, spatially explicit indicators on the characteristics of the condition of the environment, specifically, the status of conservation of biodiversity, and its relationship with economic agents.

Upon becoming a signatory of the Convention on Biological Diversity (CBD) in 1992 and ratifying it in 1998 (Federal Decree n. 2519, dated March 16,1998), Brazil undertook to fulfill the objectives of this convention, which consist of “the conservation and sustainable use of biodiversity and the fair and equitable sharing of the benefits resulting from its use, as well as those resulting from the associated traditional knowledge”. The first Biodiversity Accounts in Brazil were centered on the Threatened Species Accounts of Brazil’s Ecosystems, for the year 2014.

5.2. Methodology and data sources

The publication of this Account provides a first experimental compilation of the Threatened Species Accounts for Brazil. As a contribution to the SEEA-EA’s international methodological development efforts, an application of the methodology proposed in the manual was carried out, based on global data from the IUCN Red List. This was done for species assessed in South America, with compilation of accounts for the years of 2010, 2014 and 2018, and the calculation of a simplified version of the Red List Index (RLI) in different spatial and ecological profiles, which thereby enabled an analysis of trends in conservation status. In addition, and as a starting point for future editions of the Threatened Species Accounts, a synthesis of the available data from the National Lists of Threatened Species of Brazilian biodiversity is presented, resulting from the assessments of the conservation status of the species of fauna and flora published by ICMBio and CNCFlora/JBRJ, respectively, for the year 2014. The numbers of species (fauna and flora) are presented based on the official data of the national lists, considering the following breakdowns for analysis:

- By threat category;
- By Brazilian biome;
- By realm: terrestrial, freshwater and marine.

5.3. Results

5.3.1. Threatened Species Stock Tables

From cycles of systematic species assessments, it is possible to build a Threatened Species Account, following an accounting model, as proposed by the SEEA-EA. For Brazil, such methodological application with IUCN data resulted in a summary table of the assessment of the conservation status of species over time, allowing the monitoring of stocks and changes in stocks due to movements of species between categories. The information from a Threatened Species Account also allows the monitoring of the assessment process itself, by showing, for example, the number of species assessed for the first time and in subsequent years (IBGE, 2020b).

Table 24 below presents these results: the opening/closing stock can be observed, which is the number of species in each category in each year of the period evaluated, and the aggregations by species groups or by realm allow trends to be followed in these groups of interest. There are also the additions and reductions that are recorded during the accounting period in the lines of additions and reductions in relation to the initial numbers of species by categories. When a species is re-evaluated and changes category, this results in an addition to the new category and a corresponding reduction in the previous category (IBGE, 2020b).

Species that show an improvement or a worsening in conservation status are considered genuine category changes, when conservation measures or threats have actually decreased or increased the extinction risk of species. Species assessed for the first time, re-categorizations resulting from new data or studies, taxonomic revisions, and/or corrections of errors in the previous assessment, are considered in advances in knowledge (IBGE, 2020b).

The number of species reassessed during the accounting period that remain in the same category are so-called stable reassessments. The number of stable reassessments together with the total number of movements provide a measure of the evaluation effort of the species' conservation status assessments. Ideally, all species should be reassessed during each period, but this is not always possible (IBGE, 2020b).

*Table 24: Methodological application of Threatened Species Accounts with global data (2010, 2014 and 2018)**

* Species assessed on the IUCN Red List of Birds, Mammals, Amphibians, Corals and Cycads are considered.
**EX = extinct, EW = extinct in the wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient.

	TERRESTRIAL SPECIES								
	EX	**EW**	**CR**	**EN**	**VU**	**NT**	**LC**	**DD**	**TOTAL**
Opening stock 2010	**3**	**1**	**32**	**69**	**113**	**149**	**2182**	**305**	**2854**
Additions									
Improvement in the conservation status	0	0	0	0	1	0	0	0	1
Worsening in the conservation status	0	0	3	3	21	27	0	0	54
Advances in knowledge	0	0	4	10	13	22	95	7	151
Total Additions	**0**	**0**	**7**	**13**	**35**	**49**	**95**	**7**	**206**
Reductions									
Improvement in the conservation status	0	0	0	-1	0	0	0	0	-1
Worsening in the conservation status	0	0	0	-1	-1	-7	-45	0	-54
Advances in knowledge	0	0	-1	-3	-2	-8	-4	-1	-19
Total reductions	**0**	**0**	**-1**	**-5**	**-3**	**-15**	**-49**	**-1**	**-74**
Stable Reassessments	**0**	**1**	**17**	**33**	**71**	**96**	**1452**	**15**	**1685**
Opening stock 2014	**3**	**1**	**38**	**77**	**145**	**183**	**2228**	**311**	**2986**
Additions									
Improvement in the conservation status	0	0	0	0	0	1	0	0	1
Worsening in the conservation status	0	0	1	1	3	3	0	0	8
Advances in knowledge	1	0	3	16	16	12	207	24	279
Total Additions	**1**	**0**	**4**	**17**	**19**	**16**	**207**	**24**	**288**
Reductions									
Improvement in the conservation status	0	0	0	0	-1	0	0	0	-1
Worsening in the conservation status	0	0	0	-1	-1	-2	-4	0	-8
Advances in knowledge	0	0	-4	-8	-9	-13	-6	-10	-50
Total reductions	**0**	**0**	**-4**	**-9**	**-11**	**-15**	**-10**	**-10**	**-59**
Stable Reassessments	**0**	**1**	**23**	**48**	**101**	**133**	**1753**	**50**	**2109**
Closing stock 2018	**4**	**1**	**38**	**85**	**153**	**184**	**2425**	**325**	**3215**

	FRESHWATER SPECIES								
	EX	EW	CR	EN	VU	NT	LC	DD	TOTAL
Opening stock 2010	**1**	**0**	**4**	**8**	**26**	**31**	**752**	**177**	**999**
Additions									
Improvement in the conservation status	0	0	0	0	0	0	0	0	0
Worsening in the conservation status	0	0	2	0	3	4	0	0	9
Advances in knowledge	0	0	1	1	0	5	19	5	31
Total Additions	**0**	**0**	**3**	**1**	**3**	**9**	**19**	**5**	**40**
Reductions									
Improvement in the conservation status	0	0	0	0	0	0	0	0	0
Worsening in the conservation status	0	0	0	0	0	-4	-5	0	-9
Advances in knowledge	0	0	0	0	0	0	-1	0	-1
Total reductions	**0**	**0**	**0**	**0**	**0**	**-4**	**-6**	**0**	**-10**
Stable Reassessments	**0**	**0**	**2**	**4**	**15**	**12**	**475**	**16**	**524**
Opening stock 2014	**1**	**0**	**7**	**9**	**29**	**36**	**765**	**182**	**1029**
Additions									
Improvement in the conservation status	0	0	0	0	0	0	0	0	0
Worsening in the conservation status	0	0	0	1	1	2	0	0	4
Advances in knowledge	0	0	1	1	1	3	29	0	35
Total Additions	**0**	**0**	**1**	**2**	**2**	**5**	**29**	**0**	**39**
Reductions									
Improvement in the conservation status	0	0	0	0	0	0	0	0	0
Worsening in the conservation status	0	0	0	0	-1	-1	-2	0	-4
Advances in knowledge	0	0	0	-1	0	0	0	-3	-4
Total reductions	**0**	**0**	**0**	**-1**	**-1**	**-1**	**-2**	**-3**	**-8**
Stable Reassessments	**0**	**0**	**3**	**5**	**16**	**19**	**407**	**7**	**457**
Closing stock 2018	**1**	**0**	**8**	**10**	**30**	**40**	**792**	**179**	**1060**

	MARINE SPECIES								
	EX	EW	CR	EN	VU	NT	LC	DD	TOTAL
Opening stock 2010	0	**0**	**1**	**8**	**14**	**10**	**158**	**36**	**227**
Additions									
Improvement in the conservation status	0	0	0	0	0	0	0	0	0
Worsening in the conservation status	0	0	0	1	0	1	0	0	2
Advances in knowledge	0	0	0	0	1	2	10	0	13
Total Additions	**0**	**0**	**0**	**1**	**1**	**3**	**10**	**0**	**15**
Reductions									
Improvement in the conservation status	0	0	0	0	0	0	0	0	0
Worsening in the conservation status	0	0	0	0	-1	0	-1	0	-2
Advances in knowledge	0	0	0	-1	-1	0	0	0	-2
Total reductions	**0**	**0**	**0**	**-1**	**-2**	**0**	**-1**	**0**	**-4**
Stable Reassessments	0	**0**	**1**	**5**	**10**	**9**	**138**	**12**	**175**
Opening stock 2014	0	**0**	**1**	**8**	**13**	**13**	**167**	**36**	**238**
Additions									
Improvement in the conservation status	0	0	0	0	1	0	0	0	1
Worsening in the conservation status	0	0	0	0	0	2	0	0	2
Advances in knowledge	0	0	0	0	1	4	11	0	16
Total Additions	**0**	**0**	**0**	**0**	**2**	**6**	**11**	**0**	**19**
Reductions									
Improvement in the conservation status	0	0	0	-1	0	0	0	0	-1
Worsening in the conservation status	0	0	0	0	0	0	-2	0	-2
Advances in knowledge	0	0	0	0	0	-1	0	-14	-15
Total reductions	**0**	**0**	**0**	**-1**	**0**	**-1**	**-2**	**-14**	**-18**
Stable Reassessments	0	**0**	**1**	**7**	**11**	**11**	**151**	**3**	**184**
Closing stock 2018	**0**	**0**	**1**	**7**	**15**	**18**	**176**	**22**	**239**

	TOTAL								
	EX	EW	CR	EN	VU	NT	LC	DD	TOTAL
Opening stock 2010	3	1	33	72	117	152	2206	347	2931
Additions									
Improvement in the conservation status	0	0	0	0	0	1	0	0	1
Worsening in the conservation status	0	0	3	3	21	27	0	0	54
Advances in knowledge	0	0	4	10	13	18	99	7	151
Total Additions	**0**	**0**	**7**	**13**	**35**	**49**	**95**	**7**	**206**
Reductions									
Improvement in the conservation status	0	0	0	-1	0	0	0	0	-1
Worsening in the conservation status	0	0	0	-1	-1	-7	-45	0	-54
Advances in knowledge	0	0	-1	-3	-2	-8	-4	-1	-19
Total reductions	**0**	**0**	**-1**	**-5**	**-3**	**-15**	**-49**	**-1**	**-74**
Stable Reassessments	0	**1**	**18**	**34**	**72**	**98**	**1462**	**28**	**1713**
Opening stock 2014	3	1	39	80	149	186	2252	353	3063
Additions									
Improvement in the conservation status	0	0	0	0	1	1	0	0	2
Worsening in the conservation status	0	0	1	1	3	3	0	0	8
Advances in knowledge	1	0	3	17	16	16	215	24	292
Total Additions	**1**	**0**	**4**	**18**	**20**	**20**	**217**	**24**	**304**
Reductions									
Improvement in the conservation status	0	0	0	-1	-1	0	2	0	0
Worsening in the conservation status	0	0	0	-1	-1	-2	-4	0	-8
Advances in knowledge	0	0	-4	-8	-9	-13	-6	-25	-65
Total reductions	**0**	**0**	**-4**	**-10**	**-11**	**-15**	**-10**	**-25**	**-75**
Stable Reassessments	0	**1**	**24**	**50**	**103**	**135**	**1761**	**53**	**2127**
Closing stock 2018	**4**	**1**	**39**	**88**	**158**	**191**	**2459**	**352**	**3292**

Source: IBGE (2020b)

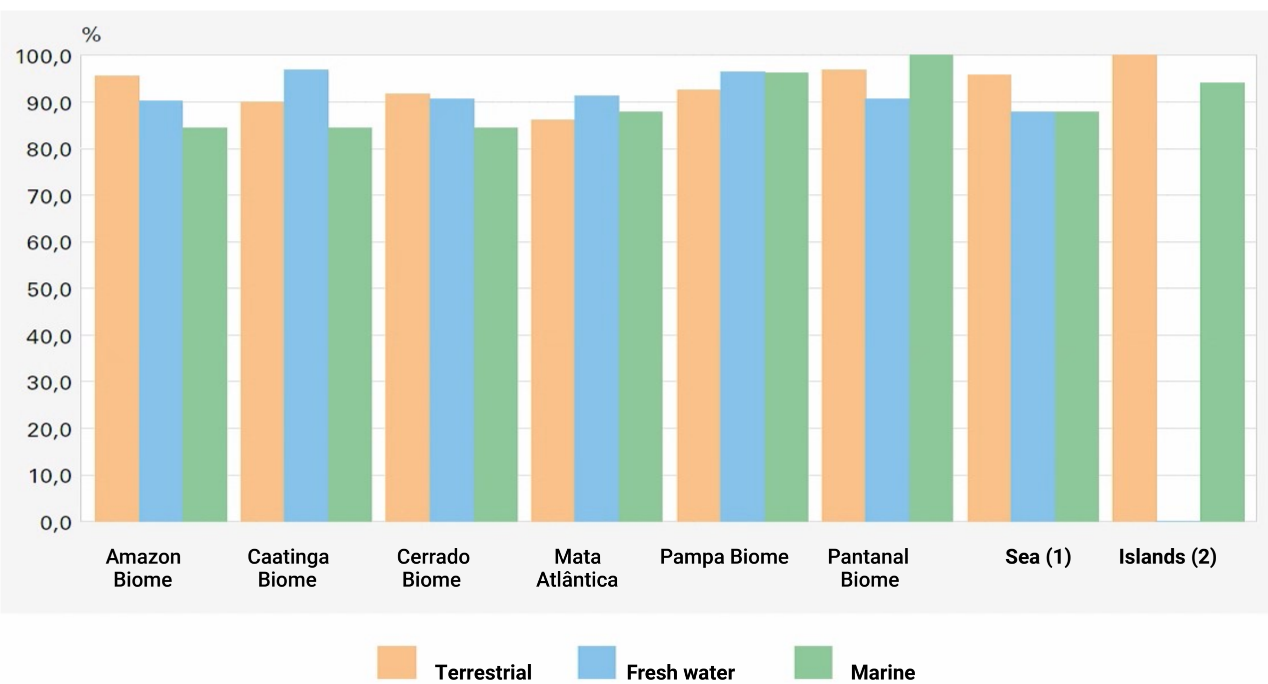
5.3.2. Analysis of the evolution of the Red List Index

The indicator of the number of threatened species, incorporates the effects of differences in species richness throughout the evaluated region, so that areas with higher total species richness may have higher values of threatened species (IBGE, 2020b). For comparisons between different realms or between trends of different species groups, which differ in total richness and aggregate indicators, a simplified version of the RLI is adopted to contribute to the analysis. The use of such indicators enables to distinguish situations where the proportion of threatened species is either due to the presence of species that are actually more vulnerable (for example, specialist species with restricted distributions) or is due to the total number of species present in each region (IBGE, 2020b).

Figure 21 shows the 2018 RLI comparison of terrestrial, freshwater and marine species for each Brazilian biome, for the marine portion of the Coastal-Marine System and for the territorial sea of the Saint Peter and Saint Paul Archipelago and of the Trindade and Martim Vaz Islands. This figure clearly displays the fact that the Atlantic Forest Biome has the lowest average index for terrestrial species (86.22 per cent). The marine portion of the Coastal-Marine System has the lowest average index for freshwater species (84.11 per cent), possibly due to the presence of aquatic birds that occur in both freshwater and marine environments (IBGE, 2020b). For marine species, the lowest average rates are observed in the Cerrado, Caatinga and Amazon Biomes (84.37 per cent, 84.40 per cent and 84.40 per cent, respectively) (IBGE, 2020b).

Following these three biomes, the lowest RLI values for marine species are observed in the Atlantic Forest Biome (87.78 per cent) and the marine portion of the Coastal-Marine System (87.80 per cent). The highest average indexes, which indicate a better conservation status by biome, are registered for the terrestrial and marine species of the Trindade and Martim Vaz Islands and the Pantanal Biome (100 per cent for both) and for the freshwater species of the Caatinga Biome (96.85 per cent) (IBGE, 2020b).

Figure 21: Red List Index (RLI) by realm, according to biome – 2018



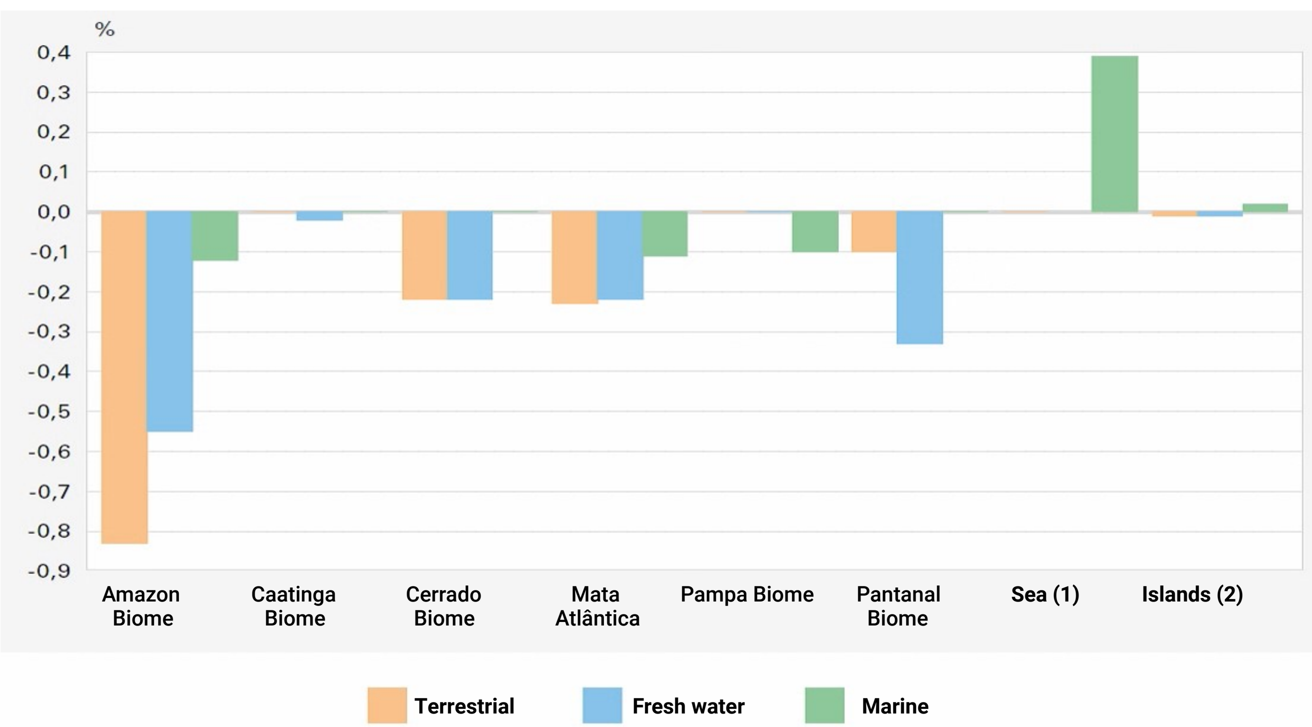
Source: IBGE (2020b)

Figure 22 shows the percentage variation of the RLI between 2010 and 2018 for terrestrial, freshwater and marine species in each biome (IBGE, 2020b). Confirming what was already evident in the previous analyses, it is observed that the species of the Atlantic Forest Biome suffered an increase in the risk of extinction across all realms, represented by the following RLI reductions: 0.23 per cent for terrestrial species; 0.22 per cent for freshwater species; and 0.11 per cent for marine species. Such evolution indicates that there was an increase in the degree of threat and therefore, the species' risk of extinction in the biome, across the three types of realms (IBGE, 2020b).

There was an RLI reduction in the Cerrado Biome of 0.22 per cent for terrestrial species and 0.22 per cent for freshwater species. Such evolution indicates that there was an increase in the species' risk of extinction in the biome, in both freshwater and terrestrial realms. The marine environment remained stable (IBGE, 2020b). The RLI for the Amazon Biome worsened for terrestrial, freshwater and marine species. It was shown that the species in all these environments experienced an increase in the risk of extinction, represented by the following RLI reductions: 0.83 per cent for terrestrial species; 0.55 per cent for freshwater species; and 0.12 per cent for marine species. In the Pantanal Biome, the main variation of the RLI was observed in the freshwater realm, with a reduction of 0.33 per cent. While the terrestrial and freshwater realms of the Pampa Biome remained stable, the marine realm showed a reduction of 0.10 per cent (IBGE, 2020b).

The Caatinga Biome recorded the lowest RLI variation among the others, with a small reduction in freshwater species (-0.02 per cent) and stable values in the other realms. The marine species of the oceanic islands and the Coastal-Marine System were the only groups to show an improvement in RLI values (0.39 per cent and 0.02 per cent, respectively) (IBGE, 2020b).

Figure 22: Percentage change of the Red List Index (RLI) between 2010 and 2018, by realms, according to biomes



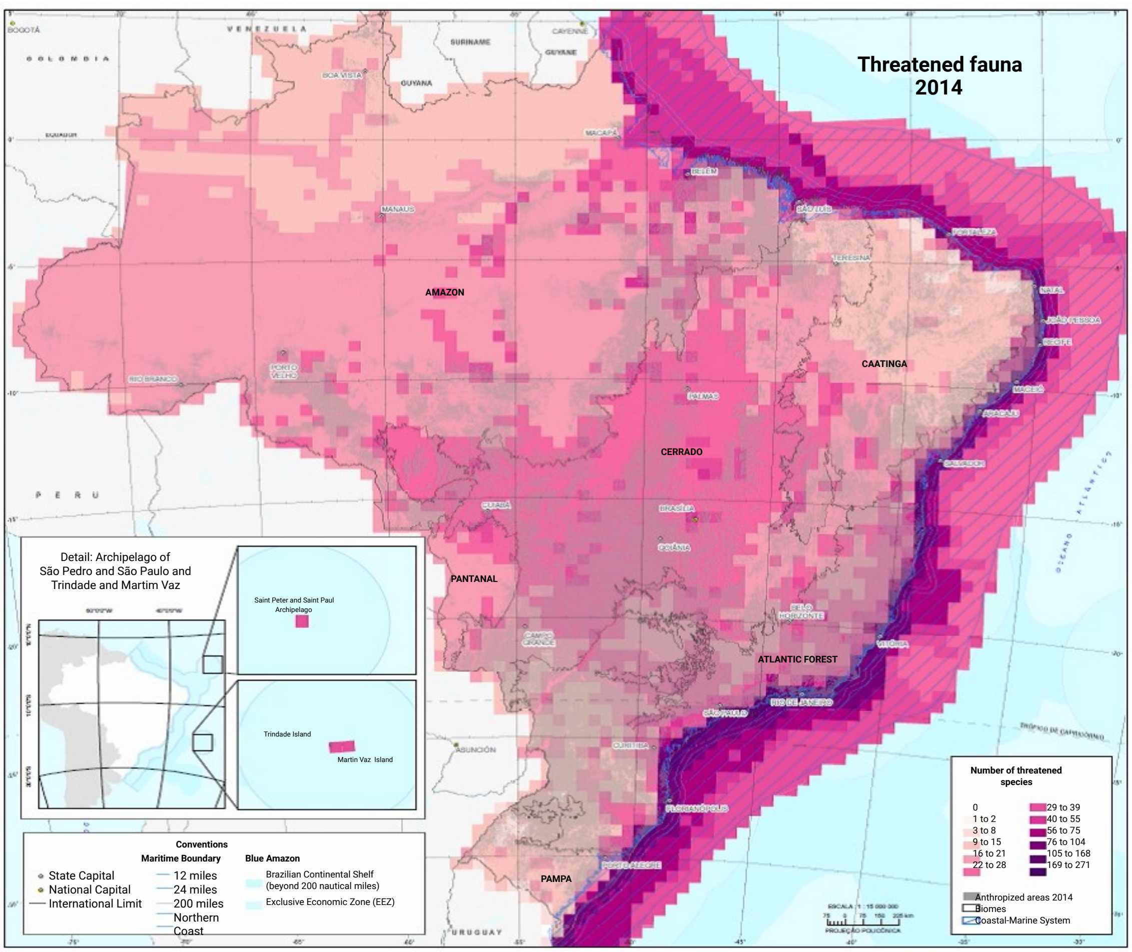
Source: IBGE, 2020b

5.3.3. National assessment: Threatened Species by realm and biome

The national extinction risk assessments for species of Flora (CNCFlora, 2013) and Fauna (ICMBio, 2018) follow the criteria for classification of degree of extinction risk defined by the IUCN and have resulted in the publication of the Official National Lists of Threatened Species (MMA Ordinance 443, 444 and 445 of 2014). Currently, a total of 49,168 plant species are recognized in Brazil (Flora do Brasil 2020) and 117,096 animal species, with estimates that the number of animal species exceeds 137 thousand (ICMBio/MMA, 2018). Of that total, CNCFlora/JBRJ assessed 4,617 species of flora until 2014 and ICMBio/MMA assessed 12,262 species of fauna.

Based on these national assessments, maps were drawn up showing the distribution of threatened species of fauna and flora in the Brazilian territory. Figure 23 presents data for fauna where it is possible to observe the places with the highest number of threatened species, as well as the distribution of anthropized areas, according to data from the ecosystem extent accounts (IBGE, 2020a). This type of analysis is relevant to public policy because the preservation of threatened species in areas with a high degree of anthropism, for example, depends on restoration initiatives and increased connectivity. On the other hand, places with a great richness of threatened species in broad natural areas are good candidates for the implementation of preventive measures, such as the creation of conservation units or stronger investments in existing units.

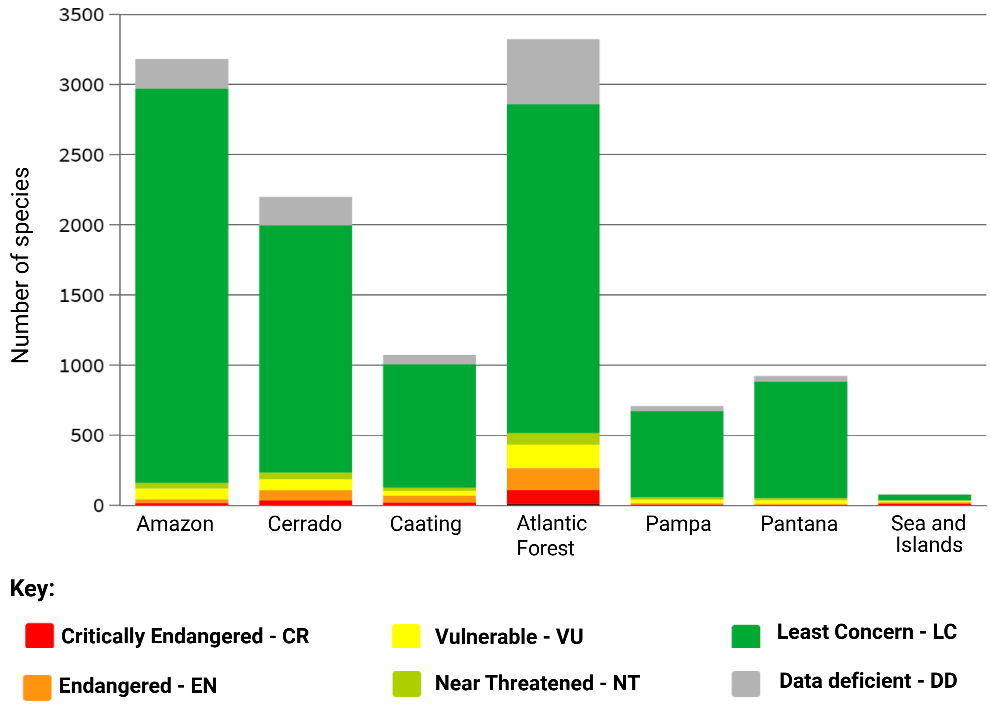
Figure 23: Distribution of threatened fauna species in the territory - 2014



Source: IBGE (2020b)

Regarding the fauna in the terrestrial realm, as shown in Figure 24 below, the largest proportion of threatened species is found in the sea and on oceanic Islands, totaling 30 threatened species (38.46 per cent of the total terrestrial species in the Sea and islands) and in the Forest Atlantic, totaling 426 threatened species (12.82 per cent of the total terrestrial species in the Atlantic Forest). Both the islands and the Atlantic Forest Biome are characterized by many species with restricted distributions, which makes these regions of special interest for preservation. In addition to the data visible in Figure 24, there are six species in the EX category in the Atlantic Forest, two in the Pampa (such as the Great Red-breasted bird (*Sturnella defilippii*), and one in the Pantanal. There is also one species in the EW category in the Atlantic Forest - the Mutum-do-Nordeste (*Pauxi mitu*) (IBGE, 2020b).

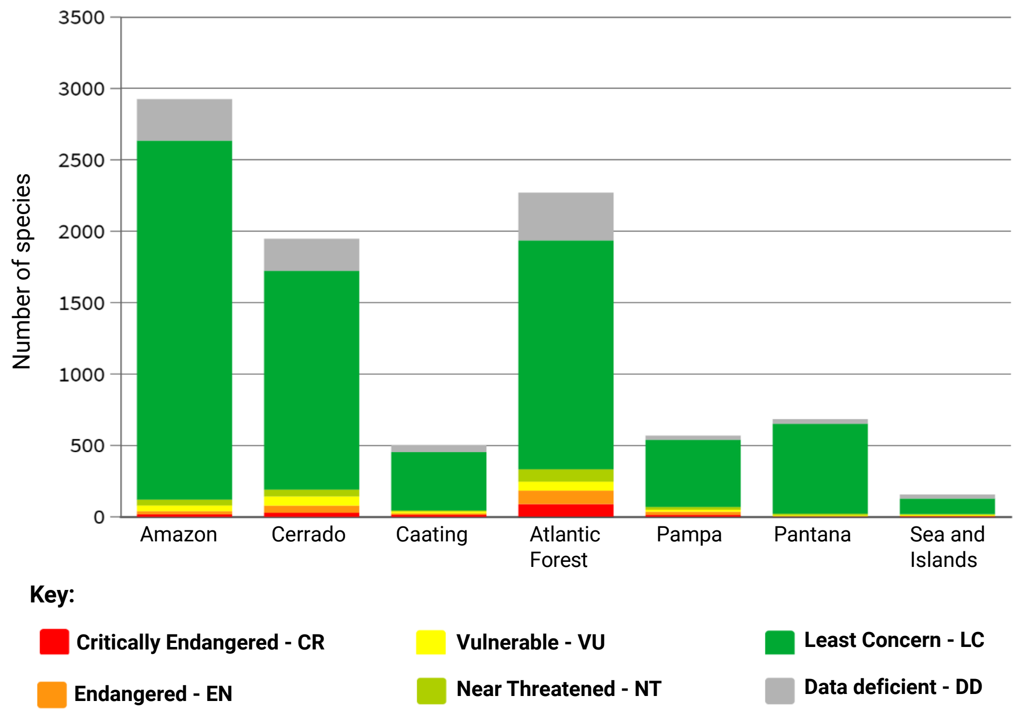
Figure 24: Conservation status of terrestrial fauna by biome (2014)



Source: IBGE (2020b).
The categories EX and EW were omitted from the figures because their numbers are small.

The preservation status of fauna in the freshwater realm, represented in Figure 25, has a pattern similar to that observed in the terrestrial realm, with slightly smaller proportions of threatened species. However, in this realm, high proportions of species classified as "data deficient" are observed for most regions, highlighting the need for better information collection for groups such as continental fish and freshwater invertebrates. In addition to the data visible in the graph, there are two species of freshwater fauna in the EX category: the fimbriae tree frog (*Phrynomedusa fimbriata*) which occurs in the Atlantic Forest and the eskimo bird (*Numenius borealis*) which occurs in the Atlantic Forest, Pampa and Pantanal (IBGE, 2020b).

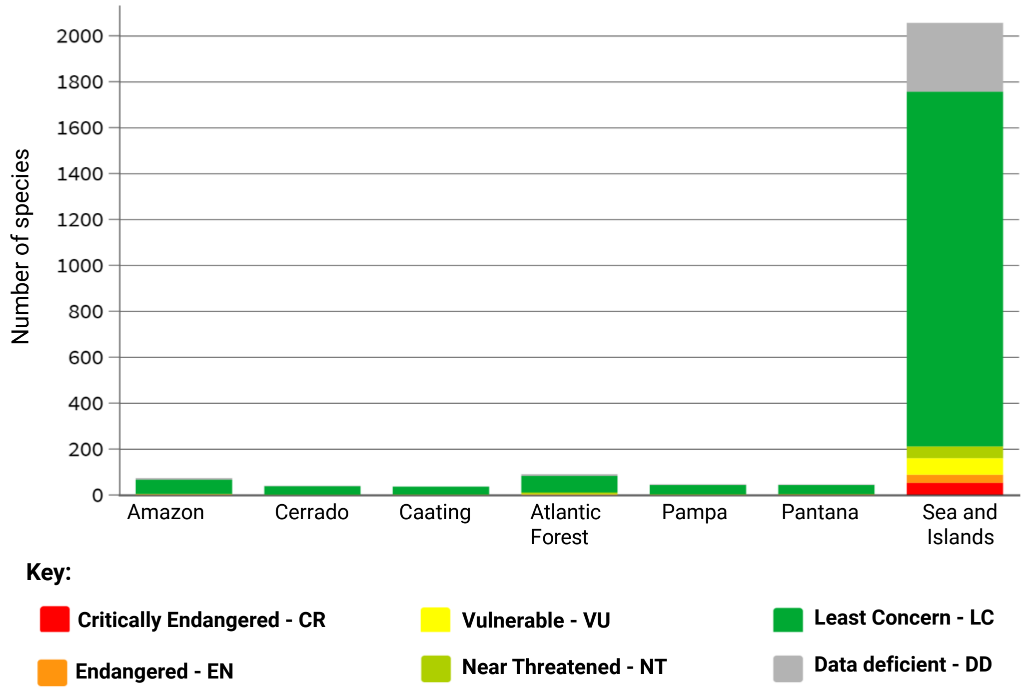
Figure 25: Conservation status of freshwater fauna by biome (2014)



Source: IBGE (2020b)

The evaluated fauna in the marine realm, shown in Figure 26, are mainly located in the sea and on oceanic islands (15 species) and in the Atlantic Forest Biome (91 species). In addition to completely aquatic groups, such as fish and several groups of marine invertebrates, coastal species such as seabirds are included here, many of which have a wide distribution and also occur in continental water environments. In addition to the data visible in the graph, there are two species in the EX category in the sea and islands - the *Carcharhinus isodon* and *Schroederichthys bivius* sharks (IBGE, 2020b).

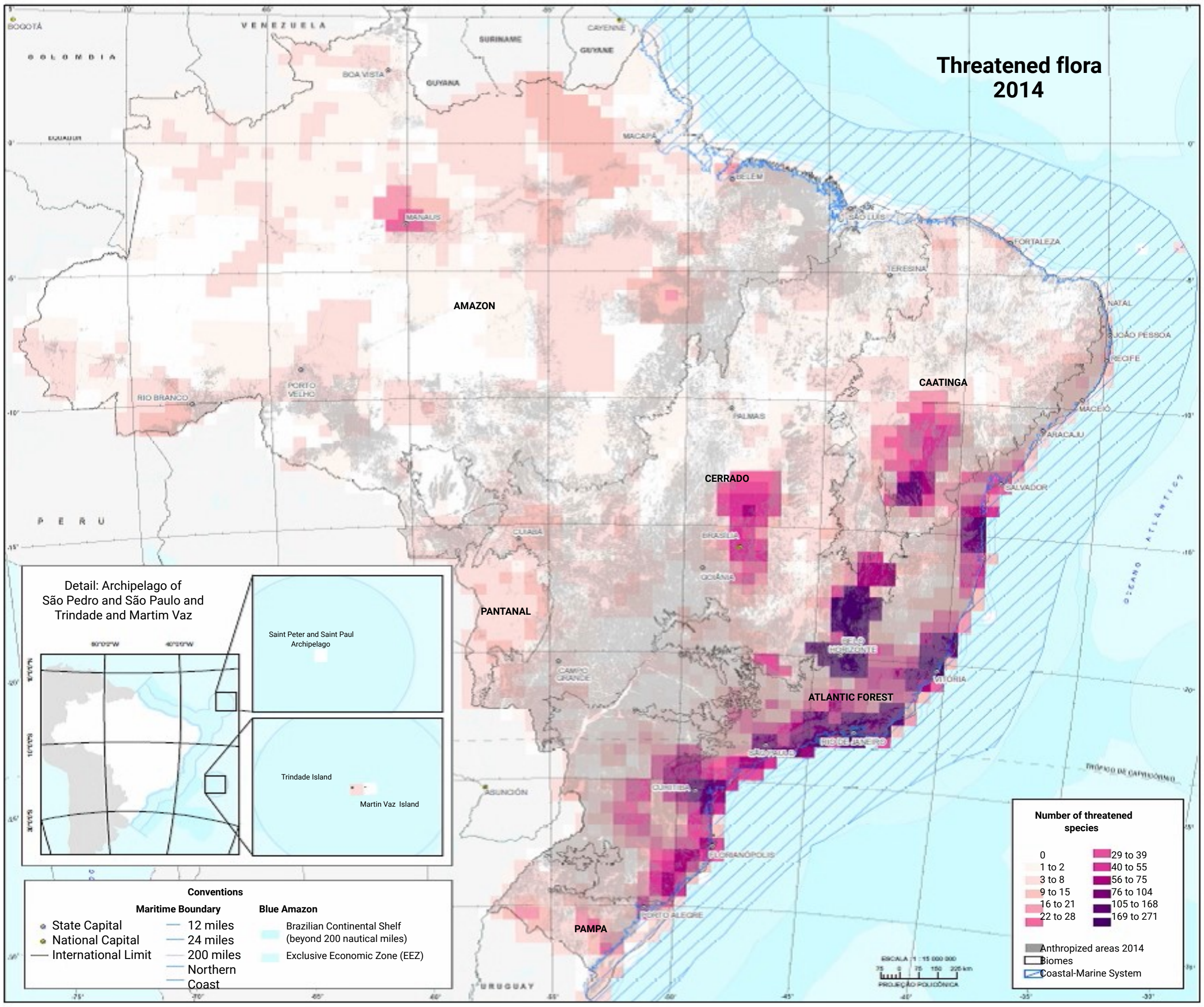
Figure 26: Conservation status of marine fauna by biome (2014)



Source: IBGE (2020b)

Regarding flora, Figure 27 shows the distribution of endangered flora in the Brazilian territory. Figure 28 shows the distribution of the number of terrestrial flora species, by risk of extinction categories, in Brazilian biomes. As observed in relation to fauna, there is a large number and a large proportion of threatened species of terrestrial flora in the Atlantic Forest Biome. For terrestrial flora, the biomes with the highest numbers of species evaluated are Atlantic Forest (3,282 species), Cerrado (1,921 species) and Amazon (714 species) (IBGE, 2020b).

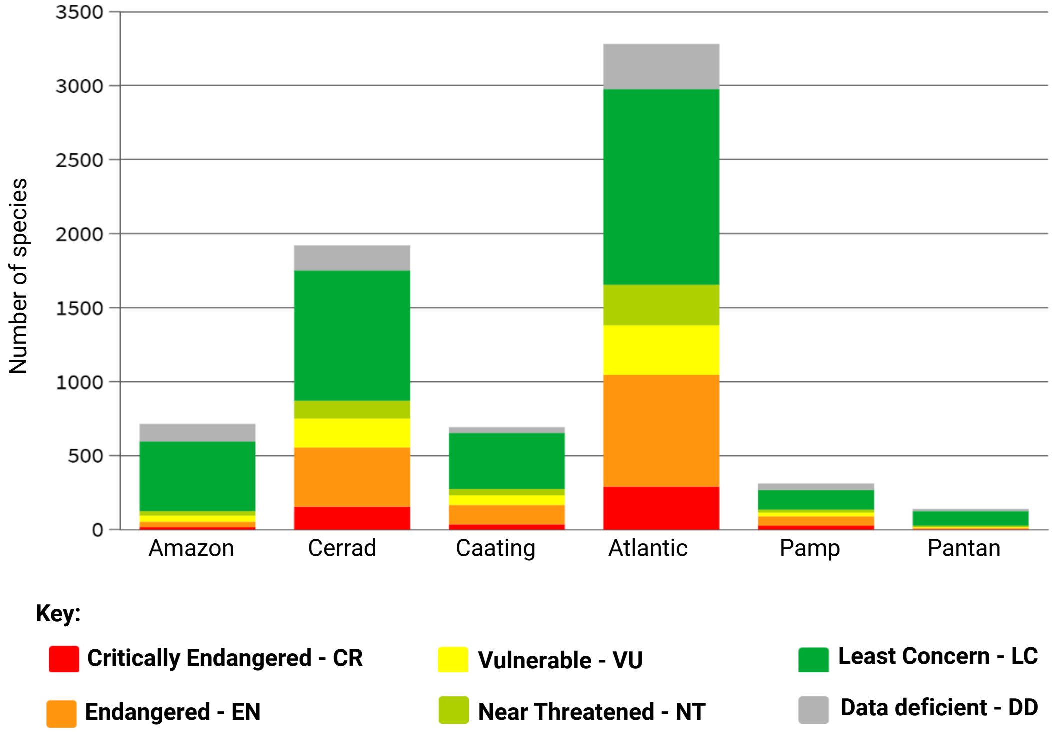
Figure 27 - Distribution of threatened flora species in the territory - 2014



Source: IBGE (2020b)

With regard to the proportion of threatened species in relation to the total number of species evaluated in each biome, the Atlantic Forest Biome stands out, with 1,380 threatened species (42.05 per cent); followed by the Cerrado, with 750 threatened species (39.04 per cent); Pampa, with 114 threatened species (36.66 per cent); Caatinga, with 231 threatened species (33.38 per cent); and the Amazon, with 94 threatened species (13.17 per cent). The Amazon biome is the one that shows the highest proportion of species in the DD category in relation to the total number of species evaluated (16.67 per cent) (IBGE, 2020b).

Figure 28: Conservation status of terrestrial fauna by biome (2014)

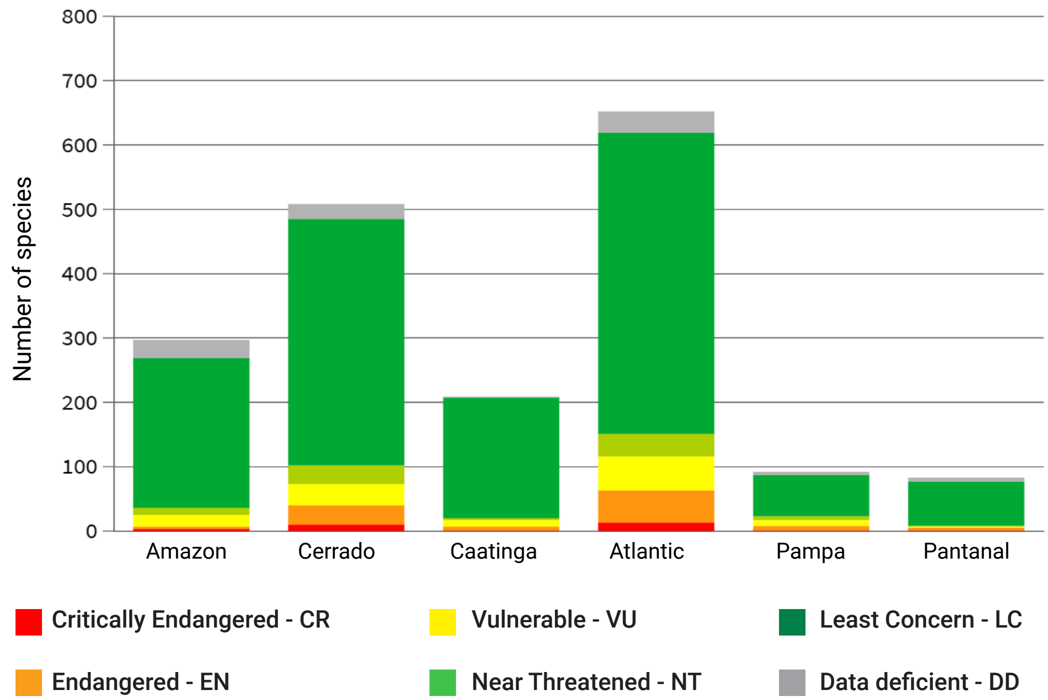


Source: IBGE (2020b)

Figure 29 shows the distribution of the number of freshwater flora species in Brazilian biomes, by risk of extinction categories. Only aquatic species and those from riverside or seasonally flooded environments are included among those associated with freshwater environments. The total number of species assessed for freshwater flora is lower compared to terrestrial flora. The biomes with the highest numbers of species evaluated are Atlantic Forest (652 species), Cerrado (508 species) and Amazon (297 species) (IBGE, 2020b).

The Pampa Biome stands out in this environment, which, despite a relatively low number of freshwater species evaluated (93 species), presents 18 of them as threatened (19.35 per cent), which makes it the largest proportion of threatened species. It is followed by the Atlantic Forest biome, which, as previously said, has the largest number of species evaluated, of which 116 are threatened, and the second largest proportion of threatened species (17.79 per cent) (IBGE, 2020b).

Figure 29: Conservation status of freshwater fauna by biome (2014)

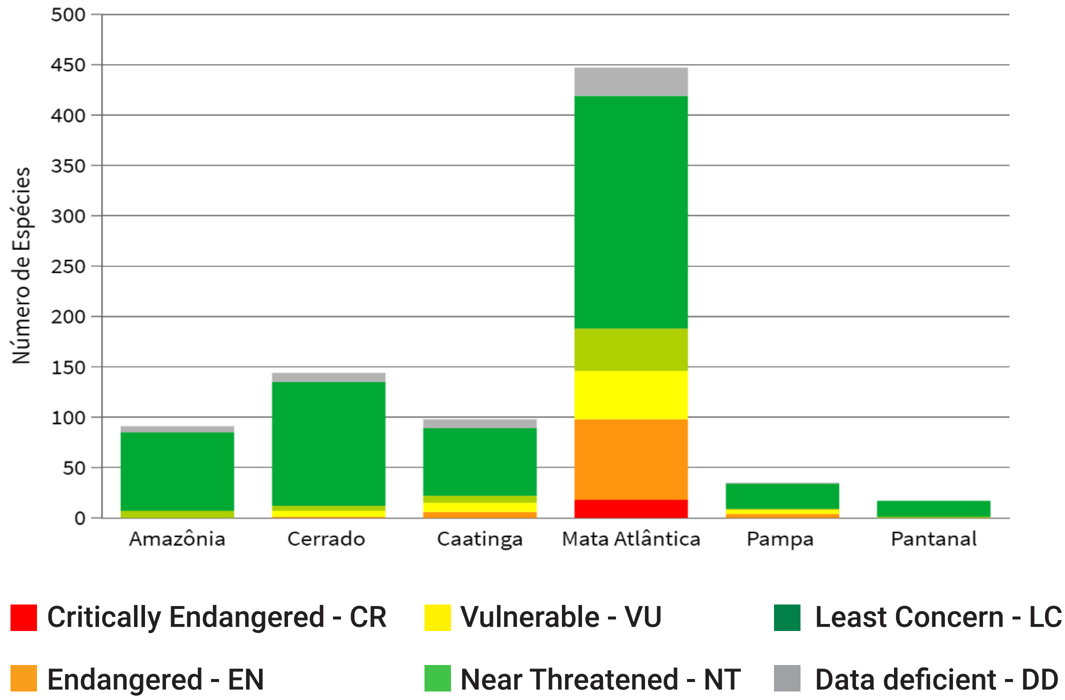


Source: IBGE (2020b)

Figure 30 shows the distribution of the number of marine flora species, by risk of extinction categories, in Brazilian biomes. Vegetation associated with the marine environment, such as mangroves and sandbanks, often have a particular flora, adapted to both salinity and high incidence of sun and strong winds. Because it comprises the largest proportion of these environments in Brazil, the Atlantic Forest Biome is home to most species of flora associated with marine realms (IBGE, 2020b).

The biomes with the highest numbers of species evaluated are Atlantic Forest (447 species), Cerrado (144 species) and Caatinga (98 species). Of the total species assessed in the Atlantic Forest Biome, 146 are threatened (32.66 per cent). The Pampa Biome, although it has a small number of species evaluated (35 species), of which 8 are threatened, also stands out as it has the second highest proportion of threatened species (22.86 per cent) (IBGE, 2020b).

Figure 30: Conservation status of marine fauna by biome (2014)



Source: IBGE (2020b)

It is important to note that, for both fauna and flora, some points of higher concentration of threatened species coincide with regions where the sampling effort is greater, such as areas close to major urban centres, where most research institutions are located, as well as access roads, such as navigable highways or rivers. This pattern of geographic bias in biodiversity information is well described in the literature and reflects the need to make more efforts in the production of primary information, which will serve as a basis for better ecosystem management (IBGE, 2020b).

Section 6: Individual Environmental Assets and Resource Accounts

6.1 Introduction

This section presents the results of the NCAVES Project related to the development of the second edition of the Environmental-Economic Accounting for Water - EEAW.

6.2 Environmental-Economic Accounting for Water 2017-2013

The second edition referring to the Environmental Economic Accounts for Water in Brazil - CEEW (IBGE, 2020f) aimed to continue the compilation and dissemination of information regarding the balance between water availability and water demand in the economy. The development of the EEAW is the result of an effort to increase the knowledge about the use of water in Brazil jointly undertaken by technicians from the National Water Agency (ANA) and the Brazilian Institute of Geography and Statistics (IBGE).

Providing water for human processes is an ecosystem service. The water accounts, through the Supply and Use Tables, inform about the abstraction of water from by economic activities, thereby identifying the use of this ecosystem service.

6.2.1. Methodology and database

For the construction of the EEAW, the methodology of the SEEA for Water Accounts (SEEA-W) was adopted. The second publication of the CEAA presents national and five major region results (North - N, Northeast - NE, Southeast - SE, South - S, and Midwest - CO) for the period 2013 to 2017, with physical and monetary indicators on the supply and demand of water in Brazil, by economic activities and by households. As they constitute an initial set of regional data subject to improvement and expansion, these results can be revised later.

In the process of building the second publication of the EEAW, the following advances were made: (i) revision and production of new estimates; (ii) construction of EEAW, for the five major regions; and (iii) extension of the time series from 2013 to 2017, in relation to the first publication of the EEAW, which covered the period from 2013 to 2015. It is important to highlight the new estimates of soil water use. In the first publication of the EEAW, the estimates on the use of water by Agriculture, forestry and fishing referred only to surface and groundwater. Therefore, for the analysis of the results, it was important to distinguish which types of water were being evaluated.

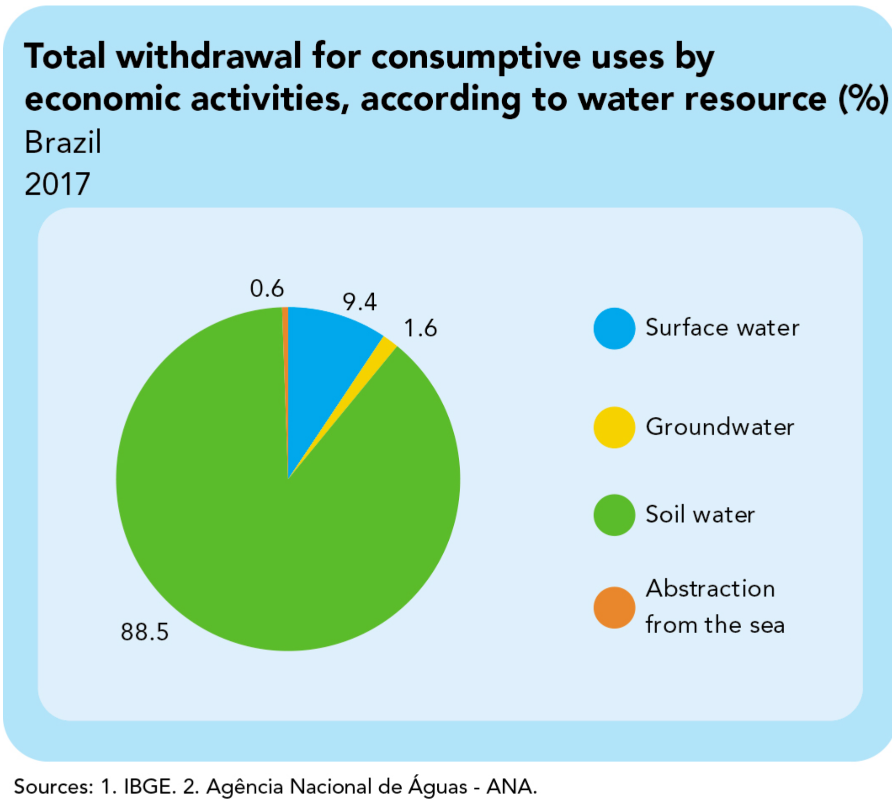
The EEAW are composed of four sets of information. The Asset Accounts shows the increases and decreases in the stock of water resources, the Physical Supply and Use Tables (Physical SUTs) describe the withdrawals of water from the environment by abstraction by the economy, the water flows within the economy, and the return flows from the economy back into the environment. The Hybrid Supply and Use Tables (Hybrid SUTs), which list the monetary values of production, consumption and costs associated with the

Water supply and Sewerage activity. Lastly, the tables provide an analysis of regional results. The breakdown by economic activities of EEAW is based on the National Classification of Economic Activities (in Portuguese CNAE 2.0) and the recommendations of SEEA-Water 2012.

6.2.2. National results: Physical Supply and Use Tables

In Brazil, in 2017, there was a total withdrawal of approximately 3.7 million hm³ of water (see Figure 32), which comprises both the withdrawal for own use as well as the withdrawal of water for distribution purposes. Of the total withdrawal, 88.5 per cent came from the soil, 9.4 per cent from surface water bodies, 1.6 per cent from groundwater and 0.6 per cent from the sea, as shown in Figure 31 below.

Figure 31: Total withdrawal for consumptive uses by economic activities, according to water resource (%): Brazil 2017



Source: IBGE (2020f)

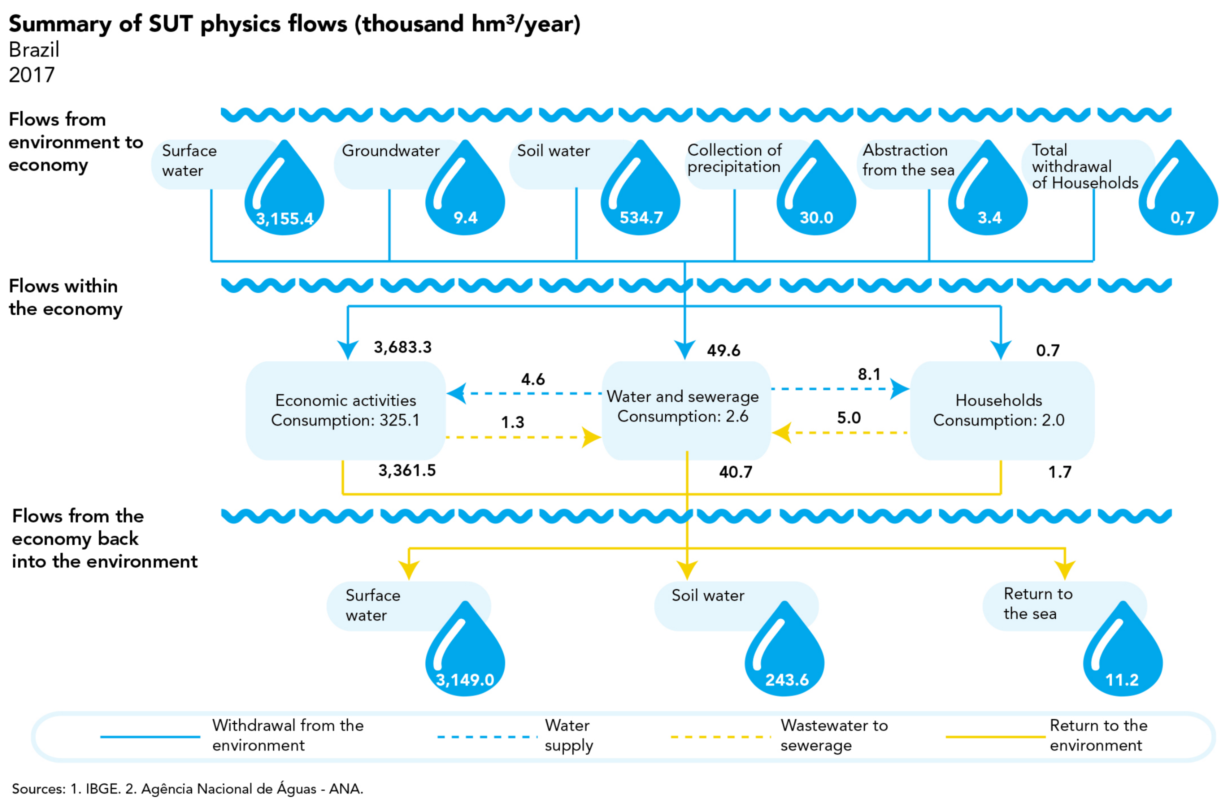
At the national level, the economic activity that contributes most to the total withdrawal volume is Electricity and gas supply, due to the large amount of water used by hydroelectric dams and the importance of hydropower in Brazilian electricity generation. In 2017, hydropower's share was 83.0 per cent, even though the volume of water captured by this activity is predominantly used and returned in the same quantity and quality, which is characterized as a non-consumptive use.

In the activity Sewerage, the withdrawal of water corresponds to the catchment of rainwater that is drained through mains (pipes), recorded with the same volume both in withdrawal and in returns to the environment (in 2017, this volume corresponded to 0.8 per cent of total water withdrawal)

Thus, excluding Energy and gas supply and Sewerage, the main activities responsible for direct water withdrawals for consumptive use are: Agriculture, forestry and fishing (94.5 per cent) and Water collection, treatment and supply (3.2 per cent). It is essential to emphasise that such results are different from those presented in the context of the survey of water provisioning services as a result of the latter having been developed by biome, and not for the entire national territory (IBGE, 2020f).

In this context, it is important to identify the types of water used by Agriculture, forestry and fishing. In 2017, 93.5 per cent of the volume of water withdrawn came from water stored in the soil (mainly used by rainfed agriculture - not irrigated), and the rest came from surface and underground water bodies.

Figure 32: Summary of physical SUT flows (thousand hm³/year) - 2017



Source: IBGE (2020f)

In 2017, the total water consumption, which corresponds to the water used minus the water returned to the environment, was 329.8 thousand hm³. The largest water-consuming sector was Agriculture, forestry and fishing (97.4 per cent), with an emphasis on the role of rainfed agriculture.

The water intensity indicator measures the amount of water consumed (in liters) for each real unit of GVA generated by economic activities. It is noted that Agriculture, forestry and fishing is the sector with the highest consumption intensity, whether the soil water is accounted for or not. The inclusion of soil water in the consumption intensity indicator shows that rainwater contributes to an increase in intensity of about 11 times in 2017. As shown in Figure 33, the intensity of Agriculture, forestry and fishing including soil and water decreased between 2013 and 2017, from 1,324.9 Litres/Real to 1,060.5 Litres/Real, while the intensity of the sector without soil water decreased from 104.9 Litres/Real to 95.5 Litres/Real.

Figure 33: Consumption intensity (Liters/R$) - 2013 - 2017

Brazil

Economic activities	2013	2014	2015	2016	2017
Agriculture, forestry, and fishing	1,324.9	1,265.0	1,290.2	1,053.8	1,060.5
Agriculture, forestry, and fishing (1)	104.9	108.9	109.5	95.5	95.5
Extractive industries	1.4	1.5	2.5	5.2	3.4
Manufacturing industries and construction	4.4	3.9	3.6	3.4	3.4
Electricity and gas	1.5	1.8	1.2	0.8	0.7
Other activities	0.2	0.1	0.1	0.1	0.1

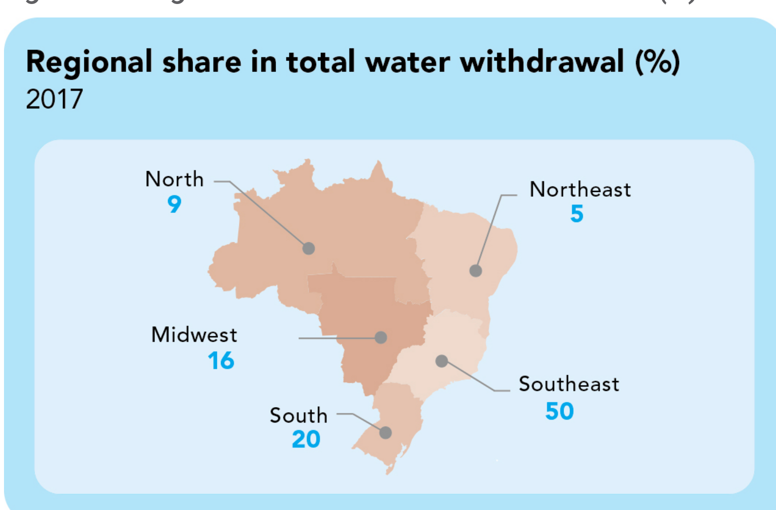
Sources: 1. IBGE. 2. Agência Nacional de Águas - ANA.
(1) Without soil water.

Source: IBGE (2020f)

6.2.3. Regional results by macro region

With regard to total water withdrawals, the economic activity responsible for the highest volumes in all major regions was Electricity and Gas supply. The Southeast is the region with the largest share in total water withdrawal in all years of the 2013-2017 series (Figure 34). If only the consumptive uses of water are considered, then the largest volume of total water withdrawal takes place in the Midwest (30 per cent), followed by the Southeast (26 per cent), South (25 per cent), Northeast (12 per cent) and North (7 per cent). In this case, the Midwest, the main grain producer in Brazil, becomes the region with the largest share of water withdrawals, mainly because of rainfed agriculture, characterized by the use of soil water, resulting from rainfall.

Figure 34: Regional share in total water withdrawal (%) - 2017

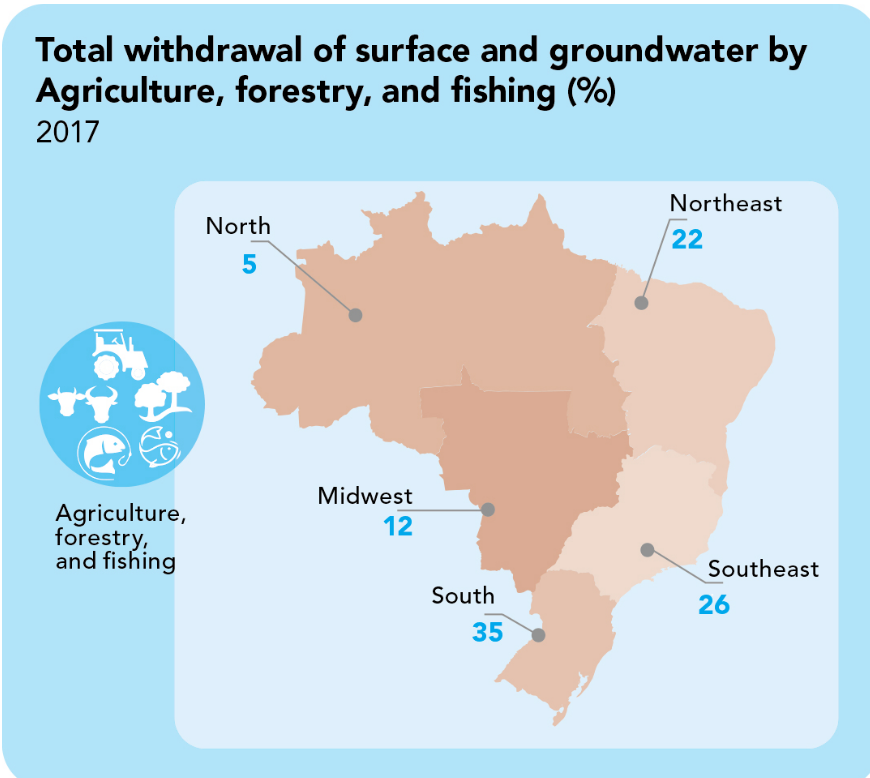


Sources: 1. IBGE. 2. Agência Nacional de Águas - ANA.

Source: IBGE (2020f)

The economic activity with the greatest share in the abstraction of surface and ground water for consumptive use in all the major regions was Agriculture, forestry and fishing. However, it is important to highlight that the share of this activity in the total withdrawal of surface and soil water is different in each region, with predominance in those regions where irrigated agriculture has greater importance, namely, the South (35 per cent), followed by the Southeast (26 per cent), the Northeast (22 per cent) and the Midwest (12 per cent) – see Figure 35.

Figure 35: Regional share of total water withdrawal by the Agriculture, forestry and fisheries sector (%) - 2017



Sources: 1. IBGE. 2. Agência Nacional de Águas - ANA.

Source: IBGE (2020f)

The analysis of water consumption intensity indicators by region, presented in Table 25, makes it possible to identify in which regions the sectors are more water-intensive. It is observed that the agriculture sector is the one with the greatest intensity, and that, when considering the portion of consumption without soil water, the region with the greatest intensity is the Northeast, followed by the Southeast, with 151.1 Litres/Real and 116.5 Litres/Real, respectively.

Table 25: Hybrid indicators of water consumption intensity by sector and region (litres/BRL) - 2017

Indicators	Unit	N	NE	SE	S	CO
HYBRID INDICATORS						
Water consumption intensity						
Agriculture, livestock, forestry, fishing and aquaculture	litres/ BRL	482.3	762.5	1,289.8	984.0	1,511.9
Agriculture, livestock, forestry, fishing and aquaculture (without ground water)	litres/ BRL	38.1	151.4	116.5	86.4	63.3
Extractive industries	litres/ BRL	4.6	1.7	2.8	10.3	7.0
Manufacturing and construction industries	litres/ BRL	1.2	7.1	3.0	1.8	6.5
Electricity and gas	litres/ BRL	0.2	1.4	0.8	0.6	0.2
Water and sewage	litres/ BRL	203.7	135.6	59.8	56.2	46.6
Other activities	litres/ BRL	0.3	0.1	0.1	0.1	0.0
Total economic activities	**litres/ BRL**	**52.0**	**52.1**	**32.8**	**84.6**	**150.7**

Source: IBGE (2020f)

On the other hand, the highest consumption intensity in the Water and Sewerage sector lies in the North region, followed by the Northeast, with 203.7 Litres/Real and 135.6 Litres/Real, respectively.

Section 7:

Applications of environmental economic accounting for deriving indicators

Brazil is part of the United Nations Sustainable Development Goals (SDG) initiative. The SDGs are a set of 17 global goals defined by the United Nations General Assembly in 2015 for the year 2030. They form the agenda to achieve a better and more sustainable future for everyone. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity and peace and justice. There are 169 targets for the 17 goals. Each goal has between 1 and 3 indicators used to measure progress towards achieving goals.

The Brazilian government has undertaken several efforts to promote the country's adaptation to globally established goals, considering national strategies, plans and programs and the country's development in the next decade. This resulted in a comprehensive SDG National Report, coordinated by the Institute for Applied Economic Research (Portuguese acronym is IPEA) with the collaboration of 75 government and civil society bodies (IPEA, 2018).

Many SDG indicators can be directly derived or reported by the Environmental-Economic Accounts. An analysis carried out under the NCAVES project concluded that more than 40 SDG indicators could be informed by accounts, with about half of them fully aligned in terms of definitions and concepts. Some examples are shown in Table 26.

Table 26: Sustainable Development Goal Indicators and relationship with the Environmental Economic Accounting System

SDG Indicator Number	SDG Indicator	Related EEA
6.4.1	Change in water use efficiency over time	EEA - Water
6.6.1	Changes in the extent of ecosystems related to water uses over time	Ecosystem Extent Accounts; Land Cover Change and EEA-Water
7.2.1	Participation of renewable energies in the Internal Energy Offer (OIA)	EEA-Energy
7.3.1	Measurement of energy intensity in primary terms and in GDP	EEA-Energy
8.9.1	Tourism GDP as a proportion of total GDP in terms of growth	Ecosystem Services Accounting
11.7.1	Average share of built-up areas in open cities in public spaces, by gender, age and disability	Extent Accounts, Land Cover Accounts and Ecosystem Service Accounts
14.5.1	Coverage of protected areas in relation to marine areas	Ecosystem Condition Accounts and Biological Resource Accounts
15.1.1	Proportion of forest area to total land area	Ecosystem Extent Accounts and Land Use Accounts
15.3.1	Proportion of degraded land to total land	Ecosystem Extent and Condition Accounts
15.5.1	Red List Index	Ecosystem Condition Accounts and Biodiversity Accounts
15.9.1	Progress towards national targets established in accordance with Aichi Target 2 of the Strategic Plan for Biodiversity 2011-2020	Biodiversity Accounting, Ecosystem Accounting

The Water Accounts developed by IBGE and ANA are used to derive indicators of intensity and efficiency of water use. The second edition of the water accounts released in 2020 indicated the efficiency of water use for 2013-2017, as shown in Table 27. These numbers, when tracked over time, provide relevant information for government authorities in charge of developing, implementing or monitoring water management policies against established national and/or global target indicators.

Table 27: Indicators of Environmental-Economic Accounts for Water 2013-2017

Indicators	Unit	2013	2014	2015	2016	2017
HYBRID INDICATORS						
Water use efficiency						
Agriculture, livestock, forestry, fishing and aquaculture	BRL/m³	0.41	0.44	0.44	0.54	0.53
Agriculture, livestock, forestry, fishing and aquaculture (without ground water)	BRL/m³	6.80	6.83	6.74	7.60	7.68
Extractive industries	BRL/m³	197.98	184.67	117.33	55.94	86.77
Manufacturing and construction industries	BRL/m³	123.94	134.50	145.48	153.91	151.98
Electricity and gas	BRL/m³	0.02	0.02	0.03	0.03	0.04
Water and sewage	BRL/m³	0.47	0.49	0.48	0.59	0.65
Other activities	BRL/m³	1.586.88	1.773.15	1.944.81	2.202.00	2.268.78
Total economic activities	**BRL/m³**	**1.32**	**1.44**	**1.42**	**1.48**	**1.51**
Cost of distribution of water and sewage services						
Economic activities	BRL/m³	2.81	2.95	3.01	3.36	3.69
Households	BRL/m³	1.89	1.98	2.10	2.49	2.77
Total savings	**BRL/m³**	**2.18**	**2.29**	**2.40**	**2.76**	**3.06**

Source: ACCOUNTS (2020f)

More generally, ecosystem accounts can contribute to the formulation of a wide set of indicators, for instance emerging in the context of the post 2020 global biodiversity monitoring framework.

Section 8:

Discussion of combined results across Extent Account, Condition Account, Ecosystem Services and Threatened Species Account

The purpose of this section is to create unity among the products that make up the Brazilian Ecosystem Accounts, listing the main results that were extracted from the development of each of the accounts. Considering that the extent account (IBGE, 2020a) constitutes the first step of the Ecosystem Accounting. This is done by defining the spatial units of the Ecosystem Accounting Area as well as the Ecosystem Assets and the Ecosystem Types, and then relating the results of the other accounts to the conversions in areas observed in the Extent Account through the ecological delineation of the Brazilian biomes.

8.1.1. Amazon Biome

According to IBGE (2020a), the Amazon was the biome that experienced the largest reduction of natural areas (269,801 km2) in absolute terms, especially due to the pressure factors associated with pasture activities with agricultural management and land use, causing a process of transition to mosaic areas, resulting from the fragmentation of the landscape. In relation to such evidence, the other developed accounts corroborate the following data:

i) Ecosystem accounts for endangered species (IBGE, 2020b) demonstrate that the Red List Index (RLI) of the Amazon Biome has worsened for terrestrial, freshwater and marine species. The species in all these environments experienced an increase in the risk of extinction, represented by the following RLI reductions: 0.83 per cent for terrestrial species; 0.55 per cent for freshwater species; and 0.12 per cent for marine species. The reduction in the RLI was greatly influenced by a change in the average index observed in the group of birds, in the order of -2.19 per cent.

i) The condition indicators related to the quantitative and qualitative water balance (IBGE, 2021a) are presented as excellent and very good, respectively, due to lower occupation of the region and high water availability.

ii) In relation to water provision services (IBGE, 2021c), although there is low water abstraction in the Amazon biome (7 per cent of the total abstracted in 2017), between 2010 and 2017, there was a 17 per cent increase in water demand for agricultural use and 11 per cent for livestock use. In 2017, the main use of direct water abstraction in this biome was for urban water supply (36 per cent), followed by drinking water (28 per cent) and irrigated agriculture (14 per cent).

iii) Regarding the physical flows of extracted NTFP provision services (IBGE, 2021b), there is a drop in the production of several products between 2006 and 2016, such as palm hearts (-33 per cent), babassu almond (-58 per cent), rubber (-69 per cent), carnauba powder (-29 per cent) and piassava (-71 per cent). This drop may be associated with different factors, such as loss of natural areas for collection, as well as the shift of labor towards alternative economic activities, such as agriculture and livestock, and with the dynamics of the national market.

8.1.2. Cerrado Biome

According to the Brazilian Ecosystem Extent Account (IBGE, 2020a), the Cerrado had the second largest reduction in natural areas (152,706 km²) in absolute terms, as a result of a continuous and accelerated expansion of agriculture, with addition of an area of 102,603 km² (+52.92 per cent), and the expansion of pasture with addition of an area of 55,451 km² (+13.22 per cent), to the detriment of a reduction in grassland vegetation and forests and tree cover (IBGE, 2020a). Such information combined with some of the results of the other accounts, show that:

i) In the Cerrado Biome, there is a reduction in the RLI of 0.22 per cent of terrestrial species and 0.22 per cent of freshwater species, indicating an increased risk of species extinction, in the biome, in these two realms. The marine realm remained stable (IBGE, 2020b).

ii) There was a reduction in the number of monitoring points that showed good levels of Total Phosphorus between 2010 and 2017, which may be indicating an increase in erosion resulting from the intensification of land use and use of fertilizers in agriculture (IBGE, 2021).

iii) Important share of the agricultural and livestock sector in direct water abstraction, representing 61 per cent and 12 per cent, respectively, in 2017, corroborating the analysis of the importance of both activities in the biome. Furthermore, in the period from 2010 to 2017, there was a 35.2 per cent increase in the demand for financial support from the agricultural sector, reinforcing the occurrence of expansion of agricultural areas.

iv) A drop in the production of extracted NTFPs was also observed in this region (IBGE, 2021b), such as yerba-mate (-61 per cent), palm heart (-61 per cent), pequi almond (-72 per cent), babassu almond (-42 per cent), powdered carnauba (-67 per cent), jaborandi (-25 per cent) and piassava (-33 per cent).

8.1.3. Caatinga Biome

The Caatinga has a degree of anthropogenic interference characterized by the continuous reduction of its natural coverage, giving rise, above all, to the growth of mosaic areas, agricultural areas and managed pasture areas (IBGE, 2020a), characteristic of a fragmented rural landscape. The Caatinga recorded the largest decrease in the rate of change in natural areas, going from 17,165 km² (2000-2010) to 1,604 km² (2016-2018). This information is corroborated by the following:

i) The Caatinga Biome recorded the lowest change in RLI, with a small reduction in freshwater species (-0.02 per cent) and stable values in the other realms (IBGE, 2020b).

ii) There was a reduction in the number of monitoring points that showed good levels of Total Phosphorus between 2010 and 2017, and the majority of the micro-watersheds that make up the Caatinga (44 per cent) have shown a very critical quantitative water balance (IBGE, 2021a).

iii) The share of direct water abstraction in the biome amounted to 14 per cent of the total water abstracted in the country in 2017. However, it is worth highlighting the large share of irrigated agriculture in the direct abstraction of water in the biome, representing 75 per cent of the total water abstracted in the biome in 2017 (IBGE, 2021a).

iv) In this region, there was also a drop in the production of wild NTFP such as pequi almond (-87 per cent), babassu almond (-39 per cent), carnauba wax (-45 per cent), carnauba powder (-51 per cent) (IBGE, 2021b).

8.1.4. Atlantic Forest Biome

The Atlantic Forest is the only Brazilian terrestrial biome whose predominant category is not natural coverage (IBGE, 2020). Along with the Caatinga, the Atlantic Forest is the biome that recorded the greatest decreases in the rate of change in natural areas, from 8793 km² in the initial period (2000-2010) to 577 km² in the most recent period (2016-2018). However, this is the only Brazilian terrestrial biome showing a predominance of loss of areas with broad anthropic uses in the studied period - the mosaics of occupation in forest areas. With a significant spatial extent in the country, this biome presented gains in categories with greater levels of anthropization, where several crops are developed.

i) It is observed that the species of the Atlantic Forest Biome suffered an increase in the risk of extinction across all realms, represented by the following RLI reductions: 0.23 per cent for terrestrial species; 0.22 per cent for freshwater species; and 0.11 per cent for marine species. Such evolutions indicate that there was an increase in the degree of threats across the three types of realms (IBGE, 2020b).

ii) The effects of the history of occupation and transformation of the Atlantic Forest on surface water ecosystems are also reflected in the higher proportion of aquatic vertebrate species threatened with extinction (IBGE, 2021a).

iii) Catchments in the Atlantic Forest are the main responsible location for the direct abstraction of water in Brazil, followed by the Cerrado, Pampa, Caatinga and Amazon. This is mainly due to the urban water supply activity. Regarding the quantitative water balance, 11% of the micro-watersheds are in a worrying, critical or very critical state and, possibly, they are the micro-watersheds with the highest population density, since main cities and metropolitan are located in this biome. Furthermore, it is important to highlight that 28 per cent of the micro-watersheds in the Atlantic Forest had a reasonable, bad or very bad qualitative water balance, which is related to the large presence and concentration of urban areas in the territory (IBGE, 2021a).

i) In the Atlantic Forest, there was a decrease in the volume of wild palm hearts (-66 per cent), piassava (-40 per cent), and an increase in wild yerba-mate (+56 per cent). Among the cultivated NTFPs, there was an increase in the volume of cultivated yerba-mate (+56 per cent), cultivated palm hearts (+114 per cent) and cultivated clotted latex (+84 per cent) (IBGE, 2021b).

8.1.5. Pampa Biome

The Pampa has a marked pattern of human occupation on the plateaus. This biome experienced the greatest percentage loss of natural areas, a reduction of 16.8 per cent of its natural area, namely, equal to 15,607 km² between 2000 and 2018. In that period, the largest areas converted to other land uses were: 58.0 per cent of Savannah, shrubland and grassland into farming area; and 18.8 per cent in forestry area (IBGE, 2020a). This result is aligned with information from the different accounts:

i) While the terrestrial and freshwater realms of the Pampa biome remained stable, the marine realm showed a reduction of 0.10% (IBGE, 2020b).

ii) Most of the micro-watersheds that make up the Pampa (34 per cent) showed a very critical quantitative water balance. The intense rice irrigation in this biome is noteworthy (IBGE, 2021a).

iii) The significant share of direct abstraction of water, used as a production input (in the irrigation of crops) (IBGE, 2021a).

iv) The Pampa has a low contribution to the production of NTFP (IBGE, 2021b). However, it is observed that there was a drop in the volume of both wild yerba-mate, from 10,601 to 5,071 tons (-52 per cent), and cultivated yerba-mate from 66,111 to 61,475 tons (-7 per cent).

8.1.6. Pantanal Biome

The Pantanal is the biome that underwent the smallest decrease in natural areas, both in absolute (2 109 km²) and in relative terms (1.6 per cent), which depicts lower conversions of use in that region of the country (IBGE, 2020a).

i) In the Pantanal biome, the main variation of the RLI was observed in the freshwater realm, with a reduction of 0.33 per cent (IBGE, 2020b).

ii) The biome has a low share in the direct abstraction of water in the country, representing only 0.2 per cent. However, the abstraction occurs mostly for livestock watering purposes (60 per cent), corroborating the expansion of pasture with management identified in the extent accounts. However, since livestock in the region is also kept in grasslands, no important changes in natural areas are identified in absolute or relative terms (IBGE, 2021a).

iii) The Pantanal has a low contribution to the production of NTFP. In the Pantanal there was an increase in cultivated rubber from 139 to 760 tons (+447 per cent) and an increase in wild pequi almonds (+145 per cent) (IBGE, 2021b).

Section 9:
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Section 10: Annex

10.1 Land cover and land use classes - Natural and anthropized areas

Land Cover and Land Use Classes	Category	Description
Artificial Surfaces	Anthropized	Areas where non-agricultural anthropogenic surfaces predominate. Their structure includes buildings and road system, in which are located metropolises, cities, towns, indigenous villages and quilombola communities, areas of highways, services and transport, energy networks, communications and associated lands, areas occupied by industrial complexes and buildings that may be located out of the urban settlements. Mineral exploration or extraction are also included.
Cropland	Anthropized	Area characterized by temporary, semi-perennial and permanent crops, irrigated or not, dedicated to the production of food, fiber and agribusiness commodities. Includes all cultivated areas, including fallow or floodplain. It can be represented by heterogeneous agricultural zones or large areas of monoculture. Also includes aquaculture tanks.
Managed Pasture	Anthropized	Areas intended for grazing cattle and other animals, with cultivated herbaceous vegetation, mainly brachiaria and ryegrass, or natural grassland vegetation, both presenting high intensity anthropogenic interference. These interference may include planting; land clearing (removal of tree stumps and stones); mechanical or chemical weeding (herbicide application); harrowing; liming; fertilizing; among others that mischaracterize natural cover.
Mosaic of Occupations in Forest Area	Anthropized	Mixed occupation of agriculture, pasture and/or silviculture associated or not with forest remnants, in which an individualization of its components is not possible. It also includes areas with natural and anthropogenic disturbances, mechanical or non-mechanical, that hinder its characterization.
Silviculture	Anthropized	Forest plantations of exotic or native species as monocultures
Forest Tree Cover	Natural	Area occupied by forests. Forests are considered tree formations over 5 meters high, including areas such as Dense Ombrophylous Forest, Open Ombrophilous Forest, Seasonal Forest and Mixed Ombrophilous Forest. Due to their size greater than 5 m, it includes other formations, such as Tree Campinarana, Tree Savannah, Tree Deciduous Thorn Woodland, Tree Steppe, Mangroves and Buritizais, according to the Manual Técnico de Uso da Terra (IBGE, 2013).
Wetland	Natural	Natural herbaceous formation (covering 10% or more) permanently or periodically inundated by fresh or brackish water. It includes estuaries, marshes, swamps and others. Inundation period must be at least of 2 months per year. Shrub or tree vegetation may occur, but these formations must not occupy more than 10% of the total area.

Land Cover and Land Use Classes	Category	Description
Savannah, Shrubland, Grassland	Natural	Area occupied by savannah, shrubland and grassland vegetation. This class comprises vegetation with features very distinct from forest, that is characterized by a predominantly shrubby stratum, sparsely distributed over a grassy-woody stratum. This category includes Savannas, Steppes, Deciduous Thorn Woodland, Pioneer Formations and Ecological Refuges. They are scattered throughout different phytogeographic regions, comprising different primary typologies: plateau steppes, coastal mountain ranges and coastal (restinga) hydrosandy fields, according to the Manual Técnico de Uso da Terra (IBGE, 2013). These areas may be subject to grazing and other low-intensity anthropogenic interference such as the natural pastures of the Pampas and Pantanal biomes.
Mosaic of Occupations in Savannah, Shrubland, Grassland Area	Anthropized	Mixed occupation of agriculture, pasture and/or silviculture associated or not with natural vegetation (savannah, shrubland and grassland), in which it is not possible to individualize its components. It also includes areas with natural and anthropogenic disturbances, mechanical or non-mechanical, that hinder its characterization.
Inland Water Bodies	Natural	Includes all inland waters, such as rivers, streams, canals, and other linear water bodies. It also encompasses naturally enclosed water bodies (natural lakes) and artificial reservoirs (artificial water reservoirs built for irrigation, flood control, water supply and power generation).
Coastal Water Bodies	Natural	It includes all coastal waters (lagoons, estuaries and bays that occupy the Coastal Plains) and waters within the 12 nautical miles, according to the Brazilian legislation.
Barren Land	Natural	This category includes locations with no remaining vegetation, such as rocky outcrops, cliffs, reefs and land with active erosion processes. It also includes coastal and inland dunes and accumulation of gravel along the river plans.